Scientometrics, Vol. 12. Nos 3–4 (1987) 149–161

USE OF BIBLIOGRAPHIC DATA BASES FOR SCIENTOMETRIC STUDIES

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(Received November 25, 1986)

The paper is a review of different applications of various bibliographic data bases to bibliometric and scientometric research such as identifying the leading journals in certain fields, investigating the structure and development of particular fields including trend analysis and forecasting, as well as the study of the contribution of various countries to world science as reflected in scientific literature presented in information files. The paper also covers the results of investigation of Polish scientific literature, as presented in the foreign data bases, in the fields of information science (LISA, ISA, INSPEC, 1977–1983), chemistry (CASearch, 1978–1985), physics (INSPEC, 1979–1985), science–various disciplines (SCISEARCH, 1980–1984). Along with many advantages of using bibliographic data bases for scientometric research some limitations are also described which may originate in data bases content, and have to be taken into account while designing such a type of investigation.

Introduction

Scientometric studies covering all quantitative aspects of the science of science also include quantitative analysis of scientific literature (bibliometrics) as a reflection of science development and state-of-the-art. *Cawkell*[1] compared science to an edifice building upon the past, and indicated the potential for examining science through its literature, since published papers being the end product of much science research and its "building blocks" show the structure of this "edifice".

Computerized bibliographic data bases presenting scientific literature, created for subject oriented searching, have rendered possible scientometric studies which are not easy or virtually impossible to perform by manual methods. While studying scientific publications through their bibliographic features one can observe many different characteristics of subjects and objects that science consists of. There are various searchable elements that describe the bibliographic characteristics of the items included in data bases. Some of them are subject oriented such as classification codes, descriptors, key words, words in the title, while other features point out the type of publication

Elsevier, Amsterdam–Oxford–New York
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(e.g. journal paper, conference paper, book, patent, report), source (e.g. journal title, country of its editor, CODEN, ISSN number, patent number, and year of publication, volume, number of issue, pages), language of publication, name and corporate affiliation of the authors (name of organization, city, country), as well as data on secondary source (year, volume and number of the abstract).

It does not mean that all available bibliographic data bases present all these characteristics (e.g. some of them do not include corporate affiliation of the authors of publication or CODEN).

Besides the mentioned characteristics of the published items presented in many bibliographic data bases one can also find (exclusively in the series of data bases developed at the Institute for Scientific Information in Philadelphia) lists of references that were cited by the authors of particular papers. This feature offers the possibility of a qualitative approach to the quantitative studies. Citation indexes have also opened up new areas of scientometric investigations and new approaches to the study of old problems, as summarized by *Garfield.*[2]

There are many possible directions of studying science through the investigation of a body of scientific literature presented in bibliographic data bases. Some of them introduced by *Hawkins*[3] and described as "unconventional uses of online information retrieval systems" were as follows:

– identifying the competitors in a particular field, both research organizations and authors,

– finding neglected areas of research,

– making comparisons of journal coverage,

– identifying the leading journals in a given field.

The last one is of particular practical importance both for researchers and librarians. Researchers would like to know which journals to scan regularly or to contribute papers to, librarians need to know this for journal collection improvements. *Hawkins*[4] examined the literature of semiconductors using INSPEC (Information Service in Physics, Electrotechnology, Computers and Control) data base and presented a listing of leading (core) journals in this field. *Stefaniak*[5] investigated chemical periodicals that were recorded in CACon (*Chemical Abstracts Condensates*) data base and found in the output delivered to SDI users. *Bonitz*[6] described a method of ranking journals according to a new parameter–Selective Impact, and applied it to study journals publishing papers on nuclear research using INIS (International Nuclear Information System) data base.

BLAISE (British Library Automated Information Service) was used by *Ritchie* et al.[7] to investigate humanities literature by studying the proportions of publications in various fields, language of publications as well as their type and size. It was concluded that the flexibility of the retrieval process and the fact that the data bases were

readily accessible, organized, maintained and updated, made BLAISE an invaluable part of this type of bibliometric study.

The other aim of studying scientific literature by means of bibliographic data bases is to perform trend analysis in research, as shown by *Hibbs* et al.[8] or *Dou* and *Hassanaly*.[9] By identifying the annual total of papers on a particular subject and observing the changes from year to year, one can develop a sense of increasing or falling interest. Trend analysis searches can be done in any data base that allows the combination of subject and date of publication. In many instances broad changes will have obvious significance, while in cases where numerical deviations are slight signifiacant changes may be recognized only when statistical analysis is applied. Forecasting scientific production is a way of estimating trends in various countries, fields, patents, thresholds of investment, etc. These analyses of trends can be used to determine research policy. *Dou* and *Hassanaly*[10] have described the use of CASearch (Chemical Abstracts Search) data base to perform the analysis of activity in the field of coal liquefaction including techniques involved, scientific potential–finances and people. They also list the core journals for this particular field. The authors point out that the small amount of money and time involved in such a scientometric study compared with the results obtained, show this approach as a valuable indication on which to base a significant programme in any considered field. Todorov and Fransazova[11] have studied the literature on robots and minicomputers on the grounds of data derived from INSPEC and COMPENDEX (Computerized Engineering Index), and found the dynamic growth of these subfields through the period 1970–1984. The authors stress the practical significance of scientometric studies.

The other interesting point of view on observation of development of science through the data recorded in various bibliographic data bases was presented by *Lancaster* and *Lee*.[12] This approach considers the use of online data bases not only to track the growth of the literature on some topic in time, but also to follow the diffusion of the topic through the different data bases, to observe spread of interest as reflected in occurence in increasing number of data bases, as well as movement from one type of data base to another (from "pure science" to "applied science" literature e.g. engineering solution of the problem) or the movement of a topic from data bases covering ongoing research to those covering conference papers or technical reports and then to those dealing primarily with the published literature e.g. articles in journals. The authors have demonstrated this kind of analysis on the example of literature on "acid rain". That term first appeared in NTIS (National Technical Information Service) data base in 1971, and has since occured several thousand times, now in more than forty data bases.

Persson[13] consiers the use of data bases for online bibliometric studies in four areas: distribution of scientific publications by country and subfield, by time, by

authors and by journals. He also presents the distribution of papers by Swedish physicists included in INSPEC data base as compared to the world-wide physics literature, and distribution by time (1971–1984) of Swedish and Japanese publications covered by INSPEC.

In fact a great deal of research has been done on the distribution of scientific literature by country, field and time, particularly in physics, as reported by *Vlachý*[14] in his comprehensive bibliography (among them many papers by the author of the bibliography).

Recently *Méndez* and *Gómez*[15] presented the results of a study on the contribution of Spanish literature into eight data bases in various fields of science (chemistry–CASearch, medicine–Excerpta Medica, biology–BIOSIS, agriculture–CAB, physics–INSPEC, engineering–COMPENDEX, food–FSTA, pharmaceutics–IPA). They also investigated the distribution of Spanish input by the type of publication, number of papers published in foreign and domestic journals, the contribution of different research institutions, and coverage of the Spanish journals by the mentioned data bases. They observed an increase of Spanish contribution to world science in 1983 as compared with the data of 1978.

The information files discussed so far, utilized for different kinds of investigations, were all subject oriented data bases. Apart from those, one of the most frequent to be used for scientometric studies is multidisciplinary data base–SCI (*Science Citation Index*) also used to study the contribution of different countries to world scientific literature. *Narin* and *Carpenter*[16] used the Corporate Index tapes of *SCI* to identify the publications by country, through a combination of computerized and manual identification of city, state, and other key words associated with the corporate affiliation of the source author. Indicators of national scientific activity (publication data, citation data) have been derived from counts of 500 thousand publications and millions of citations over the time span 1965–1971. The countries contributing most of all to the world science were the USA, USSR, then, far below UK and Germany followed by Japan and France. When the studies by *Frame* et al.[17] were done on the grounds of *SCI* data base 1973 for 117 countries it was shown that the distribution of mainstream science throughout the world is very uneven and different regions focus on different kinds of research. Five basic subject oriented patterns of national research emerged. It was found that Western countries concentrate most of their scientific potential on biosciences whereas Eastern European countries, among them Poland, focused primarily on research in the physical sciences.

Much more recent and detailed data on Polish chemical and physics literature are presented below.

Studies of Polish scientific literature

The studies of Polish scientific publications presented in foreign bibliographic data bases aimed to determine the contribution of Polish literature to world scientific literature, and in some fields to determine the internal structure of Polish literature as compared to world-wide scientific literature. Online bibliometric studies were supplemented with a more detailed analysis of data printed offline either in SDI or online searching procedures. The printouts were supplemented with additional information (e.g. type of corporate source, number of authors), coded and collected in a punched card file. Polish publications documented in different data bases were searched under the name of the country (included in corporate affiliation of the authors of publications), or under the searchable field "language" where the field "corporate source" was not available.

Information was obtained on the grounds of five data bases and included the following fields:

– information science and library science (1977–1983), on the grounds of three data bases: LISA (*Library and Information Science Abstracts*), ISA (*Information Science Abstracts*), and INSPEC C (*Computer and Control Abstracts*),

– chemistry and chemical technology (1978–1985), on the grounds of CASearch,

– physics, electrotechnology, computer science, control (1979–1985), on the grounds of INSPEC,

– science, various disciplines (1980–1984), using SCISEARCH (*Science Citation Index*).

Information science and library science

The contribution of Polish publications to the three mentioned data bases, LISA, ISA, and INSPEC C (section 72: Computer Applications, Information Science and Documentation), was studied for the period of seven years.[18] Since LISA does not include the corporate affiliation of the authors of publications, the set of Polish publications identified in this file was limited to items published in Polish. A total number of 337 Polish publications was included, which made up about 1% of the whole file (1977–1983). They were selected from seven Polish periodicals. The distribution of polish publications by time was very uneven and the number of presented papers dropped dramatically from 85 (~ 2.2%) in 1977 to four papers (~ 0.06%) in 1983.

The number of publications by Polish authors represented in the ISA data base is very low. There were only 48 items published in Polish and 43 items published in English included within the seven year period, which made up only 0.25% of the whole file.

Considering that INSPEC C includes only one aspect of information science–applications of computer technology to information processes–relatively many papers by Polish authors were found in this data base: 106 items published in Polish and 53 items published in English, which made up about 1.9% of the whole file. A drop in the number of papers by Polish authors published in 1982 and 1983 was observed, but only as far as papers published in domestic journals were concerned.

Altogether 24 foreign journals that published papers by Polish authors were included in the ISA and INSPEC C (section 72) files. The biggest number of Polish papers was published in the international journal–*Information Processing and Management.*

The contribution of Polish information science literature to the Soviet abstract journal–*Referativnyj Zhurnal, Informatika,* studied by manual methods, was found to be much higher than in the mentioned British (LISA, INSPEC C) and American (ISA) data bases. In the same period 1977–1983 the number of papers included amounted to 820 items, which represented above 3.5% of the total file.[18]

Chemistry

The contribution of Polish chemical literature included in *Chemical Abstracts* in the period of 1978–1985, as well as the internal structure of this literature was studied on the grounds of the most comprehensive chemical data base–CASearch. The content of the whole file consists of five main sections covering biochemistry, organic chemistry, macromolecular chemistry, applied chemistry and chemical engineering, physical and analytical chemistry.

The study was done in two stages. In the earlier one which included 1978–1979, data were collected offline, the second stage was conducted by means of online interactive literature searching system BRIOLIS (British Institute Online Information Service) for the period 1980–1985.

The data obtained in the course of the first stage were subjected to a thorough analysis.[19] It was found that the contribution of Polish publications to CASearch was above 9500 items per year, which made up about 2.2% of the total file. The Polish subfile consisted of different types of documents, over 75% of them being papers published in domestic and foreign journals, about 17%–patents, about 6%–conference papers and 1.4%–books. These proportions varied in different subject sections e.g. the proportion of patents was highest in the section on polymers and amounted to 33% of the Polish publications presented in this section. The publishers of books were identified and it was found that over 50% of the books were published by academic institutions.

The study of distribution of publications according to their subfields (as classified in CASearch) within the Polish subfile, showed relatively larger proportion of publi-

cations in organic chemistry and polymers sections, and relatively fewer publications in biochemistry section, as compared to the subject structure of the whole file.

A more detailed analysis was performed on the grounds of periodical literature selected from the Polish subfile. It was found that the papers by Polish authors were published in 285 domestic and 606 foreign journals from 26 countries (most of them published in the USA-118, UK-114, and FRG-105; it was also interesting to learn that 462 of these foreign journals were also included in *Science Citation Index*). Over 25% of papers by Polish authors were published in foreign journals, the highest proportion in the field of physical chemistry (42%), the lowest in the field of applied chemistry (13%). It was found out that almost half of the papers were published in foreign languages (mostly in English), with the highest proportion of foreign language publications being observed in the fields of organic and physical chemistry.

When the authorship of papers by the Polish chemists was investigated it turned out that the mean number of authors per paper amounted to 2.3, but it varied for different subfields from 2.1 authors per paper in applied chemistry to 2.5 in organic chemistry. It was also found that the number of authors of review articles was much lower as compared with the number of authors of papers on experimental research, and that the mean size of a publishing team, mainly dependent on the subfield of chemistry might have been influenced by the type of institution where the authors were working.

The distribution of papers according to their subject content and language of publication was also studied vs. the authors' corporate affiliation, which included not only the type of organization (institutions were divided into seven general classes: Polish Academy of Sciences research units, universities, technical universities, medical academies, agricultural academies, organizations sponsored by the Ministry of Chemical Industry, and other), but also its geographical location. In this way it was possible to observe the distribution of chemical research interests and efforts throughout the country.

The second stage was the continuation of the first one and covered the next six years (1980–1985). It facilitated observation of certain quantitative changes in time, yet the online analysis conducted during this experiment was much less detailed.[20] It was observed that starting from 1981 the contribution of papers by Polish authors to CASearch decreased, to reach its minimum (1.4%) in 1982, and was still relatively low (1.55% of the total CASearch file) in 1985. Within the Polish subfile, the drop in number of publications has been much more substantial for the Polish-language literature (journal and conference papers, books, reports) than for foreign language publications. The number of the latter, after the drop in 1982, increased in the following years, almost returning in 1985 to the initial level (the same level for

journal papers) as compared with 1980 data although the number of papers in domestic journals published in English was still much lower than in 1978–1980.

It was also observed that the novelty ratio* of publications by Polish authors presented in CASearch (particularly those published in Polish) was much lower than novelty ratio of CASearch files in subsequent years (in 1980–1985 the novelty ratio of CASearch files was rather high, within the range 0.51–0.59, which meant that 51–59% of abstracts presented items published and included in the file in the same year).

Physics

The contribution of Polish literature in the fields of physics, electrotechnology, computers and control, presented in bibliographic data base INSPEC (printed version: *Science Abstracts*) was studied for the period of 1979–1985.

The results obtained in online searching have shown that the numbers of publications by Polish authors were at this time within the range of 2990–2380 items per year, which made up 1.76–1.27% of the total file. The most substantial decrease in the number of publications was recorded in 1982, concerning mainly papers in domestic journals.

Among publications by Polish authors a great majority (about 90%) were journal papers, then some conference papers and a few books or book chapters, no patents.

A more detailed analysis was performed for physics literature of 1979–1984 on the grounds of the data retrieved from INSPEC A (printed version: *Physics Abstracts*) data base.[21]

Abstracts of Polish Publications made up about 1.5% (range 1.56 to 1.30%, in 1982) of the total amount of abstracts included in INSPEC A file, with the average number of 1650 publications per year. The proportion of journal papers in the Polish subfile was higher than in the total file. The detailed offline analysis of journal papers by Polish physicists, included in 1979 and 1984 files of the data base has shown that the papers were published in 44 domestic and 333 foreign journals (286 of them included also in *Science Citation Index*) many of them international, published in 21 countries. The highest number of foreign titles came from UK, the USA, the Netherlands and the FRG.

The distribution of papers by Polish physicists among the foreign periodicals was highly uneven. There was a relatively small set of 19 journals that published as many as 12–53 items per year, accompanied by a set of 211 titles that published one

*Novelty ratio is the proportion of items published in a particular year and included in the data base in the same year to the total of entries in that year.

Polish paper each. The journal articles were published in different languages, mainly in English. The distribution of publication languages in 1979 and 1984 was as follows: English–77.2 and 86.1%, Polish–18.8 and 12.3%, other–4.0 and 1.6% respectively. It is to be remembered that a certain number of papers published in the mentioned or other languages might be missing because they could not be selected on the basis of corporate source.

The study also covered the distribution of Polish physics literature among the physics subfields as compared to the subject structure of the total file. The analysis was performed for the 1984 file. It was found that the contribution of Polish papers included in subject sections classified as nuclear physics, geophysics, astronomy and astrophysics, was relatively low, whereas the proportion of papers on condensed matter physics was much higher in the Polish subfile than the average observed in the total file. It was shown that the distribution of Polish literature among various physics subfields did not fit the general world pattern. The differences were even more significant when comparisons were made at a lower level of classification. The specific subject structure of the Polish physics literature presented in INSPEC A bibliographic data base could also be observed while examining the distribution of Polish papers among specialized physics journals.

The occurence of uneven distribution of efforts in different physics subfields, as compared with the world-wide picture, was also observed in the literature of other countries.[22] As it was shown, these disproportions were more evident in the case of countries having medium potential (among them Poland) than in the case of countries of great economic and intellectual potential.

Science, multidisciplinary approach

Polish scientific literature included in SCISEARCH was studied using online searching for journal papers published within the period 1980–1984. The annual number of publications by Polish authors in this period fell in the range of 5500–4300, with the minimum in 1982. The proportion of Polish papers which equalled 0.96% in 1980 dropped to 0.72% in 1982, and did not exceed the level of 0.83% in next two years.

Only 10–12% of papers within the Polish subfile were published in Polish. The list of Polish journals covered by *Science Citation Index* does not exceed 30 titles, most of them being published in English.

On the grounds of the obtained results it was estimated that the numbers of papers by Polish authors published in 1980–1984 in highly prestigious foreign journals fell within the range of 3000–3500 items per year. It confirms the findings of the study of Polish chemical and physics literature.

Publishing in foreign journals, particularly those in English, has become very popular among scientists, and as it was mentioned by *Lancaster* et al.[23] who studied Indian and Japanese scientific literature, scientists publishing abroad are likely to seek out the most prestigious journals. There are different reasons for publishing papers abroad. Some of them, as indicated by *Inhaber,*[24] were that domestic journals might be weaker than the science done there, they might be inadequate for the size of the scientific population of the country, and the native language might be a barrier for readers outside of the country. Besides it seems that having some papers published in foreign or international journals of high prestige is also a question of author's prestige.

Comments

Investigation of science as reflected in scientific literature presented in bibliographic data bases can be carried on in many different directions such as distribution of scientific activity by country and field, the growth (or decline) of scientific potential in time, the dynamics and trends of development of various fields, internal structure of science. Studies can cover general problems of science or can focus on a particular area. As it was mentioned, citation indexes made possible more sophisticated featuring of science e.g. mapping the structure of science, revealing interdisciplinary links, observing formation of new disciplines or qualitative characteristics and obsolescence of scientific literature.

Although bibliographic data bases have turned out to be such a powerful tool for scientometric studies, one has to be aware of some features that may restrict certain kinds of investigations. The limiting features may refer to coverage of a particular field as far as world literature is concerned, span of time for retrospective searches, time delay in abstracting, lack of some data in bibliographic records or variation and inconsistency in representing certain data.

Coverage of the literature presented in a given data base as compared to world literature of a particular field may be limited for different reasons. Producers of some data bases include publications in selected languages or coming from certain geographic area. Even in data bases covering basically the world literature, publications of the country of the producer and countries of the same region or language often show better completness than the others. Some data bases include only certain types of publications. Widely used for international comparisons *SCI* data base covers mainly English-language journal literature (not because the producer eliminates deliberately coverage of journals published in other languages, but because authors of publications most frequently refer to English-language sources), and scientific literature published in other languages hardly seems to exist in certain fields. *Carpenter*

and *Narin*[25] found that *SCI* was representative of scientific literature for most countries and most fields. However the coverage of Soviet literature was so deficient that the scientific activity of the USSR in total, and in clinical medicine and biology in particular, did seem to be significantly underrepresented. *Lancaster* et al.[23] also admit that the use of *SCI* is likely to lead to underestimation of the proportion of literature published by Japanese and Indian authors since many of their own national journals including some important ones are not covered. Nevertheless, although *SCI* does not cover all the literature of science, it is certainly one of the most comprehensive of data bases, it is devoted to the complete range of science, and for certain studies cannot be replaced by any other of accessible information files.

For studies on dynamics of development of certain disciplines e.g. for analysis of trends, forecasting, historical point of view, some data bases available on line may have too limited time coverage.

The other limitation, especially when one intends to study state-of-the-art of certain discipline or recent achievements in a particular field, may be caused by the time delay in presenting publications in a data base. It is the experience of the author of this paper, who studied novelty ratio of Polish literature included into several data bases, that apart from results obtained for various sets of publications (retrieved from the same data base for various aspects such as country, language, type of publication) some data bases achieve on the whole a high level of up-to-dateness (novelty ratio within the range of 0.9–0.6, e.g. SCISEARCH, ABI/Inform, Management Contents, Excerpta Medica) while others are much less up-to-date (novelty ratio within the range of 0.15–0.30, e.g. FSTA, EI :Engineering Meetings, METADEX).

Lack of some information in bibliographic records such as corporate sources, type of publications, CODEN or ISSN symbols for journals, classification codes, make certain kinds of studies impossible (e.g. distribution of publications by country and field) or make analysis much more complicated (e.g. journal studies).

The last of the mentioned barriers is inconsistent presentation of certain data like the names of journals, names of institutions (corporate sources) and sometimes other information. As far as journal titles are concerned, in some data bases one can find the full titles, in the others abbreviations of the titles that happen to be different from base to base or even within the same data base, and, as it was mentioned, CODEN are not available in all data bases. In case of conference proceedings it is even more complicated. Yet the most difficult problems for online studies are usually created by a considerable variety in corporate sources presentation. This variety sometimes derives from optional translation of foreign names and/or inconsistency in producing the abbreviations of the names of the institutions.

The above shortcomings in data presentation could be eliminated by standardization put into practice by both editors of publications and producers of data bases.

But before this comes about scientometrists aware of all unquestionable advantages of using bibliographic data bases for research purposes should also take into consideration all possible limitations to improve the quality of their studies.

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