BIBLIOMETRIC ANALYSIS AS PART OF A TREND RECOGNITION SYSTEM IN SCIENCE

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Abstract - This study aims to describe the way in which bibliometric analysis can become a trend recognition tool. The research work shows the application of bibliometric analysis in science. Such analyses provide information about the response received by scientific publications. The paper indicates how, with the aid of a tripartite division, it becomes possible to examine the past, present and future. For the past, it is above all the scientific output that is examined, for the present the response to this output is considered, and for the future perspective future fields are defined which provide information about this aspect. Indicators are introduced for each of the above-mentioned perspectives and the way these indicators are established is explained. With respect to the perspective of future fields, this involves investigating the interdisciplinarity of scientific publications. Bibliometrics is associated with methods of information management. These methods include, for example, critical success factors for trend recognition. A workflow additionally describes in four steps the different activities necessary for achieving the goal of trend recognition. Consideration is also given to possible forms of trends and how they are to be dealt with. The study concludes that it is possible to perform trend recognition by bibliometric methods.

Keywords - Bibliometrics, Trend Recognition System, Interdisciplinarity, Output Analysis, Response Analysis

INTRODUCTION AND BACKGROUND TO THE STUDY

Strategic trend analyses, as performed in the science sector using bibliometrics, may function as a link between trend perception and scientific research. Applied and applicable methods will be presented and their benefits described in connection with trend recognition.

In a society that is oriented to competition, attention is frequently focused on achieving a response. This may not be so apparent in scientific research. However, the fact that third-party funds and financial support are increasingly also granted according to the perception and visibility (response) of scientific results leads to the conclusion that in this connection response is often associated with the act of publication and response to publications. It is becoming more and more important for decision makers to have the right data available at the right time so that these data can then be compressed into information and knowledge.

In the following, the benefits that trend analyses may have for scientific research will be discussed with the example of bibliometric analysis.

Since 1969, the term "bibliometrics" has been used to describe the science of the quantitative dimensions of scientific research[3]. This also includes the response to scientific publications and findings. Citation analysis is concerned, for example, with the perception of publications by a research group or an institute. "Citation analysis is a branch of bibliometrics based on the assumptions that references reflect conceptual associations of scientific ideas." [11]. The whole idea is to provide information about the perception and impact of these publications and the associated scientific findings. The number of citations is a direct measure of the response or the impact that a publication achieves among specialists [9]. At this point, a precise distinction should be made between perception and quality. Quality is essentially characterized by interests and by ideals and is not quantitatively measurable [9].

Bibliometric analysis is an instrument for obtaining insights into scientific publication performance, integration into the science scene and international visibility of research findings. 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 [14]. In order to do justice to this goal, it is not sufficient to merely consider figures (e.g. the number of times an article is cited), but rather the publication habits of scientific disciplines are just as significant as general developments in the science sector.

DEFINITION OF BIBLIOMETRICS

The term "bibliometrics" was coined in 1969 by A. Pritchard. The purpose of bibliometrics is the application of mathematical and statistical methods to elucidate the processes of written communication, and also the nature and developmental course of a scientific area, by counting and analyzing the various aspects of written communication.

Citation analysis is a field of bibliometrics concerned with the study of relations between cited and citing articles and their application as a bibliometric diagnostic method. As a bibliometric parameter, citation analysis counts the number of citations relating to a certain publication, a certain document or a certain author. The greater the citation frequency is, the greater its value is considered to be [5].

- BIBLIOMETRICS, SCIENTOMETRICS AND INFORMETRICS

Bibliometrics, scientoetrics and informetrics overlap. The use of one term or the other depends very greatly on which aspect is to be emphasized - library, science or information [5].

- ORIGIN OF BIBLIOMETRICS

The first bibliometric study appeared in 1917 and was a publication by Cole and Eales of a statistical analysis of the literature on anatomy in the period between 1550 and 1860 in order to show the fluctuating interest in this discipline. In 1927, P.ÊGross and E.ÊGross were the first to use citations as a source of bibliometric data. They counted and analyzed the citations made in the individual articles made of a chemical journal and arrived at a list of journals that they considered as indispensable for chemical training [5].

- THE "SCIENCE OF SCIENCE"

In 1966 a book was published in the Soviet Union "Nauka o nauke" by G.M.ÊDoborv with the subtitle "Vvedeniye v Obshchee Naukovedeniye" [sic!]. In 1969, this publication was issued for the first time in German as "The science of science". According to Dobrov, the science of science is the complex investigation and generalization of the functioning of scientific systems with the aim of enhancing the potential of science and increasing the efficiency of the scientific process by organizational means [5].

In the following chapters, the three standpoints of the past – present – future will bc discussed for a bibliometric analysis with the example of these three perspectives, and indicators will illustrate how the individual perspectives can be represented. In Chapter 5, the summary will illustrate the transition from bibliometrics to trend recognition.

Chapter 2: Perspective of Output Analysis (past looking towards the future)
Chapter 3: Perspective of Response Analysis (present looking towards the future)
Chapter 4: Perspective of Future Fields (with the example of interdisciplinarity of journal publications)
Chapter 5: Summary: From Bibliometrics to a Trend Recognition System

PERSPECTIVE OF OUTPUT ANALYSIS (PAST LOOKING TOWARDS THE FUTURE)

- DATA SOURCES

Before beginning an analysis, one should review the usable data sources. These sources may be annual reports, scientific reports or other lists of publications. It is also possible that a database may be available providing information on publications. Before using a data source, its topicality and completeness should always be determined in order to obtain an impression of the database's information content.

The output for this bibliometric analysis may be composed of two variables: the number of publications by an institute and the number of lectures.[4]

PERIOD UNDER CONSIDERATION

At least the past ten years should be taken as the period under consideration. Due to different publication and citation habits, this period varies among the scientific disciplines.[5] A useful upper limit is about 20 years since otherwise it may well be possible that too many "old" results distort the picture. Indicators in this perspective could be the *number of publications by the institute as a function of the number of staff* or *the proportion of financial resources*.[6] The higher-level research institution can provide a rough framework for this first classification.

The publications can also be split up according to type: *articles in refereed and non-refereed journals, books, online publications, proceedings and posters. In the case of lectures, an additional distinction can be made between invited and uninvited.*

It should be noted that there is often a time lag between obtaining results and publishing them in journal articles. In the case of refereed journals, this may take one to two years due to the peer-review process. For this reason, the maximum number of articles in refereed journals is reached roughly one year later than the maximum total output. Even if the output stagnates, the number of articles in refereed journals may still continue to rise.

- PEER-REVIEW PROCESS FOR JOURNALS

The trend towards individual forms of publications may have consequences for the future. For example, a move towards more publications in non-refereed journals may lead to the research findings of an institute no longer being so highly regarded since significantly fewer articles pass through a peer-review process. It might happen that non-refereed journals in general attract less attention in the flood of publications. This may lead to a vicious circle: since the journals are not so highly regarded they are less frequently cited and thus lose the opportunity to become more highly regarded. Papers in a scientific journal compete with each other for the scientists' attention, which is ultimately reflected in the citation [1].

THE URN MODEL

Use can be made here of the mathematical urn model. There are the same number of balls of two different colours in an urn. Taking a certain ball from the urn and replacing it again is a method that is always based on the same probability. The second possibility is to pick a ball and not replace it again. This method always leads to different probabilities of picking a certain ball.

This urn model can also be used to describe the probability that a publication will be cited. The initial situation is identical, and there are equal numbers of the different coloured

balls (black and white). Picking a white ball means citation and a black ball noncitation. Until a white ball has been picked the chances are equally distributed. However, as soon as a white ball has been picked there is a basic change. The white ball is replaced in the urn but the urn is additionally supplemented by another white ball. In future draws, the chance of picking a white ball again will increase each time a white ball is picked.

Articles, authors or journals that have already been frequently cited behave in the same way as the balls in this model [3].

PERSPECTIVE OF RESPONSE ANALYSIS (PRESENT LOOKING TOWARDS THE FUTURE)

The methods presented for the perspective of response measurement are largely only valid for the scientific disciplines. This is due to the fact that completely different citation and publication habits are found in the humanities. The central issue in this chapter is a consideration of the present. However, statements can also be made about future developments if the development over time is included in the considerations.

- ECONOMY OF ATTENTION

Who wouldn't want to increase his success and the associated response? We are living in an "e*conomy of attention*" [4]. If you are in the public eye and attract attention then you can increase your success. If you handle trends properly and recognize them in good time then this could mean that you receive attention in the future. "For whosoever hath, to him shall be given, and he shall have more abundance: but whosoever hath not, from him shall be taken away even that he hath."[7]

In bibliometrics, it can be observed that articles which have overcome the attention threshold are quoted for a while almost as a matter of course, whereas other comparable articles simply disappear from the scene. This is called the Matthew effect: "A principle postulated by Merton which can also be paraphrased by saying 'success breeds success'. It refers to the initially undisputed fact that well-known authors have a higher probability of becoming even better known since they are invited to make further publications and are cited more frequently" [13].

- THE SCIENCE CITATION INDEX

In the case of scientific publications, the first port of call for a response measurement is the Science Citation Index Expanded (SCI). This data source contains an index of at present 5907 internationally respected science journals,[8] of which only a selection are dealt with here. This database is the only collection of references in connection with their citation.

The data collection was created by Thomson -- ISI, a major provider of scientific data. Direct online access via the Web of Science replaces the previous paper version by a powerful Internet information tool. There are additional possibilities of access via CD-ROM or directly via the host STN. The first starting point for measuring response may be the proportion of articles listed in the ISI in relation to the total number published. As a next step, the citation rate[9] may provide information about the response to the articles listed in the ISI.

Other reference points should be used, including the higher-level research institution and also, as an absolute necessity, other institutes dealing with comparable topics on a national and international level. The citation behaviour of the respective scientific discipline can also be determined via the average value of citations from all journals for this discipline (scientific community).

The following information can be obtained from the three indicators:

Citation rate: How often was an article cited on average?[10]

Citations/year: How often was an article cited on average in one year?[11]

Impact factor: How many articles has a group/institute or a journal published in one year and how often were these articles cited in the two following years?[12]

- COMPARATIVE VALUES

ISI also offers comparative values. All the listed journals are allocated to one or more of the 170 ISI subject categories. This intended to cover part of the scientific scene. In accordance with the research, publications by the institute investigated can be allocated to a category and compared with its average citation rate or impact factor if this research area is covered by the Science Citation Index. The indicators described are also applicable to countries, whole research institutions/ universities, sections of research establishments or working groups.

- ISI SUBJECT CATEGORY

Each journal listed in the ISI database is assigned to one or more categories. These categories are intended to map the world of science as faithfully as possible. For this reason, ISI does not weight all categories equally but rather distinguishes between those with more and those with less journals. All 5907 journals currently indexed are assigned to one of the 170 categories in ISI. This results in 9288 allocations since a journal may be assigned to several categories simultaneously.[13]

- WEB IMPACT FACTOR

A possibility for comparison, which is also internationally applicable, is the response to

an Internet presence. Parameters, such access figures in the form of visit time or visitor numbers, can be used to measure response. A special parameter is linking, that is to say the reference by an external institute to the website of the institute studied. This has a similar status to a citation. In order to make a direct comparison with the overall research institution or the reference institutes determined, internal references should be filtered out.[14]

The web impact factor (WIF) can be calculated as follows:

WIF(c) = (links to pages of c) / (pages within c)

The general principles of calculating the WIF are provided, for example, by the AltaVista search engine in the "Webmaster Search" [8].

- GOOGLE PAGERANK

Another interesting indicator is the Google PageRank. The Google search engine ranks every website indexed on a scale from 1 to 10. This indicator can provide a rough overview of the presumed importance. The indicator should not be neglected if only for the reason that others could regard it as important.[15]

PERSPECTIVE OF FUTURE FIELDS (WITH THE EXAMPLE OF THE INTERDISCIPLINARITY OF JOURNAL PUBLICATIONS)

Future fields are taken to mean those areas which will attain greater importance in future. In the scientific sector such a field is interdisciplinarity. Other future fields may be subject-oriented (e.g. "ultramicrotomy") or other issues relevant to the future, for example, cooperations, international projects or strategic partnerships.

This third perspective complements the other two to achieve a holistic approach giving equal attention to the past, present and future.

- DEFINITION OF INTERDISCIPLINARITY

Interdisciplinarity is the bringing together of distinctive components of two or more disciplines in research or education, leading to new knowledge which would not be possible without this integration. Multidisciplinarity occurs when disciplines work side by side in distinct problems of aspects of a single problem. Interdisciplinarity occurs when disciplines intermesh, integrate and collaborate amongst themselves [15].

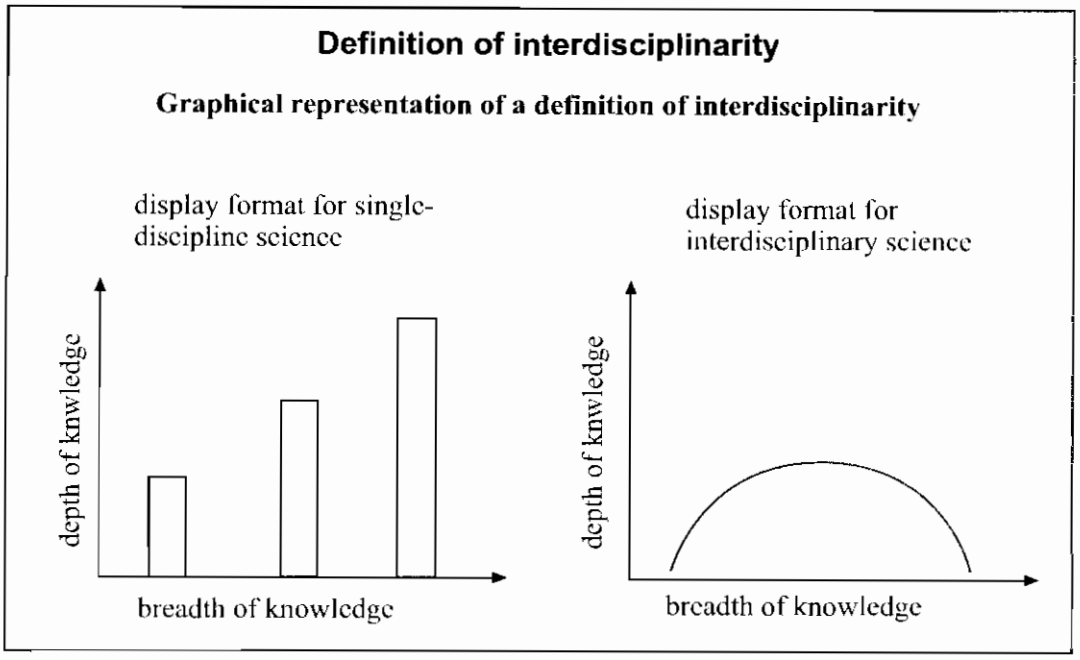

Figure 1: Graphical definition of the concept of interdisciplinarity [7].

The possibility of measuring interdisciplinarity has already been tested in a procedure. The procedure, presented by [2] concentrates on the occurrence of the word "interdisciplinarity" or "multidisciplinarity" in the title of a publication. In the Science Citation Index, a query was started for the period from 1980 to 1999, which displays the greatest number of hits for the life sciences. Publications on mathematics achieved the lowest number of hits. What is the information value of this result? It only reflects the use of a word. As expressed in the definition of interdisciplinarity, the major component in the meaning of interdisciplinarity is the application of findings beyond subject boundaries. The mere assumption on the part of an author that his findings are interdisciplinary is not sufficient.

In order to remedy this deficit, it is meaningful to use a procedure in which it is not the author of an original article who determines whether his publication is interdisciplinary but rather the authors who cite him. For this study of interdisciplinarity, the 20Êmost frequently cited articles in the subject categories of mathematics and physics were selected from the ISI product "Essential Science Indicators". In addition, the 20Êmost frequently cited articles in the subject category of "multidisciplinary" were also used. The main goal is to demonstrate the applicability of the indicator for interdisciplinarity, and the following will describe how this indicator is established.

METHOD OF CREATING AN INDICATOR FOR INTERDISCIPLINARITY

In order to reach the goal, that has been set, of obtaining an indicator for interdisciplinarity, the following methodology is applied.

For each article, the 10 journals were identified in which the original article had been cited most frequently. This means that as a rule about 60% to 75% of all citations of each original article were considered. The following point system was applied.

Starting from the ISI category of the original article, a comparison of the ISI categories is made. One point is awarded for every different category (upon the first occurrence). Large scientific fields (Chemistry, Physics, ...) are assigned to a superclass. Different or new superclasses are given two additional points (upon the first occurrence). All the points allocated are added up and divided by the total number of categories of the paper. The result obtained is the indicator of interdisciplinarity.

The author of the articles has no opportunity of influencing the result. Only those making the citations can influence the classification of the original article by their choice of journal. This means that the reception by a large group of authors decides on the degree of interdisciplinarity. This is justified to the extent that since, for example, only if the findings of Physics are also applied in Chemistry can one speak of a transfer of knowledge between disciplines.

This methodological approach for measuring interdisciplinarity is taken from [6] and has been further developed to create an indicator.[16]

INTERDISCIPLINARITY CAN BE VERIFIED

Interdisciplinarity is present and verifiable in the articles investigated. The higher the indicator of interdisciplinarity (Interdisciplinarity Score [IS]), the stronger is the measurable transfer between the disciplines will be.

In the study, it was striking that each of the three groups investigated displayed a high peak, but all at a different point on the scale. In this study, the scale ranged from 0 to 1.2. Due to the possibility of allocating journals to several subject categories the upper end of the scale cannot be precisely located. Furthermore, since the number of superclasses, and thus the two additional points, to be distributed, could not be precisely defined in advance, it was not possible to indicate a precise maximum number of points and allocations. The smallest measured value is 0.18 in the field of Physics and the greatest measured value is 1.17 in the same field.

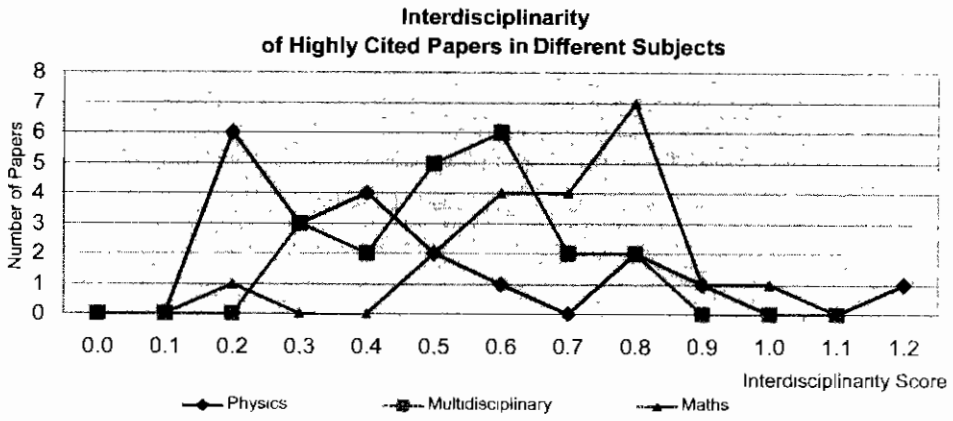

Figure 2: Results of the study on interdisciplinarity.

The diagram shows the peaks of the three disciplines compared. In Physics, the major proportion of the articles occur in the range of 0.2 to 0.4. These are overwhelmingly single-disciplinary articles that are only cited within Physics. In the category of "multidisciplinary" the majority of articles occur in the range of 0.5 to 0.6, and in mathematics this range is from 0.7 to 0.8. This means that the articles studied from the field of mathematics were most frequently applied in other disciplines.

With the aid of this method it is possible to establish a ranking with the focus on interdisciplinarity and to specify a set of articles with the highest degree of interdisciplinarity.

It is furthermore possible to make comparisons of interdisciplinarity between different disciplines.

The average value of the indicator for interdisciplinarity in the three fields provides the following picture:

1. Mathematics: 0.68
2. Multidisciplinary articles 0.53
3. Physics: 0.45

On average, the articles studied from the field of Mathematics are more interdisciplinary than articles from the field of Physics or the articles classified as multidisciplinary.

These results differ from those in the above-mentioned article by [2]. Braun and Schubert investigated the occurrence of the word interdisciplinarity in journal titles and projected the image that articles from the field of the Life Sciences displayed the most frequent mention of the word interdisciplinarity, followed by Physics, Chemistry and finally Mathematics. Articles are not necessarily published with the awareness of having achieved an interdisciplinary result. The reverse conclusion is also possible: Articles are claimed to be interdisciplinary although they do not justify this label.

EXAMPLE OF CALCULATING INTERDISCIPLINARITY USING THE ARTICLES WITH THE MOST AND THE LEAST POINTS

In the following, the point distribution will be illustrated by two examples. In the first example, all the categories except for Physics (condensed matter) receive points. Each subcategory receives one point upon its first occurrence, and each scientific field (Chemistry, Engineering Sciences) two additional points upon its first occurrence.

Bioliographic Data (Author, Title)	Kresse, G; Furthmuller, J	Efficient iterative schemes for abinitio total-energy calculations using a plane-wave basis set	
Interdisciplinarity Score, Original Journal	**1.17**	PHYSICAL REVIW B	
ISI Subject Categorie of the Original Journal	PHYSICS, CONDENSED MATTER		
ISI Subject Categorie of the Citing Journals	PHYSICS, CONDENSED MATTER PHYSICS, MULTIDISCIPLINARY PHYSICS, ATOMIC, MOLECULARY & CHEMICAL CHEMISTRY, PHYSICAL PHYSICS, APPLIED PHYSICS, ATOMIC, MOLECULAR & CHEMICAL PHYSICS, APPLIED CHEMISTRY , MULTIDISCIPLINARY MATERIALS SCIENCE, MULTIDISCIPLINARY METALLURGY & METALLURGICAL ENGINEERING ENGINEERING, CHEMICAL CHEMISTRY, PHYSICAL		0 points 1 points 1 points 3 points 1 points 0 points 0 points 1 points 3 points 1 points 3 points 0 points
	Total		**14 points** **12 categproes**

Figure 3: Overview of the most interdisciplinary articles.

From the categories of the citing journals it can be seen that the article, which originally comes from physics (condensed matter), is not only applied in other subareas of Physics but also in other fields such as Chemistry, Materials Science and Engineering Sciences.

The process of allocating points proceeds in the same way with the second example. All the categories from the citing journals are compared with Physics (particles & fields) since the original article is assigned to this category.

Bioliographic Data (Author, Titlc)	Groom, DE; Aguilar-Benitez, M; Amsler C; et al.	Rcview of Particle Physics	
Interdisciplinarity Score, Original Journal	**0.18**	EUROPEAN PHYSICAL JOURNAL C	
ISI Subject Categorie of the Original Journal	PHYSICS, PARTICLES & FIELDS		
ISI Subject Categorie of the Citing Journal	PHYSICS, PARTICLES & FIELDS PHYSICS, MULTIDISCIPLINARY PHYSICS, MULTIDISCIPLINARY PHYSICS, PARTICLES & FIELDS PHYSICS, NUCLEAR PHYSICS, NUCLEAR PIIYSICS, PARTICLES & FIELDS PHYSICS, NUCLEAR PHYSICS, PARTICLES & FIELDS PHYSICS, PARTICLES & FIELDS PHYSICS, NUCLEAR		0 points 1 points 0 points 0 points 1 points 0 points 0 points 0 points 0 points 0 points 0 points
		Total	**2 points** **11 categproes**

Figure 4: Overview of the article with the lowest number of interdisciplinary points.

The article with the least number of interdisciplinary points also comes from the field of Physics (particles & fields). There is no sign of a transfer of knowledge between disciplines since all the citing journals also come from the field of Physics and altogether only two other subcategories can be found.

The example of interdisciplinarity demonstrated, on the one hand, the application of bibliometric methods in finding an answer to a complex issue, and, on the other hand, this example also illustrates the opportunity of opening up future fields. The benefit is that, for example, the applicability and transferability of one's own results can be monitored and possibly also substantiated. In any case, future fields should be used to complement the view of the past and present.

- EXAMPLES OF OTHER INDICATORS ARE:

The increase in response: What does the time curve for the development of response increase look like? A possible upward or downward trend can be read off.

Number of citations (C) / [current year (y) – publication year (Py)][17]

The proportion of current research results in the response obtained: Do only older findings experience a response or also more recent results? The distribution of

response between older and more recent findings enables a statement to be made about the acceptance of and response to findings from current research.

The speed with which the response changes: Trends always progress at a certain rate. They may rise or fall precipitously or there may also be a sideways movement, or only a very slight fluctuation.

Future fields are intended to represent a complement in this study and form an integrated whole with the other fields presented.

SUMMARY: FROM BIBLIOMETRICS TO A TREND RECOGNITION SYSTEM

It was to be shown that it is possible to produce bibliometric analyses not only with respect to the past and present but also with a view to the future. After this very detailed description of some indicators and methods with the example of bibliometrics for the science sector, these elements will be incorporated in the framework of a trend recognition system.

In the same way as a bibliometric analysis, a trend recognition system can also be regarded as a management support tool in the science sector [12]. For both applications there are critical success factors.

- CRITICAL SUCCESS FACTORS

Topicality: What use are the best results if they come too late? Close cooperation with the controlling department is useful in creating new indicators.

Short communication channels: Exchange should not take place through official channels – possibly even by internal mail – this path is simply too long. Channels of communication should be laid down and structured from the very beginning.

Handling data: Every signal may contain important data. No signal should be intentionally suppressed or restricted from the outset even if company policy or other considerations have a different direction. It must be ensured that all available data are processed and examined with respect to their relevance content.

Personal information: Technically and personally available data exist side by side. It must be ensured that consideration is given to both types of data.

These critical success factors relate in general to trend recognition and handling time-critical data. For this reason, a workflow may be of assistance in taking critical success factors into consideration and permitting a standardized approach.

- WORKFLOW FOR A TREND RECOGNITION SYSTEM

Data input: In the bibliometrics example, these data are taken from thc ISI database Science Citation Index.[18] Supplementary information, especially on output, can be found in publication databases, scientific reports or annual reports in all scientific institutions.

Data for comparisons with other scientific institutions can be found on the Internet or online databases.

Data enhancement: The input data should not be considered separately but only regarded and understood in context. The data must above all be inspected, assessed, interpreted, selected and further processed. For bibliometrics, this means when the first queries have been made in the ISI database, the manual detective work first begins with Excel or Access. Data must sometimes be added up, large volumes of data sorted or even a whole database created if interlinked queries have to be started. At this stage of work, it is also meaningful to keep in mind the three forms in which trends occur.

These three forms are:

- **Familiar trends**

  This form causes the least difficulties; it is merely necessary to follow up and observe the development of familiar trends.

- **Hidden trends**

  The basic features of this trend form are known but the precise relation between cause and effect is still not clear.

- **Unknown trends**

  This is the most difficult form since broad-based searches must first be made to seek clues for this type of trend.

Data evaluation → information gathering: Data become information if there is added value. The added value in the example of bibliometrics is the comparison: knowing whether, for example, the institute[19] performs better or worse than average, or some other reference value, in the analysis.

Data can be processed with respect to trends using the described indicators for future fields. This may also represent a time benefit in the sense of economy of attention.

Examples of possible action in the science sector: All these efforts would be in vain if the analysis did not lead to any action.

Some examples:

- attempting to maintain the high potentials[20] as long as possible.
- attempting to reverse a trend by strategic measures in the case of a threatened loss of quality or declining response.
- attempting to work in a more application-oriented manner in order to increase the degree of interdisciplinarity.

Bibliometrics can be implemented as part of a trend recognition system in the science and research sector. The methods presented here form a framework which has to be adapted according to requirements. Above all, three possible perspectives were presented for bibliometric analysis and its structure. Furthermore, the results to be obtained by these

methods are intended to give an example in connection with trend recognition of how such trend recognition can be performed systematically.

ENDNOTES

1. Dirk Tunger studied media documentation in the library and information department at Hamburg University of Applied Sciences. During and after his university studies he was involved in various sectors with information resources, their use and management. He is currently at Research Centre Jülich where he is concerned with establishing standard bibliometric products and is also working on a PhD dissertation on the topic of early warning.
2. Cornelia Plott studied media documentation at the University of Applied Sciences in Hamburg. During and after her university studies she concerned herself with the use, perception and management of media and information resources in various fields of business. At present, she is at Research Centre Jülich where she is involved with electronic publication processes and database searches.
3. The first article recorded in ISI using the term bibliometrics was published in 1969 and has been cited 94 times so far. This is the article by A. Pritchard: Statistical Bibliography or Bibliometrics, in: Journal of Documentation, 25 (4); pp. 348 ff; 1969.
4. Studies of patents or other forms of scientific output would also be conceivable.
5. In biotechnology, for instance, the pace is faster than in basic physics.
6. If reliable figures are available, information can be provided on third-party funds attracted.
7. Quotation from the Gospel According to Saint Matthew, Chapter 13, Verse 12; which has given its name to the Matthew effect.
8. In order to discover which journals are included see Journal Citation ReportÊ2003, which is available from ISI (Institute for Scientific Information, Philadelphia) as a supplementary product.
9. Average number of citations per article.
10. Number of citations/articles; after Noyons et al. (2003).
11. (Number of citations per article)/years since publication of the article
12. (Total citations in 2002 of articles published in 2000 + 2001) / (number of articles published in 2000 + 2001); from: ISI Journal Citation Report.
13. Journals such as Science and Nature are included in the category of "Multidisciplinary Science" so that no direct statement on interdisciplinarity can be derived from this assignment.
14. The larger the institute studied the greater the manual effort required, which unfortunately cannot be avoided here.
15. However, not all websites are indexed so that only a section can be assessed. In the

same way, not all scientific journals are indexed in ISI.

16. The methodological approach for measuring interdisciplinarity is taken from Havemann (2002) and has been further developed by Cornelia Plott and Dirk Tunger (2004).
17. Response increase = C/(y – Py).
18. Attention: It should be noted that not all scientific journals are indexed.
19. Also: institution / research society / country ... studied
20. The scientists with the highest visibility or the highest potential in future

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