Jointly published by Akadémiai Kiadó, Budapest and Springer, Dordrecht

Scientometrics, Vol. 66, No. 3 (2006) 561–577

Bibliometric analysis – A new business area for information professionals in libraries?

Support for scientific research by perception and trend analysis

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Supplying library users with literature by a seamless linking of media is the goal of (scientific) libraries. By the digitization of primary and secondary data and the convergence of products and providers, libraries have already come very close to achieving this ideal. A digital library is the realization of this goal. However, many librarians are in danger of running out of imagination. What will come after the digital library? Will information professionals still be needed? What services can libraries offer? Bibliometric analysis is an example of new business areas in libraries. This paper will discuss what shape this service could take in practice, who needs it and what target groups exist in the scientific environment. Concrete examples of bibliometric analysis from the Central Library of Research Centre Jülich will round off the overview.

Introduction

The boundary conditions for library work have changed radically in the past few decades. All types of libraries are experiencing a re-evaluation, in the course of which their traditional fields of activities are being increasingly called into question. The situation is characterized by dramatic technological developments in the information sector, automation of operations, by an acquisitions budget that is being reduced in real terms together with continually rising book and journal prices, as well as by change in and diversification of the media in the holdings (Figure 1), by completely new information supply concepts that have become necessary (for example the discussion on "access vs holdings"), a corresponding change in user behaviour, new concepts of scientific communication (*Berlin Declaration*, 2003) and last but not least by drastic staff cuts in the largely publicly funded university libraries and other scientific institutions (HOMRIGHAUSEN, 2003; EBERBACH-HOUTROUW, 2003).

Received July 7, 2005

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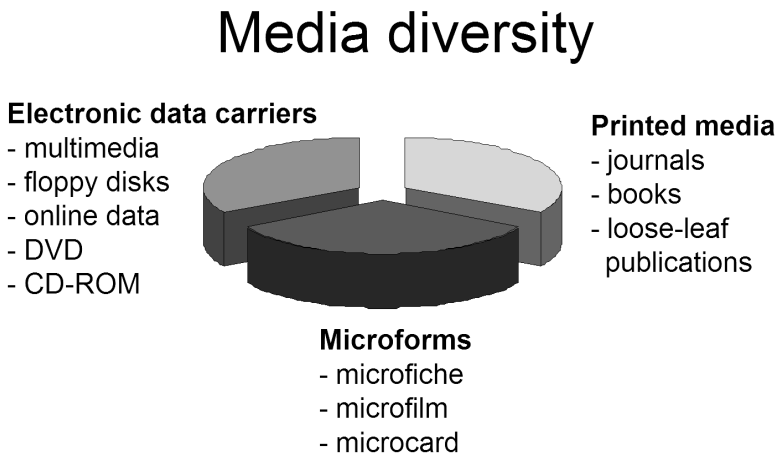

Figure 1. Media diversity in modern libraries

A completely new and increasingly more important role is being assigned to "information" in industry, science and society. At the same time, the concept is being understood in a more extensive and comprehensive sense and does not only involve knowledge already explicitly available on paper or in databases but also, and increasingly, the processing and provision of information for customers.

Traditional libraries and a new self-image

Previous tasks

Libraries have existed for thousands of years as collections of literature and knowledge, as places of reading and of scholarly study, and occasionally as a type of museum with collections of books of the most varied nature. The traditional tasks of a library can be described as the creation, preparation, processing and maintenance of holdings for authorized users. In order to fulfil this central core function, the classical tripartite function distinguishes the fields of acquisition, cataloguing and user services. Collection building and development is the central goal of acquisitions.

The definition of a library as a business enterprise (and thus the necessity of appropriate control and corresponding management) is relatively new. Libraries should

no longer resemble museums but should be business enterprises with the greatest possible efficiency. They should make an important contribution to research and teaching and the general promotion of education (JOCHUM, 1993).

Against the background of this concept, whether a library can provide the right books and information is no longer the sole criterion today, but the decisive issue is increasingly the contribution that the library can make to its host institution. Whereas the performance and significance of a library used to be measured by its holdings of books and journals, in the seventies progressive libraries began to demonstrate their efficiency by fulfilling certain, mostly rather questionable, performance figures. One example is the library index published by the Bertelsmann Foundation for public and research libraries. This library ranking is based exclusively on in-house data (BERTELSMANN FOUNDATION, 2004).

Today it is known from management theory that purely operational data cannot provide valid information on the significance of an institution (library). Operational data are no longer an appropriate controlling instrument for public and research libraries. On the one hand, "soft factors" have long proved to be much more influential in ensuring survival (lobbying, stakeholder approach), and, moreover, the significance of the library is now assessed according to its contribution to the enterprise as a whole. A library that only buys and lends books can do this quite efficiently (and thus provide excellent performance figures), but if its contribution is not effective (that is to say if it provides the wrong services) then it is superfluous for its funding body. It is therefore more important than ever to scrutinize a library's products and to examine them in a portfolio analysis with respect to their significance (BALL, 2000). It soon becomes apparent that traditional library services are no longer a guarantee for survival and are not enough to justify the existence of a library.

Libraries as service providers

Many examples from the literature show that the traditional picture of libraries and librarians is changing. Krasser, for example, reports on the transition from librarian to information manager and as the goal of library services in industry postulates "the learning enterprise or knowledge management in the sense of a systematic generation, storage, transfer, application and controlling of knowledge throughout the company so that all those involved have access to the knowledge of relevance to them" (KRASSER, 2001).

It is immediately evident that libraries have, or should have, the know-how for selecting and supervising information management systems. They seem destined for this function, especially in smaller companies (LIM & KLOBAS, 2000).

The change in traditional library tasks is also described by other librarians (LAPP & WÄTJEN, 1999)

In developing a comprehensive model of a "library", Brophy considers that the library has always been a growing organism, and, together with Licklider, postulates that it is the tasks of analysing, processing and reorganizing primary information for the user that characterize a library rather than the classical tasks of storing, indexing, searching for and delivering documents (BROPHY, 2000).

Other sources speak of a service mix for customers or indeed predict the collapse of traditional services (GRENZDÖRFFER, 2000). The Special Library Association publishes a whole catalogue dealing with new fields of activities for information professionals in the 21st century (ABELS et al., 2003). In identifying new fields of action, however, the question needs to be asked of the "concentration on core competencies vs diversification of the service portfolio" (BALL, 1999).

Bibliometric analysis as a business area in libraries

A interest in bibliometric data and the emergence of analytical methods first began to any appreciable extent in the eighties of the 20th century. Initially, mathematicians, information scientists and sociologists concerned themselves with mathematical models in bibliometrics. After that, interest in bibliometrics faded somewhat until in the late nineties information and library scientists took up bibliometrics once more against the background of a new science scene. Large volumes of digital bibliometric data, now easily processible, as well as the necessity of providing reliable, quantifiable information on scientific output and the frequent introduction of performance-oriented allocation of funds in science and research made the question of the possible application of bibliometrics a hot topic again. "The German Scientific Council regards the performance-oriented allocation of funds as a central instrument for supporting research and teaching, which is to be applied both within the faculties and also on the level of the federal state […..]. The aim is to reward high achievers and to provide incentives for increasing performance in research and teaching." For the further development of these instruments, guidelines have been drawn up in the Standortübergreifenden Stellungnahme zur Weiterentwicklung der Universitätsmedizin in Baden-Württemberg (UNIVERSITÄTSMEDIZIN, 2004).

Bibliometrics is thus experiencing a revival, not primarily with respect to mathematical modelling and theoretical principles, but as an instrument of science management.

Bibliometrics is gradually escaping from the "pigsty" of science evaluation and its reputation as a "conspiratorial element" and is beginning to establish itself as an accepted instrument in the orchestra of the overall evaluation of persons and institutions. Expert opinions from the German Science Council, for example, draw specific attention to bibliometric analysis, in France an institute was set up especially for this purpose in 1990 (Observatoire des Sciences et des Techniques, OST), and

bibliometric analysis will also play an important role in the recommendations of the Science Council on a ranking concept for scientific establishments in Germany (expected in July 2004, but not yet available, WISSENSCHAFTSTRAT, 2004). In the "Location-independent Commentary on the Further Development of University Medicine in Baden-Württemberg" (UNIVERSITÄTSMEDIZIN, 2004) the Science Council also refers to a bibliometric analysis of German medicine which it has commissioned from a sociological institute abroad (TIJSSEN et al., 2003).

In the USA, for instance, bibliometric data have already been used since the mid-seventies as a basis for funding decisions, and the use of quantitative indicators is just as widespread in the Scandinavian countries as in Switzerland where "research maps" have been drawn for certain disciplines.

On the other hand, the question is still completely unclear of who has the competence to implement bibliometric analysis. There are only a few experts specializing in bibliometrics who have the necessary knowledge of the scientific community and who at the same time can meaningfully handle the amount of data at their disposal. A few sociological and political science institutes attempted to make use of bibliometrics, but frequently only on a metalevel as a science OF bibliometrics. Information scientists themselves have not been active in this field either and have at most supplied a scientific commentary. It is therefore not unusual for assistants and secretaries of science managers to be entrusted with such tasks, which means they are completely out of their depth as are the scientists themselves, whose competence in the use of electronic information sources still leaves much to be desired (KLATT et al., 2001). A scientists who wishes to or has to make a bibliometric analysis rarely has the necessary know-how or the proper instruments available for making such an analysis.

Information professionals in libraries and information facilities have also taken up this business area much too late. Most members of the library community are still chasing the "digital library" without being able to see that this has almost been achieved and that they are now rather helplessly looking at a seamless supply of information, which, once established, can be routinely operated with a fraction of the human resources previously required by a library.

Information specialists are today at the focus of enormous volumes of data made available worldwide from science and its output. As information professionals they are basically in a position to handle these volumes of data and to distil reliable information from them. Who else in the scientific environment is able and willing to provide bibliometric data as a service for science managers – in an interdisciplinary manner and independent of their own scientific interests? Only libraries and information facilities are independent, interdisciplinary institutions capable of providing these central services.

Bibliometric analysis at the Central Library of Research Centre Jülich

As described above, there is great uncertainty with respect to responsibility for this controlling tool at scientific institutions. Without having been commissioned with this task by the Research Centre's management, the Central Library at Research Centre Jülich has concerned itself with bibliometrics for two years after acquiring the necessary know-how by appointing qualified personnel, by staff training and congresses.

A special type of bibliometric analysis has already been developed and used for holdings decisions. In the course of which the citations of the diploma and PhD theses produced at Jülich have been analysed and recorded to discover whether the cited literature is available at the Central Library of the Reseach Centre or not (BALL et al., 2003).

The Central Library offers the most varied types of bibliometric analysis for science evaluations. This involves institute-related analyses and trend analyses.The starting point is two standard products with the names "bibliometric report" and "bibliometric message". The products originated within the framework of the conference on "Bibliometric Analysis in Science and Research" held at Research Centre Jülich (RESEARCH CENTRE JÜLICH – CENTRAL LIBRARY, 2003). All the products in the bibliometric product line have the same logo for easier brand recognition.

"Bibliometric message" is a short version providing a brief and concise answer to a concrete query, for example the number of citations of an article or their distribution. "Bibliometric report" is the long version consisting of a summary and data section. This product is used for the analysis of complex issues that cannot be conveniently delimited. This includes, for example, a perception analysis. The inclusion of these products in the Central Library's portfolio has proved its worth and is attracting increasing interest.

Institute-related analysis (perception analysis)

The term "perception analysis" is used to describe a direct comparison of scientific institutions. For this direct comparison, institutes must be involved in the same scientific field. If the institutes work in different disciplines then a field normalization is required to relate the different fields to each other.

The main subject of perception analysis is a ranking in accordance with the perception of the scientific articles. This scientific perception can, for instance, be measured by the indicator of cites per paper.

The target group for this service is, on the one hand, the heads of the scientific institutes who want to know how their institutes stand at the present moment. "Every enterprise and almost every organisation or corporation is confronted with the task to monitor and evaluate the performance [...] of teams or of the whole unit"

(WAGNER-DÖBLER, 2003). Target groups of interest are also the staff involved in science planning. They attach major significance to the evaluation of larger research components (e.g. energy research).

The Central Library provides support for these tasks in the form of well-designed analyses:

- output analysis
- response analysis
- comparative analysis (national and international comparison)

Output analysis. The ISI Science Citation Index only covers a selection of journals. In order to obtain an overall picture, the core statement of the output analysis is to be found in the comparison of the development of publication numbers and publication types. Not only articles in journals are of interest here but also books, proceedings and lectures. The sources of this information are internal scientific reports and a database of publications by Research Centre staff set up by the Central Library in 2000. Similar objects are found in many research libraries and are maintained there. In addition, information professionals can provide a knowledge compaction.

With the aid of the publication database, information can be obtained according to institute or main areas of research on how the proportion of certain types of publications has changed over a period of time.

The most commonly used definition for the "output" parameter is the sum of all publications (without internal publications) and lectures. In the case of journals, a distinction is also made between refereed and nonrefereed. The output indicates how scientific findings are disseminated. The observation period is optimally selected according to the scientific discipline.

Response analysis. In the second step of a perception analysis, the response generated by publications is measured. The Science Citation Index can be used for this purpose. At the moment, this is the only multidisciplinary database that counts both literature references and also the associated citations.

The response can be defined in the form of the citation rate (CCP) as the number of citations per publication (NOYONS et al., 2003). However, this figure alone is not very meaningful and only attains significance as part of a national or international ranking. In addition to the citation rate, the development of the number of articles can indicate a rough trend. This picture can be further rounded off by listing the top papers with the largest number of citations and the papers which have accumulated the greatest number of citations in relation to their year of publication.

Comparative analysis (national and international comparison). In order to provide information on the impact of a scientific institution, a comparison with other institutes dealing with similar topics is indispensable, even if two institutions with identical topics will never be found.

If a mere Internet search were to fail at the point, an analysis of co-authors of the institute being studied may be of assistance since articles are often published jointly with partners from other institutions. It is also possible to identify comparable institutes from journals dealing with a similar topic in which articles from the institute in question have been published.

A response analysis is then also made for a selection of comparable institutes. Other possibilities of achieving a comparison are:

- number of citations of the institute studied in comparison to the journals in which the majority of articles are published
- number of cooperation partners
- patent statistics
- taking interdisciplinarity into consideration

Achieving added value by the library

The description of this perception analysis shows that a library can position itself at the top of the innovation scale with the aid of bibliometric products.

The use of existing information to create added value products means that the classical image of the object-oriented library is finally transformed into that of a service provider. Its function as a provider of raw data or data carriers is complemented by highly qualified information processing. Offering an added value service such as bibliometrics leads to the creation of a real information provision service of benefit to users.

Recognizing trends in scientific topics

Bibliometrics can be even further extended by the use of data sources to provide support in recognizing trends. The following example shows how the development of scientific topics can be analysed with the aid of bibliometrics in order to provide information on future developments.

What is a trend?

Is a trend just a chain of events consisting of coincidences, are they strategies or coincidences? Or can patterns be perceived? Trend research was introduced into classical economic theory by Igor Ansoff in 1975 and has become known as "weak signal research" (RUST, 2004). This concept provides a fairly accurate description of what a trend is: a weak signal that has to be identified in a large amount of data.

It is only possible to register trends as such by means of the methods described in the following sections.

Recognizing trends in science

The example of three scientific topics will be used here to show how it is possible to recognize trends with the aid of bibliometric methods. Two advancing and one declining topic were selected:

- ultramicrotomy (The term comes from materials science and it is used in connection with the preparation of objects for microscopy studies.
- bibliometrics / scientometrics / informetrics
- fast breeder reactor (This term comes from reactor engineering and is used to describe a reactor with no moderator. The fast neutrons prevailing here gave the fast breeder its name. This topic is now only dealt with in the USA.)

Three aspects will be taken into consideration:

a. The *past* is characterized by the development of the articles on the topic in question which can be found on the ISI and other databases. The development should be outlined over a sufficiently long period in order to draw the correct conclusions.
b. The *present* is represented by the citation behaviour of the community in question. The response generated can be read off from the development of the citation curve over time.
c. The *future* can be derived from the convergence of the regions of the past (a) and present (b). This approach will be discussed in detail in the following.

Past (number of articles on a database). The observational period for all three subject areas ranged from 1945 to 2003. This long period was chosen in order to cover the complete development of the three subject areas. Figures 2 to 4 do not always show the entire period studied but only about 5 years before the first publication was identified.

The picture emerges for ultramicrotomy. From 1965 onwards the number of articles increases in both databases. This increase is less pronounced in SCI since new topics do not always immediately succeed in overcoming the hurdle of publication in refereed journals, or else relevant publications are not necessarily covered in SCI. Ultra-microtomy is a very specialized subject so that the complete spectrum of the topic will probably be included on the PubMed database that was also used. PubMed is broader-based with its major emphasis on medicine. The connection between bibliometrics and libraries can already be seen in the choice of database.

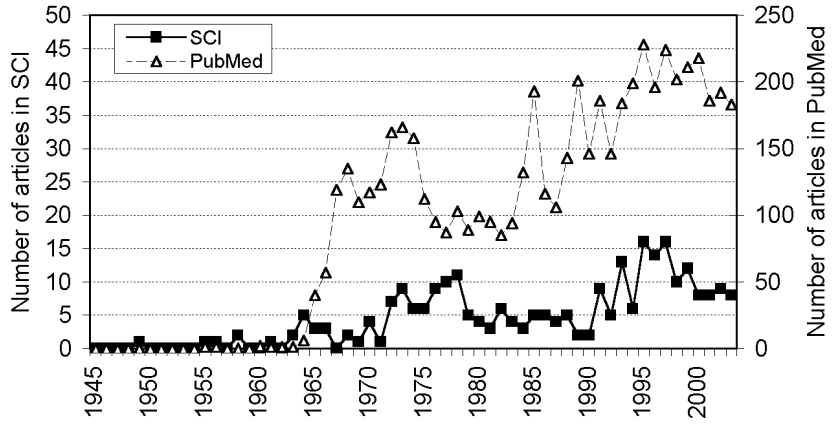

Figure 2. Development of the articles identified on the Science Citation Index (SCI) and PubMed databases on "ultramicrotomy"

Only information professionals have the appropriate know-how to select the correct information sources.

In order to obtain a differentiated picture, scientific trend analyses, and also "perception analyses", should always search for publications in different sources independent of each other.

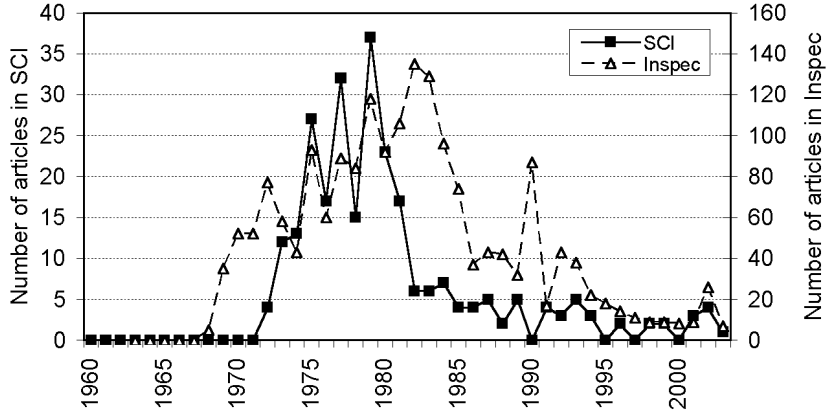

Figure 3. Development of the articles identified on the Science Citation Index (SCI) and Inspect databases on the "fast breeder" in the USA

This diagram shows the development of the "fast breeder" topic in the period from 1963 to 2003. Only articles published in the USA are taken into consideration. Similar curves could be drawn for other countries (e.g. Japan) but the exclusion was made in order to achieve a clear picture.

Similar pictures also emerge for this topic from the Science Citation Index and the Inspec databases where the articles are recorded. Documents on the "fast breeder" are recorded in Inspec from 1968 onwards, but the zenith of this topic was already reached within 20 years.

In the Science Citation Index, documents can only be found after 1972. This is due to the fact that SCI does not cover these topics as thoroughly as the subject-specific databases and an attention threshold must first be overcome in order to get articles published in refereed journals. In SCI the maximum is already reached in 1979 and is followed by a very sharp drop, which can also be seen in Inspec. On both databases, a relatively small number of new publications per year can be found, fluctuating between 0 and 5 in SCI and between 0 and 20 in Inspec.

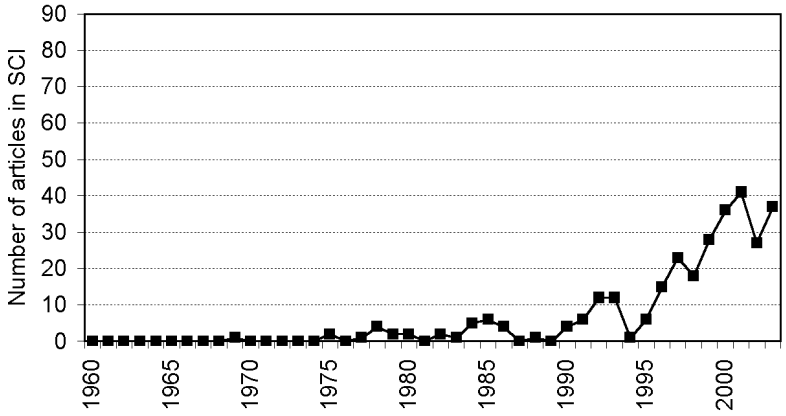

Figure 4. Development of the articles identified on the Science Citation Index (SCI) database on "bibliometrics"

The development of bibliometrics as a science displays similar features to that of ultramicrotomy. There have been occasional publications since 1969, and their frequency continues to increase. Since 1992 the number of new publications per year has increased further and a maximum of 41 articles was found in 2001.

By way of summary, it can be said that all three subject areas display similarities in their development phases. Whereas ultramicrotomy and bibliometrics display an upward trend, the "fast breeder" topic is characterized by a downhill trend. The

precondition for the appearance of new publications is obtaining new findings in order to attract interest in these publications. If no new findings can be obtained, either because all opportunities have been exhausted or because there is no demand for further research, then the number of publications drops. If the opposite is true and if research in a new discipline is expanded then the number of articles rises. This increase in the number of publications is associated with the possibility of generating response in the form of citations.

Present (number of citations). This chapter examines the form in which response was generated for the three subject areas and at what period. Response in the form of citations can only be demonstrated in the Science Citation Index, in which case, two forms must be distinguished: citations according to date of publication and citations according to year of citation.

The representation of "citations according to year of citation" enables conclusions to be drawn about the course of the response, that is to say the number of citations in a given year. This means that it can be seen in which years the publications were more frequently cited and, above all, how frequent the citations were in a particular calendar year. Depending on this frequency, conclusions can then be drawn about interest in the respective subject.

If one considers the topic of the "fast breeder" then it can be seen that the maximum number of citations (41) was reached in 1981, two years prior to the maximum number of publications. This shows the close relation between the publications and the number of citations. However, both aspects are only an expression of a higher-level indicator, namely the growth dynamics of a subject area. This includes, in particular, as mentioned above, the interest and the scientific significance, which with respect to future developments is also expressed in the behaviour of the publication and citation.

Figure 5 shows a rising citation curve for the fields of ultramicrotomy and bibliometrics, which is synonymous with increased interest. This strong growth begins for ultramicrotomy in 1991 and for bibliometrics in 1996. How long this growth will continue cannot be directly predicted since this depends on the interest and on further scientific developments.

Figure 6 also enables conclusions to be drawn about the time curve of citation behaviour, but from a different perspective. This approach reveals which years account for most citations. The frequently quoted articles in these years enable conclusions to be drawn about interesting aspects of the scientific area or interesting personalities.

For the fast breeder, 1977 was the year with the greatest response. A comparison reveals that this was not the year with most publications nor was it the year in which most citations were published. There must therefore be a topical reason for this increase. The curve shows that altogether there were only two years of such great significance. Apart from 1977, this was 1973.

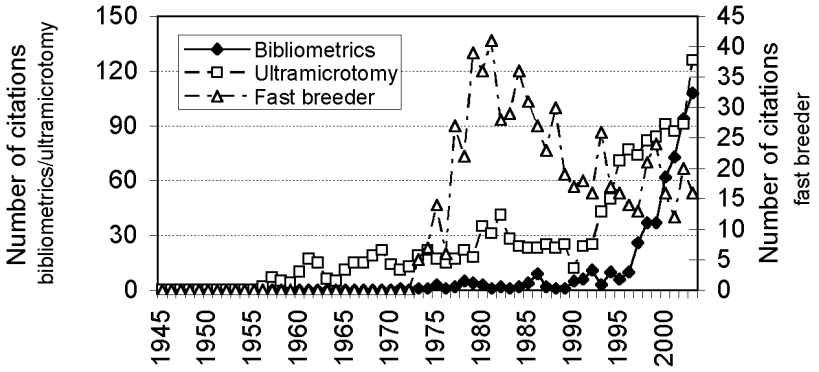

Figure 5. Citations according to year of citation for the three topics investigated

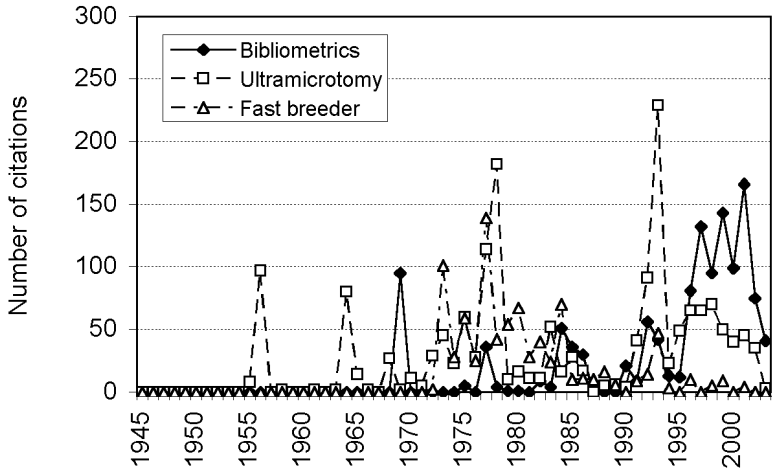

Figure 6. Citations according to date of publication for the three topics

It is striking that the publications from 1973 account for more than 100 citations, although this was only the second year in which publications on this topic could be found in SCI.

For ultramicrotomy there are four outstanding years: 1956, 1964, 1978 und 1993. It is striking here that the time interval between the years with frequent citations becomes

greater. At the same time, the response becomes stronger and stronger. As can be seen from Figure 5, the response to the entire subject area also becomes stronger and stronger. Together with the rising number of publications, the conclusion can therefore be drawn that interest continues to increase.

This is true of bibliometrics in the same way as of ultramicrotomy. The only difference is that the intervals between the years with frequent citations become smaller, although the intensity of these outstanding years varies greatly. Together with an increasing number of citations and publications this enables increasing interest to be identified here; for example in new findings or methods.

Table 1. Highly-cited papers in different subjects

Topic	Author	Title	Year of publication	Source journal	Times cited
Ultramicrotomy	FURNEAUX, R. C.; THOMPSON, G. E.; WOOD, G. C.	Application of ultramicrotomy to electronoptical examination of surface films on aluminium	1978	*Corrosion Science*	153
Ultramicrotomy	VANMEERBEEK, B.; DHEM, A.; GORETNICAISE, M.; BRAEM, M.; LAMBRECHTS, P.; VANHERLE, G.	Comparative SEM and TEM examination of the ultrastructure of the resin-dentin interdiffusion zone	1993	*Journal of Dental Research*	169
Fast breeder	BLACKBURN, P. E.	Oxygen pressures over fast breeder reactor fuel	1973	*Journal of Nuclear Materials*	87
Bibliometrics	PRITCHARD, A.	Statistical bibliography or bibliometrics	1969	*Journal of Documentation*	95

Future (variation range of publications and citations). However, a consideration of the past and present does not provide any direct insights into future developments. It is therefore necessary to also take into consideration the fluctuation in the number of articles on a database and the number of citations. A decrease in the number of publications and citations can be observed for the topic of the "fast breeder". If the absolute figures are relativized and the development of the increase and decrease considered then it becomes apparent that the variation range is greatest at the turning points.

In Figure 7, the distribution of the increase and decrease of citations for the fast breeder is plotted according to year of citation. In the years from 1977 to 1979 it is striking that first a disproportionate increase occurs, which is then rapidly reversed and symbolizes a decrease in citations over a period or several years. Again and again increases of up to 10 citations per year are found, but these are relativized again by such decreases.

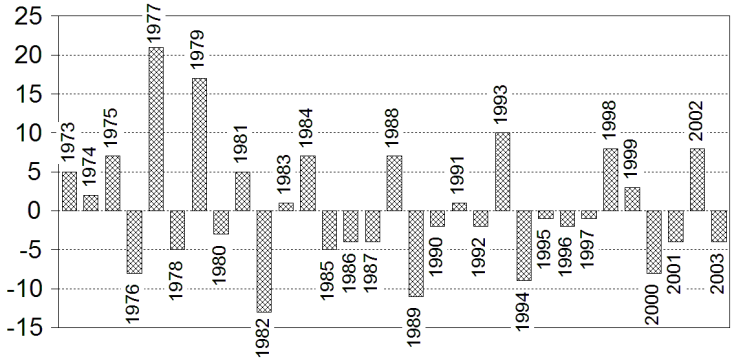

Figure 7. Increase and decrease in citations for the topic of the "fast breeder"

Taking all the discussed indicators into consideration, nothing essential will change in the current status of the "fast breeder" topic. There still continues to be interest in the topic, but without some stimulating impulse the development of the topic remains on the same track it has followed for years.

A different picture emerges for bibliometrics and ultramicrotomy. Here there has been a permanent growth in citations for a number of years, which represents a basic premise for a further increase in interest and research in these fields. The decreases displayed for individual years do not themselves symbolize a reversal in a trend but only several sharp drops in succession.

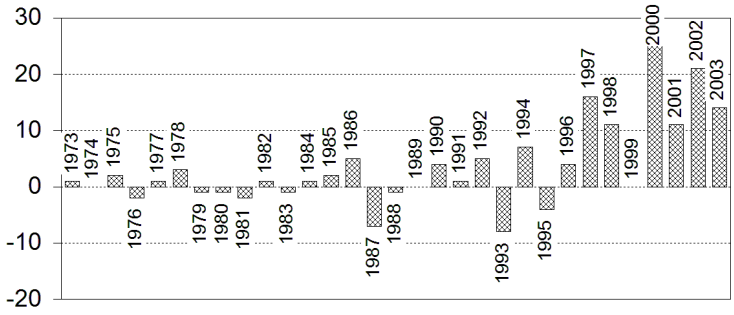

Figure 8. Increase and decrease of citations for "bibliometrics"

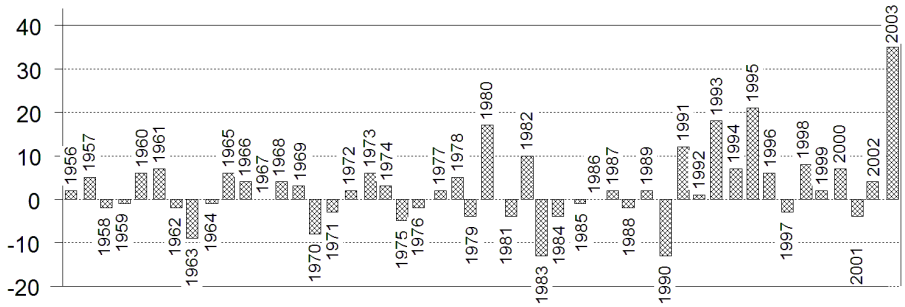

Figure 9. Increase and decrease of citations for "ultramicrotomy"

It is possible to use bibliometrics as an indicator for recognizing trends in analyses of subject areas. A three-step model as outlined here can be regarded as a method that, although it cannot be used to predict exact numbers, can nevertheless reveal development trends in the basic structures.

Conclusions

An extension of the portfolio of library products by including bibliometric analysis represents a valuable addition reflected in lively interest on the part of library users. Moreover, especially bibliometrics represents a win-to-win situation for customers and libraries. The customer is offered an added-value service going far beyond traditional library services, while the library can employ the know-how of its information professionals in a strategic and forward-looking manner.

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