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Bibliometric Analysis in Science and Research

Applications, Benefits and Limitations

2nd Conference of the Central Library

Conference Proceedings

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Preface

An 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 bibliometry. After that, interest in bibliometry faded somewhat until in the late nineties information and library scientists took up bibliometry 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 bibliometry a hot topic. Bibliometry is thus experiencing a revival, not primarily with respect to mathematical modelling and theoretical principles but as an instrument of science management.

The conference "Bibliometric Analysis in Science and Research: Applications Benefits and Limitations", the second conference held by the Central Library on important topics of current interest in information management, is now taking up this issue in an international framework. The contributions are of equal interest to bibliometricians, sociologists, science managers, political decision-makers and information specialists and indicate the part that can be played by bibliometry and bibliometric methods in modern science management. However, the lectures also intend to make clear where the limitations of bibliometric methods are to be found.

It is of particular significance that this event should be hosted by the Central Library. Information specialists are today at the focus of enormous volumes of data made available world-wide from science and its output. As information professionals they are 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? Libraries and information facilities are independent, interdisciplinary institutions capable of providing these services. A special concern of this conference is to inspire and encourage librarians to establish the business area of "bibliometry" and to provide qualified staff for it.

The present volume contains the text versions of the lectures as well as one article that was not presented at the conference.

I would like to take this opportunity of thanking all those involved for their lectures, their assistance and their participation at the conference. Special thanks are due to Research Centre Jülich for supporting the conference and for making it possible.

Rafael Ball, Research Centre Jülich, Head of the Central Library
Jülich, November 2003

Keynote Speech

Evaluation of research performance: the danger of numbers

Peter Weingart

The Evaluation craze out of control?

When the first evaluations of research institutions were carried out – by Martin and Irvine in 1983 in the UK – the reaction of the scientists concerned was predictable. They challenged the possibility of the enterprise on methodological grounds, and they threatened to take the analysts to court because they feared that the results would have adverse effects (Weingart 2001, 316). The reaction was predictable because first of all the very attempt to measure research performance by 'outsiders', i.e. non-experts in the field under study conflicted with the firmly established wisdom that only the experts themselves were in the position to judge the quality and relevance of research and that the appropriate mechanism to achieve that, namely peer review, was functioning adequately. The second reason for scepticism if not outright rejection was the methodology employed. Bibliometric measures, although quantitative and therefore seemingly objective, appeared to be theoretically unfounded, empirically crude, and dependent on a data that were known to be imprecise. The rejection of bibliometric indicators on the part of the scientific community was supported by policy makers and government administrators, although mostly because of disinterest.

Since then times have changed in several respects. As budgets for research have levelled off and priority decisions *re*-distribute rather than add funds the pressure to legitimate such decisions has focused interest on measures that do not involve policy-makers in experts' arguments that they are unable to engage in. First the focus, at least in the German higher education system, was on the regulation of teaching loads and student flows by numerical formula, implemented in the 1970s. That will not be of concern here but as a historical example is indicative because for the first time it demonstrated that the seemingly complex world of teaching with its different subjects, types of instruction and levels of qualification could be regulated by the application of a few crude numbers. Of course, here the matching of student numbers and teaching capacities and thus ultimately the control over the number of staff was the objective. Although indicators of research began to be developed in the 1970s as well they were not implemented until a little further down the line when the assessment of departments, of individual researchers, and the ranking of universities became an important instrument for the competitive allocation of funds replacing the supposedly more costly system of block grants.

Indicators of research quality are not yet generally accepted. The US government, despite its bent on performance indicators for the rationalisation of budgetary decisions, does not use bibliometric measures of research (Roessner 2002; Feller

2002).[1] In the EU the situation is very mixed with various degrees of institutionalisation of bibliometric indicators. The extreme is probably represented by Finland, "the only country in which the journal impact factor has been canonised in the law of the land", implying that the publication of just one paper in a higher impact journal can boost the budget of a university hospital by about US$ 7000 (Adam 2002, 727). But the lure of quantitative measures appears to be increasingly attractive to other governments as well, and by way of a mix of copying, outside pressure and mutual observation one can now witness internationally a dramatic shift away from the well founded scepticism to an uncritical embrace of bibliometric numbers. This change of mind is not limited to policy makers and administrators but has taken hold of deans, department chairmen, university presidents and officials in funding agencies and research councils as well, i.e. of representatives of the scientific community that were most strongly opposed to external evaluation of research with any means.

And as can be expected this new demand for numbers unlocking the secrets of the world of research and internal allocation of prestige and rewards, allowing outsiders a direct look at the international standing or provincial isolation of their local scientists, thus giving them the power to dismantle unfounded claims to fame, has brought many players into a rapidly growing market of research evaluation and bibliometric analyses in particular. Several countries have set up their own institutions collecting and processing data on the performance of their respective research installations, others use any one of the independent and either university-based or commercial institutes or research groups specialising in bibliometric studies to do particular or routine evaluations for them. In the US the NSF/NSB Science Indicators Report is published since the 1970s and was the first to contain bibliometric output indicators. France has set up its 'Observatoire des Sciences et des Techniques' (OST), and so have the Netherlands (NOWT). The Swiss and the German Science Council respectively make use of bibliometric indicators in their reports. The focus of these and other agencies' reporting are primarily the national science systems.

All of them are up to now and for the foreseeable future dependent on one single provider of data, the Institute of Scientific Information (ISI), the producer of the only multidisciplinary databank of scientific literature that contains citation data and thus allows the compilation of citation counts and impact factors of journals as well as the development of more sophisticated measures such as co-citation maps. While originally conceived as a literature databank designed to identify uses of knowledge and networks of researchers ISI's database soon proved its value as a tool for sociology and history of science research as well as for the evaluation of

[1] Private assessment by S. Cozzens. Roessner's and Feller's articles give an overview of performance indicators for the evaluation of S&T programs in the US in general.

research institutions and even individual researchers. After many years of somewhat reluctant response to this sideline use of their products ISI has now recognised the growing importance of the demand for bibliometric indicators and moved to produce tailor-made evaluation tools like ISI Essential Science Indicators and ISI Highly Cited Com. These are powerful tools that allow anyone with an Internet access to a university library to identify the highly cited scientists of their local university, the relative impact of that university compared to others in the country or internationally, or the rank of that university in a particular field and so on. These tools are now actively marketed, and a growing demand contributes to their rising price. The effect of their more aggressive commercialisation pursued by the new owner of ISI, Thomson Company of Toronto, is twofold. First, the intermediary research groups that used the ISI database for evaluations, cleaned and prepared the data for specified purposes and developed the skills to interpret them are being squeezed out of that market. Second, the ready availability of seemingly exact indicators whose methodological and operational origins are concealed from the end user and the theoretical assumptions implied in their construction he or she is not able to reflect upon suggests nonetheless that any layperson can evaluate researchers and their products. This has led to a growing number of incidents when administrators in government science policy and higher education agencies refer to these data when negotiating budget decisions, or when department chairs use them for recruiting and salary decisions. The healthy scepticism of years ago, albeit often for the wrong reasons, appears to have given way to an uncritical embrace of bibliometric measures.
The implications of this development are disquieting, at least. The evaluation process that was hitherto internal to science, i.e. peer review, has been ‘externalised’, i.e. made accessible to the lay public by proxy, namely numbers reflecting the quantitative aspects of the communication process in science. These numbers become the basis of budgetary decisions directly affecting the research process as well as the operation of universities, of clinics and other research institutions dependent on public funds. The production of these numbers is in the hands of a commercial company that presently holds a virtual world monopoly on them and, whether conscious of it or not, structures political decisions affecting research systems all over the world by the profile and the quality of the data it provides to its customers. The evaluation of research, and the budgeting of university departments based on it, to the extent that they depend on bibliometric data, have effectively been handed over to a private company with commercial interests.[2] This makes the critical examination of the validity and reliability of ISI’s data as well as of the uses made of them especially by governments and of the

[2] There are presently no serious efforts anywhere to challenge ISI’s position. Cf. NATURE, 415, 14. Feb., 2002, 728.

unintended steering effects of their use a task of paramount importance – in the interest of both governments and the scientific community.

Validity and reliability of bibliometric indicators in the evaluation of institutions and individuals

From their inception onwards questions of validity and reliability of bibliometric indicators have been the concern of researchers engaged in the development of such indicators. These questions become urgent as indicators are being implemented and tied to budgetary decisions, i.e. that so called evaluation based funding (EBF) is expanded. In addition to these traditional concerns linked to the construction of any policy relevant indicator comes another one, the unintended and/or the adaptive effects of the actual application of these indicators. Especially the former concerns are waged in relation to peer review which "remains the backdrop against which all other types of research evaluation appear, and often the standard against which their validity is judged" (Roessner 2002, 86). However, part of the reason for the increased popularity of quantitative bibliometric indicators among public officials is the growing scepticism and disenchantment with peer review. Initial doubts about its openness triggering allegations of 'old boy networks' have been seconded by a number of fraud scandals reaching high up into the elite layers of the biomedical and physics establishments. Although it would be difficult to gauge precisely it can be hypothesised that the trust lost by the peer review mechanism has been shifted to the use of numerical indicators. This is, of course, tantamount to the loss of autonomy for the scientific community and a greater involvement of the political public in the direction of its affairs.

The peer review process, especially the reliability and consistency of peer evaluations, have been the target of many empirical analyses. The most active disciplines in terms of the concern about the functioning of their own peer review are the medical sciences and psychology. Recently the physicists have joined them.[3] The findings were, indeed, not encouraging. Different approaches to test and measure the reliability of judgements of peers both in decisions about research proposals to funding agencies and articles to be published always reveal the same results: Peer evaluations diverge, they contradict each other, and they do not remain consistent over time. Cichetti in a review of a multitude of studies concludes that the reviewers of research proposals have more agreement about which proposals not to fund than about which to support. In the review of articles for journals it is the other way around: Reviewers agree more about acceptance

[3] Four international conferences on peer review in the medical sciences were organised by JAMA in the 1990s. Cf. for an overview of similar activities and analyses of peer review Hirschauer 2002. As an aside: it is an interesting question why these disciplines are especially concerned about their peer review mechanism.

than about rejection of articles (Cichetti 1991; Bakanic et al. 1989). Others have pointed to the considerable role of extraneous factors such as sheer luck or being well integrated into the right networks, belonging to the right institution (Cole et al. 1981).

However, upon closer inspection these findings are not surprising given the nature of the scientific communication process of which peer review is an integral part. The process is open, controversial and ongoing. Differences of opinion are essential for the productivity and innovativeness of the process and for preventing the undue dominance of just one opinion. Unanimity would be the exception and, consequently, is very rare until a particular research question is settled and the researchers' attention is directed elsewhere. The expectation of unanimous evaluations stems from a 'disappointed scientism' coupled to issues of justice (Hirschauer 2002). As the basis for the various critiques of peer review in general and for justifying the use of bibliometric indicators in particular it creates the wrong benchmark.

Why is this relevant to evaluations based on bibliometric measures such as citations?

To the extent that the introduction of these measures was and still is based on the distrust towards peer review it is mistaken for two reasons:

It assumes that they are independent of the peer review process.

It assumes that these measures are more exact than peer review because, being quantitative, they appear to be more objective.

In fact, publication and citation measures are representations of the communication process as it unfolds in journal publications. Thus, they also embody the peer review evaluations that have led to actual publications. For that very reason they cannot be more exact or objective than peer review judgements. In addition, since they are based on a large volume of accumulated data they contain data processing mistakes, and since they are selective for certain journals as well they only represent selective parts of the whole process. Depending on the data base these measures may entail biases towards countries, disciplines, journals (Braun et al. 2000, Zitt et al. 2003).

Another problem is that of definitions of fields. In certain cases publications are excluded because the definition of a field in the data bank based on a particular journal set is incomplete or overlaps with other definitions. In particular, interdisciplinary fields present a problem to a proper categorisation. A seemingly clearly defined research field like 'high temperature superconductivity' has connections into 'low temperature' and 'solid state physics', physical chemistry, 'materials science' and 'thin film preparation' that make a clear cut delineation of the field impossible. Thus, such problems of delineation of disciplines may ultimately lead to mistaken citation counts (Weingart 1993).

Furthermore, and generally speaking, too little is known about the use of citations in the scientific communication process, positive, negative, or perfunctory (Case &

Higgins 2000, Cronin 2000). For the time being the application of citation indicators has to be based on the conviction emerging from a number of studies that, given sufficiently large numbers, different motives for citing an article neutralise each other, what remains is the attention for the piece cited. We also know that different disciplines have developed very different customs of citing. Articles in basic biomedical research are being cited six times more often than articles in mathematics. Such regularities have to be taken into consideration when comparisons between institutions across disciplinary lines are undertaken. An accepted theory of citation decisions, however, on which the better informed use of citation indicators could be based is lacking and may never be achieved (van Raan 1998, Small 1998).

Finally, an additional problem arises from a statistical viewpoint. In many evaluations based on citation counts, especially those of individuals or small institutions, the numbers are small. Single digit differences of citations may be due to the time window chosen, they may depend on the particular position of papers in the communication under way, on the amount of time an article has had a chance to be cited, and thus they may change rapidly. In institutional evaluations and rankings the relatively small number of citations involved can lead to ‘extreme’ cases such as that one highly cited publication may decide the relative position of a respective institution regardless of the ‘quality distribution’ throughout its staff compared to others. Needless to say that the author of that paper may have left the institution a long time ago while its rank is still on record. Small differences or differences based on small numbers cannot justify budgetary or salary decisions because they do not reliably indicate meaningful differences of competitive effort, of productivity and even less so of quality of institutions or individuals. The general conclusion to be drawn from these insights is common knowledge among researchers and evaluators who are experienced in using these measures: Citation measures can only be applied on a high level of aggregation.

How does this relate to peer review? The use of bibliometrics can have a beneficial effect on the peer review process in several respects. Precisely because bibliometric measures are based on mass data they reveal patterns in the communication process that cannot be seen from the highly limited and selective perspective of the individual researcher. The unique contribution of bibliometrics to the collective communication process in science and their greatest value to the scientific community itself as well as to policy makers and the public is in providing this ‘greater picture’. It can ‘inform’ the process about macro-patterns in scientific communication, for example about the unsuspected connection between research fields that are not yet institutionally connected. The interpretation of these patterns, of unexpected contradictions to the common wisdom of the community or other irregularities must be left to the experts in the respective fields or at least assisted by them. Peer review must ‘correct’ bibliometric analyses wherever necessary.

Another aspect of the relation between peer review and bibliometrics may become highly important as well. Bibliometric analyses can also 'control' peer review. The rapid decline of attention for a research field that had been prominent before and whose institutional dominance tends to protract past relevance would be likely to escape the review process because of its inherent selectivity and/or vested interests involved. Peer review judgements especially in evaluative contexts that are counter-checked by bibliometric studies are better protected against the operation of 'old boy networks' which, in turn, will strengthen the outside credibility of the mechanism.

Intended and unintended steering effects of bibliometric measures

Do individuals and institutions react in the way intended by the application of bibliometric (and other) measures or are they in some ways evading or circumventing the intended goals?

Bibliometric indicators, when applied in conjunction with budgetary decisions and other types of sanctions are so-called *reactive measures*. That means as they affect people these react to the implementation of such measures by altering their behaviour. Behaviour change is intended, for example the link of citation measures to the allocation of funds is supposed to induce researchers to engage in more competitive publication routines such as to increase their publication activity and to publish their papers in high impact factor journals. In many cases funding formulas are linked to more than just one indicator combining, for example, bibliometric measures with received external grants as indicators. The latter is intended to induce researchers to apply for research grants. A further indicator sometimes entered into funding formulas supposed to measure research quality, the number of doctoral students supervised, is intended to achieve a greater output of PhDs. Sir Gareth Roberts, president of Wolfson College, Oxford, sees the reform of the British Research Assessment Exercise having to go exactly in this direction: "Figures such as the number of doctorates produced, external research income and number of papers produced could be used as proxies for research quality to work out how much research funding a university should receive" (Roberts 2003). Each of these indicators assumes a one dimensional mode of reaction or an incentive compatibility but that is an illusion. Researchers can and are known to increase their publication count by dividing their articles to a 'least publishable unit', they can propose relatively conservative but safe research projects, and they can lower their standards for their PhD candidates. These are just examples how individuals can manipulate indicators or evade their intended steering effects. Institutions can do the same. Obviously, the effectiveness of research policy employing evaluative indicators depends entirely on the sound theoretical base of the indicators and on the requisite knowledge about the reactions they trigger among the individuals and organisations whose behaviour they are supposed to change.

So far only very few studies have been undertaken to identify the effectiveness and unintended reactions of this kind to bibliometric measures as well as secondary consequences for the university or the communication process in science as a whole. Sociology of science and ethnographic studies show that scientists do, indeed, react to non-epistemic influences (Gläser et al., 2002, 16). An Australian study showed that upon the implementation of formula based funding, i.e. linking the number of publications in peer reviewed journals to funding, the number of publications went up, indeed, but the quality of the papers had not increased as measured by citations. "With no attempt made to differentiate between quality, visibility or impact of the different journals when funding is allocated, there is little incentive to strive for publication in a prestigious journal" (Butler 2003, 41).

The Spanish National Commission for the Evaluation of Research Activity (CNEAI) rewards individual researchers with salary bonuses for publishing in prestigious journals. A study shows that the researchers have responded by increasing their research output. Comparing the Australian with the Spanish experience Butler states that "in the Spanish case CNEAI achieved its stated aims, which were to increase productivity and the internationalisation of Spanish research. In contrast, the Australian funding formulas were designed to reward quality, but in fact reward quantity" (Butler 2003, 44). Worse yet, Australia fell even behind nearly all OECD countries.

A comparison between two Australian universities (Queensland and Western Australia) "provides further support to the assumption that the coupling of increasing quantity and decreasing quality is due to the introduction of quantity-based funding formulas" (Gläser et al. 2002, 14). UWA introduced a quantity of research output based funding formula while UQ sought to improve its status with a recruitment drive for bright young and international researchers. While the UWA status in terms of its relative citation impact (RCI) declined UQ could even increase its RCI significantly (Gläser et al. 2002, 14).

Another study on changes in universities suggests that there is now a bias in favour of research quantity rather than quality, that there is a bias towards short-term performance, not long-term research capacity, and that there is a bias in favor of conventional approaches (Marginson, Considine 2000, 17 cited in Gläser et al. 2002,12). This reflects that under a regime of evaluation-based funding scientists have been found to publish more but less riskful, mainstream rather than borderline papers, and try to place them in lower quality journals as long as they are in the ISI journal index. Under such circumstances publishing has become an end to boost publication counts and to obtain funds, a legitimate but unintended reaction as, e.g. in the Australian case, price tags can be attached to publications: A$ 3000 for an article in a peer reviewed journal, A$ 15000 for a book (Butler 2003, 40).

Since detailed citation studies are costly and time consuming many evaluating bodies have taken a short cut. They "look at scientists' publication records and evaluate the quality of their output in terms of the impact factors of the journals in which their papers appear – figures that are readily available" (Adam 2002, 727). Impact factors of journals are "the poor man's citation analysis" (van Raan) are problematic as indicators of research quality when compared between fields because of different citation practices. They are also unreliable because of the highly uneven distribution of citations in a given journal which means that a certain paper may be published in a high impact journal but receive fewer citations than papers in less a renowned journal. Per Seglen notes that "there is a general correlation between article citation counts and journal impact, but this is a one-way relationship. The journal does not help the article; it is the other way around" (Adam 2002, 727). Thus, it is not surprising that publishers of scientific journals are eager to use favourable impact factors for the promotion of their products. This has led a well known journal in critical care medicine ("SHOCK") to an attempted manipulation of the communication process that borders on the absurd. Upon the provisional acceptance of an article the associate editor added that the journal "presently requests that several references to SHOCK are incorporated in the reference list." When the manuscript was sent back with the required revisions the editor insisted that before sending the manuscript to the publisher it would be greatly appreciated "if you could incorporate 4-6 references of appropriate articles that have been published in SHOCK in your revised manuscript urgently. This would be of tremendous help…to the journal".[4] Whether successful or not, and however far spread at this time, this kind of practice demonstrates that not only the behaviour of individuals but that of organisations may be affected by bibliometric measures in ways that are clearly unintended. Long before they assume the magnitude of structural effects they are warning signs. Together with the growing realisation of unintended adaptation effects of the British Research Assessment Exercise through a few studies they are urgent reason to do more thorough research on adaptation processes in reaction to evaluation-based funding schemes in general and the use of bibliometric measures in particular. What effects do they have on the content of knowledge, on the questions asked, the methodologies used, the reliability of results? What effects do they have on the communication process in science, on the mechanisms of organised scepticism, on the attribution of excellence and reputation? In some of the recent cases of fraud or premature speed into publication the use of bibliometric measures and the resulting pressure to publish have been identified as causing that behaviour. If proven to be true this link would be the ultimate evidence that the rush into EBF does more harm than good. It would amount to the fact that the academic culture in which knowledge production thrived on a unique combination of competition,

[4] Copies of letters are in the possession of the author.

mutual trust and collegial critique is being destroyed. Whether what will emerge in its place will be easier to direct and less costly to sustain is an entirely open question.

The publics of bibliometric indicators

Part of the future culture of knowledge production becomes already visible on the borderlines between the scientific world and the world of information and data production as well as the publishing business and the media. To understand what is happening one has to realise that the evaluation industry that has been created is serving several different publics. One of them are policy makers who have brought this industry into existence and are responsible for its growth by using it as a tool to exert control over the operation of research institutions in the name of public interest. Their motives are legitimated by reference to the public interest that public funds are spent efficiently and parsimoniously on research serving the needs and interests of that public. Another public are the media that, in turn, refer to the public interest that the operation of research institutions, their relative status and quality, be made transparent to the lay public.

The legitimating power of these publics is best demonstrated by the rhetoric of the public representation of evaluation data by both the producers of these data and the media.

Undue simplification is only one problem such as when cumulative data of publication counts and of grants appear in the media without any weighting by appropriate factors such as size of institution. Resulting conclusions such as rankings are meaningless and misleading but seem to evidently serve the media's needs to dramatise. Likewise, ISI offers rankings of universities on Science Watch under such titles as "Harvard runs high in latest 'Top Ten' Research Roundup". This ranking is based on citations-per-paper (impact) score for each university in 21 fields, based on papers published and cited between 1997-2001. That figure was compared to world baseline figure representing the impact for the field during the same period. This produces relative impact scores expressed as percentages. Sometimes rankings are based on the hundredth of a decimal point. The exactness suggested by such measures may be a promotional gimmick for ISI's products. In the context of responsible policy decisions it is misleading, meaningless and irresponsible. One could even go further and say that it is unethical given the unhealthy combination of the unavoidable limitations of competence on the part of policy makers and media exposure.

On another level ISI employs the language of media hype. The company conveys an image of individual popularity contests by presenting highly cited scientists in its "Science Watch". Their January/February headline reads: "Astrophysicist Andrew Fabian on Rocketing to Prominence", this evaluation being based on more than 6000 citations over the last decade. The language of the marketing and of sensationalised competition has penetrated the hitherto self-contained discourse of peer review. This is not to claim that the scientific community did not know competition before the days of bibliometric indicators, quite the contrary.[5] But it rarely ever had an outside audience nor commentators employing the language of sports events.

One may speculate about the repercussions of this development. It seems highly likely that the orientation to media prominence that is already visible in other contexts will be strengthened. Short term successes such as high positions in rankings that will be watched and commented like the national soccer league, and that may trigger favourable decisions from science councils and university administrations are likely to gain prevalence over more sustained strategies. A metaphor too far fetched? The magazine SCIENCE commented already in 1997, that "the tactics of soccer managers have taken over the world of higher education". According to the journal's assessment the results of that year's RAE in the UK "revealed how soccer style transfers of researchers and other tactics aimed at improving department's rating are now part of British academic life" (Williams 1997, 18). This loss of control over its own system specific time scale and mode of evaluation will probably have a profound long term impact on knowledge production. Unfortunately this will never be known in detail as there will be no possibility to compare.

What follows from this analysis? The point is not to denounce bibliometric measures and indicators. They are a very valuable tool for research as well as for science policy making. The warning is against their uncritical use outside of the peer review process. At least the following principles should be observed. Bibliometric (and similar indicators):

1) have to be applied by professional people, trained to deal with the raw data. (ISI's data are not cleaned, and are not fit to perform in depth analyses in other countries).

2) should only be used on highly aggregated levels, when the mistakes can be hoped to be neutralised by larger numbers.

3) should only be applied in connection with qualitative peer review, preferably of the people and institutions being evaluated. The principle is that bibliometric indicators support peer review and can possibly correct it where individual evaluations are confronted with aggregated data and patterns. On the other hand, the bibliometric measures may be corrected by peer review judgement where formal algorithms fail. This conjunction of bibliometric measures with traditional peer review, i.e. so-called 'informed peer review', can serve the legitimate needs of transparency of the general public, and at the same time it retains the expert nature of the judgements that have to be passed.

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[5] The most prominent example has been the Watson/Crick story about the discovery of the double helix as told by Watson.

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Introduction

The system of research and development indicators: entry points for information agents

Roland Wagner-Döbler

Introduction

Science has become an industry; and big science has become a big industry. Every branch of industry is usually accompanied by clusters of services of most different shape and aim. For efficient and effective performance, also science needs services of different kinds. Think of lab technology supply and services, of computer services, of publishing and editing services, of information design services, of statistical services, to mention just a few. As a core service especially for basic and applied research, we will of course not forget library and information services. It is ridiculous to think that this kind of service will vanish in the future "because of the Internet", as sometimes is assumed; on the contrary, more information and knowledge management and services than ever will be needed to keep science productive, including the management of digital sources and libraries.

Every enterprise and almost every organisation or corporation is confronted with the task to monitor and evaluate the performance of individuals, of teams, or of the whole unit. This is useless as a mere retrospective exercise, apart from legal obligations to deliver retrospective reports and references. But the main purpose of such evaluations is to improve future decisions. So, evaluation is a key to the future development of an organisation. To monitor and evaluate in this sense is especially difficult and arduous in science - what I only claim and do not prove. Here bibliometrics was coming in.

Bibliometrics is sometimes understood as evaluation of science with the help of bibliographical statistics. But I find this interpretation misleading, even nonsensical. Think of econometrics, for example: econometrics surely is not the evaluation of economies with the help of economical statistics. I would like to remind you of a simple and elegant short definition coined by Anthony van Raan of the CWTS in Leiden: Bibliometrics is the quantitative study of the written output of science. In my eyes, those studies began in the last decades to contribute to a deeper understanding of the functioning of science as a self-organising system. Direct scientific connections to theories and models of other natural self-organising systems were explored, and those studies begin to complement the theory and logical analysis of science which have made so much progress in the last decades. We have to do with basic research *on* research using quantitative insights into the research process or the scientific communication process.

Thus, bibliometric descriptions and models contributed to a clearer and more transparent picture of science. For a long time it was impossible even to gain a merely descriptive picture *not* being an insider of the area under examination. With the help of bibliometric indicators it is now possible to get basic information on key players, on most cited institutes, on research fronts, and so on; and it turned out that in some respects a more objective and more comprehensive picture is gained than delivered by individual experts - although subject experts are indispensable for interpreting such a picture or map. This is not only valid for natural science. The well-known philosopher of science Nicholas Rescher (who 25 years ago also used some bibliometrics in his path-breaking book "Scientific Progress") once stated that to yield an adequate overview even of a philosophical field one is now drawn back to bibliometric analysis, apart from content analysis which remains necessary, of course. All this has nothing to do with evaluation, rather with statistical description and transparency. Obviously, bibliometrics may thus *contribute* to an evaluation process as a mosaic piece. Contributions of this kind offered in a professional manner I would like to call service for science, and understand as part of a service industry for science.

A "system" of indicators

One of the possibilities to explore bibliometric indicators (for such a service as well as for research on research) is to examine their role and their place in the process of knowledge production. In different phases of knowledge production different bibliometric indicators will be needed.

Phases of knowledge production in research and development are basic research, applied research, and experimental (technological) development. Basic research leads to scientific discoveries, technological development leads to - often patentable - inventions, whereas applied research lies in the zone between scientific research and technological development. These phases should not be understood as a necessarily linear sequential scheme, although such a sequence may often appear. Rather it is a functional scheme: successful technological experiments can precede, stimulate, and lead to basic research, for example. It is not so that basic research always precedes applied research and development.

Further on, I would like to distinguish, in accordance with authors like Grupp or Geisler, between input indicators, output indicators, and efficiency indicators. Input indicators capture what is used to produce knowledge; financial means as a basic necessity, for example, further on equipment, labs, and so on.

Output indicators deal with the outcome of knowledge production. Outcome could be in mathematics, for example, an new theorem or a paper in a respected journal.

Efficiency indicators try to capture the relationship between investment and outcome. For technological research and development in enterprises, this is, of course, a most crucial relationship.

For each of the three categories and each of the three phases I distinguish between four descriptive statistical approaches to the indicator in question: a manpower, a financial, a technological, and an informational indicator approach.
Plenty of the indicators I shall describe in what follows are apparently no bibliometric indicators. I hope that to consider these non-bibliometric indicators improves the understanding of the specific meaning of bibliometric indicators and their possible interplay and interconnections with other indicators.
Mainly, I have profited from a standard text of E. Geisler, "The Metrics of Science and Technology" (Geisler 2000), and of Hariolf Grupp's "Messung und Erklärung des Technischen Wandels" (Grupp 1998). In describing these indicators, I will go not into details which can be drawn from the sources I mentioned. The category "informational indicators" cannot explicitly found in the current literature; I view bibliometric indicators as part of such informational indicators. When I speak of a *system* of research and development indicators one must not presume that a these indicators form a coherent and smoothly interconnected system. Progress has been made, but such a system has yet to be developed fully.

Input indicators

I show you a summarising scheme of input, output, and efficiency indicators (Table 1). The scheme is heuristic and only tentative, and by far not exhausting. For further differentiations the standard texts of Grupp or Geisler are recommended.
Let us begin with input and output indicators for basic research.

Indicator category	**Indicator type**	**Basic research**	**Applied research**	**Experimental development**
Input	manpower, human resources	scientists, engineers, other staff	scientists, engineers, other staff	engineers, other staff
	financial	cost (expenditures, grants)	expenditures, grants	expenditures, subsidies
	technological	equipment, labs	equipment, labs	equipment, labs
	informational	literature use, scientific library and documentation use	literature use, enterprise library and documentation use	unpublished information, tacit knowledge, patent library use

Output	manpower, human resources	post-graduates	? (unclear)	? (unclear)
	financial	human capital	human capital, business scenarios	business prospects
	technological	technological ideas	technological concepts and models	new technological products and processes
	informational	publications (discoveries) communicative influence (citations)	publications, patents (technical ideas, inventions) influence	patents (economically relevant technological knowledge)
Efficiency, effectivity, returns	manpower, human resources	increased scientific problem solving capabilities	increased applied problem solving capabilities	increased inventive productivity
	financial	cost per output unit	cost per output unit	returns on investment, effects on economic growth and welfare
	technological	technometrically plausible progress	technometrically proved progress	technometrically confirmed progress
	informational	effects and impact on scientific progress	effects and impact on technological progress	relevant information for productive progress

Tab. 1: Indicators for basic research, applied research, and development. The scheme is heuristic and exemplary, not exhaustive. Micro- and macroscopical levels are not differentiated systematically.

Among the established indicators are figures of the personnel engaged in basic research. From a human resources point of view one has to consider here different levels of education. Difficult is the assessment of the degree of involvement separated, for example, from administrative or teaching duties. For university research, the extent to which scientists or teachers are able to devote themselves to research has to be estimated. Despite I cannot go into detail here I would like to mention that the examination of the disciplinary profile of universities has to be paid attention: research in arts and humanities, social sciences, and natural science, respectively, is of quite different direct economic relevance so that behind the same university research manpower volume quite different types of research are hidden behind figures of such an indicator.

One can count the number of employees, but one can also try to get figures of the expenditures connected with research personnel. One has to distinguish here between expenditures for wages and expenditures for equipment.

After personnel and expenditures, with equipment a third category has to be introduced: the *technological input* into basic research. In many disciplines, technological progress plays a crucial role for the development of research possibilities. Enhanced and new technological capacities lead to new scientific insights; N. Rescher postulated here, with exponentially growing costs of research technology and not just as fast growing knowledge, a principle of diminishing marginal returns of scientific research at work. To the best of my knowledge, however, no indicators were developed so far in a sufficiently systematic manner for the influx of technology into basic research. Promising would be, in my view, the use of *technometric* indicators which are sketched in a minute. Usually, financial indicators have to function as surrogates.

In principle, the similar indicators can be used for applied research. However, the major part of applied research is conducted not in universities, but in enterprises and in state laboratories.

For experimental development the direct worth and impact of published information is by far not as high as for basic or applied research. Although tacit knowledge is important for conducting basic research, too, I consider tacit knowledge as the most important informational component of experimental development. I cannot go into further details of this interesting topic.

A remark on informational input indicators

In the literature I did not meet so far a systematic approach to indicators of the *informational input* neither for basic nor for applied research. It goes without saying here that despite quite limited possibilities of quantification an important part of information and knowledge work of applied research and of development in enterprises happens without any direct involvement of formal documents. Conversational exchange, meetings, informal memos or reports, and drafts of ideas determine the picture. Information professionals are primarily involved in delivering access to (from the standpoint of a research unit) external information resources through the Internet channel or through the supply and delivery of printed or electronic documents. Unsurprisingly, information professionals stress the importance of that input. But for the importance of this kind of external information sources has been argued in innovation research, too. There is empirical evidence of significant differences between innovating firms with regard to the successful introduction of innovations: In one sentence: The higher the openness to external information, the more successful firms are performing innovations.

The informational input of certain works, on a microscopic level, can partially studied by the analysis of references given in papers. Of course there are uncountable studies of that kind; I would like to mention only one not yet so well-known approach. To study the science intensity of applied or experimental research, one can study the extent to which publications of applied or experimental research refer to basic research. One can examine this phenomenon also in patent documents, and the *Fraunhofer Institut für Systemtechnik und Innovationsforschung* in Karlsruhe presented results in a book called "Wissenschaftsbindung" (science intensity) (Grupp & Schmoch 1992). In addition, statistics of firm libraries supply a general view of information input in the sense described above. There is an additional entry point. Interesting enough, H. Grupp mentioned the extent to which firms use external scientific libraries as a possible indicator of research or science intensity of enterprises. He suggests to develop a systematic geographical overview of that library use in order to supplement other indicators of science intensity. Of course, in high tech fields the research intensity should be higher than in low tech fields. Such a geographical comparison of user statistics with concern to the involvement of enterprises would add quite an interesting mosaic piece to innovation studies.

Output and efficiency indicators

We now come to output indicators. It can be counted to one of the major shifts of science studies and science evaluation of the last three decades or so that in addition to input indicators as described above (foremost personnel and financial figures) also output indicators were developed and used to a much greater extent than ever before. Among output indicators bibliometric indicators play a central role. For basic science, paper counts are suitable, of course. For experimental development, bibliometric indicators insofar they deal with publications are not suitable, because for developers it is of no importance to publish their knowledge gained through their development work. Sometimes it may be even quite foolish to publish that knowledge. If that work leads to inventions which are worth, in the view of the inventor, and suitable, in the view of a patent office, to be protected against imitation, the inventor is forced to publish a comprehensible explanation of his invention in a patent document. Applied research stands between basic research, on the one hand, and experimental development, on the other hand. Sometimes it was overseen that the more applied a research is orientated the less publications plays a role as output, and so some bibliometricians as LePair and others warned to overlook a "bibliometric gap" of research.

Under bibliometric indicators, citation indicators are used to reflect the influence of a work. For the sake of bibliometric correctness I do only mention here that in the last decade bibliometric methods have developed further as *advanced bibliometrics*. In advanced bibliometrics, for example, self-citations are excluded; citation scores are related to a subfield, not to a discipline, and so on; plenty of different computational indicators are presented.
Publications and citation indicators belong to the information output. To measure the effectiveness of communicative acts as papers or citations concerning scientific (or technological) progress one had to establish a relationship between papers or citations and scientific progress in the sense of new theorems, technometric improvements, improved scientific explanations, and so on. Of course, only for a small part of these phenomena quantitative bibliometric indicators are known at the present time.
With which output indicator could the "bibliometric gap", however, be filled? The answer are the above mentioned technometric indicators. With the help of these indicators, developed in Germany by the *Fraunhofer Institut für Systemtechnik und Innovationsforschung* in the last years, it is tried to measure important performance properties of technologies (Grupp 1987). Such a performance property could be, for example, the efficiency of engines, the computing speed of computers, failure-free operation time, and so on. Improvements might be visible in technometric time series. This aspect is of no direct concern for information professionals. We emphasise, however, that technological progress can be measured in a more objective manner than scientific progress. The analogy in science would be that a certain problem is better understood or is even solved. All existing science indicators are far from characterising such a scientific event. Only quite vague conclusions are drawn: If, for example, a new scientific method is cited highly, the usefulness of the method is presumed. But the improvement is neither measured in a technometric way nor any input-output to study efficiency is established so far.

Conclusions

The purpose of the scheme parts of which I discussed is to stimulate an *integrative* view of the working of information infrastructures and personnel and a debate how to include this in a systematic manner, of course with concern to all statistical information which is available (and which is not available, but desirable) on that infrastructure. It would be a subject of a philosophical dissertation, in my eyes, to establish such an integrative view. And of an additional pioneering dissertation to investigate possible correlations between indicators of information work and infrastructure and other science and technology indicators as they are outlined in the scheme. This could be done, for example, considering some decades of the last century. It would not be a work of only historical interest. Internet access to scientific sources changes many aspects of information use, but it does not

change the fact that scientific information is produced, distributed and resorbed by scientists.
Bibliometrics must not only be understood as a service for science and technology. Not only can information specialists in libraries and documentation centres enrich the system of indicators through suitable statistics of their institutions as I tried to argue. Moreover, they are called upon to play a more active and substantial role in the discussion and development of bibliometrics because many of them are not only experts for media and information tools, but in addition subject experts. Bibliometrics is intricate if details of publications, databases, publication market and publication behaviour have to be considered together. Thus, German information professionals can outplay their educational strength and join bibliometrics and scientometrics to the same extent as many colleagues abroad.
There is also much interesting theoretical work to be done, not only on the level of indicator building. To understand scientific developments as a process of information and knowledge production and diffusion, the topic of Erhard Oeser‘s oeuvre (Öser 1976); the understanding and interpretation of technological progress as a process of information accumulation brought forward by the economist Werner Pfeiffer many years ago in a thorough treatise (Pfeiffer 1971), interpreting science as a cognitive economy, as N. Rescher did some years ago (Rescher 1989), all that is potentially connected with bibliometrics and scientometrics, and all that is only in the beginning, as far as I can see.
In any case, quantitative analysis of information processes has old roots in Germany even in the so-called *Geisteswissenschaften*, even in the 19th century where Wilhelm Dilthey was one of the outstanding humanities scholars, well-known until today, but certainly not as an advocate of statistics. In 1883, once he stated the following:
"Von der Epoche der Geschichte ab, in welcher der Bücherdruck auftritt [...], sind wir durch die Anwendung der statistischen Methode auf den Bestand der Bibliotheken imstande, die Intensität geistiger Bewegungen, die Verteilung des Interesses in einem bestimmten Zeitpunkt der Gesellschaft zu messen"[1].
But he was not the only German humanities scholar with such a far-sighted assessment. Fourty years later, an ecclesiastical historian and theologist, and among others, for some time director of the "Preußische Staatsbibliothek", and also president of the former "Kaiser-Wilhelm-Gesellschaft zur Förderung der Wissenschaften" (the precursor of the Max-Planck-Society), coined the apercu on

[1] Dilthey (1933) Einleitung in die Geisteswissenschaften. Bd. 1. 3. Aufl., unveränd. Nachdr. d. Ausg. 1883. Leipzig: Teubner, S. 115. - „From the inception of book printing on [...], through application of the statistical method we are able to measure the intensity of intellectual movements, the distribution of interests of a society for a certain time interval“.

library science to belong to national economics in a special sense: in the sense of a *cognitive economy*[2]. I would like to add that an economical approach must not confused with a commercial approach. Rather, with his apercu Adolf von Harnack obviously anticipated most important modern currents of thinking on science, and I find it adequate and attractive also from this pivotal point to let bibliometrics come in.

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[2] In the German original: „geistes-wirtschaftlich". Harnack 1921. My thank to Prof. W. Umstätter for his reference.

On the meaning of Journal Impact Factor values

Barbara Stefaniak

Introduction

The journal Impact Factor (IF) was created years ago by E. Garfield and I. H. Sher (Garfield 1999) as an aid in the process of selecting source publications for Science Citation Journal (SCI), as a device to balance the effect of the size of a journal on the number of citations it received. After some time, however, IF evaded designers' control, and started "the life on its own". Being accused of "claiming a right" to judge the importance of scientific journals and to evaluate the research performance of scientists, and even research institutions, IF (apart from the wide use or may be because of that) has been an object of widespread criticism by many of those who are evaluated, particularly in the countries where English is a foreign language (Meenen 1997, Golder 1998, Hecht et al. 1998, Golder 2000, Adams 2001, Bloch & Walter 2001, Jennings 2001, Rey-Rocha et al. 2001, Bordons et al. 2002, Neuberger & Counsell 2002, Ojasoo et al. 2002, Winkmann et al. 2002a, 2002b, Zetterstrom 2002). On the other hand it is welcomed and applied, as a ready to use quantitative indicator, by some evaluators and following them money distributors, who sometimes even tend to consider more valuable the uncited papers published in journals of high IF than cited papers but published in journals with lower IF values (Wróblewski 2002).

In general IF transfers all the deficiencies of citation indexes that come from one of the basic selection criterion of journals, namely citation rate. Such a criterion is the reason that ISI is blamed for discriminating foreign journals in general, and those that are not published in English in particular, whereas this in fact is unwittingly done by authors' citation habits. The authors usually publish either in their native language (and for many of them English is native) or, for different reasons even preferably, in English. The same refers to citations. This creates kind of a feedback mechanism. Both - high proportion of citeable documents published in English and higher citation potential of papers published in English (also from foreign authors) eliminate valuable journals published in German, French and other languages from the list of sources. As a result the titles of very high or relatively high (depending on the subject category) IF values are almost exclusively – first of all – American, and then British or international published in English. This seems to be comprehensible, when what was mentioned above is taken into account, but what is the real meaning of this high values is not at all so clear.

According to the Dictionary of Bibliometrics (Diodato 1994, 82) *impact factor* is "a measure of importance or influence of a group of documents .... is the number of citations received by an average document in the group", and if examining *impact factor of a journal* "then, the group of documents are all the articles published in the journal during a given period". So, if IF is a measure of importance or influence (which is more or less the same) the question is – *influence on what or on whom* (discipline, other journals, authors)?, and if *a measure* – it suggests that the value shows the degree or extent of this influence. However, I could not find any specified *expressis verbis* answer not only in the dictionary but also while reading many papers on the use or misuse of this indicator, including short papers presented in the Proceedings of the 8th International Conference on Scientometrics & Informetrics (Sydney 2001), where Special Session was devoted to "Journal Impact Measures: Their Role in Research Policy and Scientific Information Management".

Data sources and method

Trying to answer these questions I studied data recorded in two annual files of Journal Citation Reports: Science Edition and Social Sciences Edition (JCR SE 2000 & 2001, and JCR SSE 2000 & 2001) for the journals of the highest IF values (Journal Rankings Sorted by Impact Factor). Other data employed in analysis of individual journals were taken from the lists of "Cited and Citing Journals", from respective "Publisher Information" files, and from the current ISSN Online via Internet. The data involved in analyses included journal citation rates in two former years (being the base for IF counts), as well as, number of articles and total cites in 2000 and 2001, and if needed some data concerning the currency of publication.

From the both editions (science and social sciences) and the both annuals, for the purpose of analyses, the following lists of journals were completed:

20 top journals ranked by the IF value derived from the total annual files (SE ~ 5700 titles, SSE ~ 1700 titles), and

20 top journals selected (filtered) by subject category from both editions: for SE - Mathematics (~ 160 titles); for SSE - Information Science & Library Science (~ 60 titles), and then sorted by Impact Factor, to give the ranked lists.

For each title included in the lists cited and citing data, as well as, "self citations" (when both cited and citing articles were published in the same journal) were searched, recorded, and then used to calculate Interjournal Impact Factor (IIF) for all the journals under review, as below:

$$IIF = \frac{\text{number of all last two-year citations to journal "X" articles - self citations}}{\text{number of last two-year journal "X" citations to all journals - self citations}}$$

IIF for an individual journal ("X") shows how much other journals used the articles published in the journal "X" ("X" cited by other journals) as compared to how much this particular journal used from what was published in other journals (journal "X" citing articles from other journals). Consequently, IIF values over 1 show journals which are more "givers" than "receivers" – those which give more to other journals then receive from them, whereas IIF values below 1 show the titles "receivers" which take more than give to others.

Results

As it could be expected, in the sets of 20 highest IF value journals, extracted from JCR Science Editions, almost all represented life sciences. Among them as many as 10 titles were "Annual Review of ....." or "..... Review" or "Advances in .....". These review journals usually publish yearly up to 40 articles and receive several to a dozen or so thousands of citations. Within the groups of social sciences titles with the highest IF values, one can find slightly lower number of review journals (8 of 20) and the subject structure of these sets shows mainly psychology, psychiatry and law.

Since it was not possible to present in this short paper the contents of 8 big tables which would show some peculiarities of data describing individual journals under review, only the range of indicators' sizes are presented below. Table 1 shows the highest and the lowest numbers of articles published and citations received by twenty leading (by IF value) journals in science and social sciences in general, as well as, in selected disciplines - mathematics and information science & library science which were not represented in the prominent groups.

Subject category & year	Articles/max.	Articles/min.	Total cites/max.	Total cites/min.
SE All journals - 2000	1315	12	306 184	2 348
2001	939	19	315 640	720
SE Mathematics - 2000	156	9	4 949	23
2001	161	8	4 679	212
SSE All journals - 2000	314	5	26 160	1 265
2001	302	4	27 047	503
SSE Inf. & Libr. - 2000	106	0	1 532	32
2001	211	0	1 916	52

Tab. 1: Data on productivity and citation rates in the four groups, of twenty journals each, of the highest IF values in 2000 and 2001 (SE – Science Edition; SSE – Social Sciences Edition).

In table 2 one can observe how different were the individual journal impact factors both calculated on the grounds of all citations (IF) and on citations received from and given to other journals (IIF). It is also shown how many journals of the highest IF values, in the selected groups (of 20 titles each), gave more citations to other journals than received from the others.

Subject category & year	IF max.	IF min.	IIF max.	IIF min.	No.of IIF>1
SE All journals - 2000	50.340	19.524	5.852	0.480	14
2001	46.233	20.556	6.019	0.123	11
SE Mathematics - 2000	2.750	0.800	2.070	0.121	5
2001	2.650	0.792	2.741	0.403	7
SSE All journals - 2000	14.250	4.468	2.622	0.232	5
2001	17.312	3.980	2.700	0.448	8
SSE Inf. & Libr. - 2000	3.089	0.429	1.750	0.071	3
2001	2.021	0.600	3.000	0.006	1

Tab. 2: The range of Impact Factor and Interjournal Impact Factor for all the journals under review. The last column shows how many titles of being analysed belong to "givers" (IIF>1).

Results concerning individual journals are even more interesting when we think about the meaning of the IF value. The highest IF among science journals, over 50 and over 46, attained *Annual Review of Immunology*, which in 2000 and 2001 published 32 and 24 articles, and received 12 584 and 13 191 citations, respectively. In the same years *Journal of Immunology* published 1732 and 1811 articles, received 97 345 and 103 290 citations, and attained IF values of 6.834 and 7.065. Similarly in 2000 and 2001 - *Annual Review of Biochemistry*: 31 and 23 articles, 16 436 and 16 413 citations and IF values over 43 and over 31, when in the same years *Journal of Biological Chemistry* published 5549 and 6341 articles, received 344 256 and 359 126 citations, and attained IF values 7.368 and 7.258.
In social sciences the top title is *Behavioral and Brain Sciences* - subject category: psychology, biological, which in 2000 and 2001 attained IF over 14 and over 17 (table 2: IF max., SSE All journals) published 10 and 8 articles, and received 3008 and 3478 citations, respectively. In the same time *Physiology and Behavior* (the same subject category) published 271 and 281 articles, received 9141 and 8850 citations, attained IF values of 1.419 and 1.328, respectively.
The first ones, of the pairs mentioned above, include few highly cited valuable review articles which sort out and summarise what has already been done and published. These articles as a rule contain some "added value" since they are usually worked out by experts who can not only summarise but also critically evaluate what was published by others. The second ones, however, publish many

papers presenting results of just completed research, and receive altogether many more "total cites" than the first ones. Are the second ones in the pairs – "Journals" achieving IF values about 5 to 7 times lower than "Annual Reviews", so many times less important for the progress in immunology and biochemistry? Is it possible that *Behavioral and Brain Sciences* would be 10 to 13 times more important for the development of biological psychology than *Physiology and Behavior*?

Some striking examples, of a different kind, come from Information Science & Library Science files. In 2000 rank list, right after *Journal of the American Society for Information Science* (IF = 1.226, 106 articles, 1439 total cites), both with the fifth rank IF = 1.167, come two journals: *Internet World* - 98 citations, 0 articles (no longer published since 1998), and Japanese - *Library and Information Science* altogether 33 citations (with 4 citations of 1999 articles and 3 of 1998), number of articles unknown. If the importance of the journal for a discipline development would be judged by its IF value, looking at the rank list – 4th and 5th positions, and their IF values, the last two journals would be having similar importance or influence on the progress in information science as the *Journal of the American Society for Information Science*, which is far away from the truth.

Another assumption that the journals of the highest IF values have also the highest influence on other journals (are more frequently cited by other journals than citing others) also does not prove correct. For example *Science* being 13th and 14th on the lists ranked by IF in 2000 and 2001 (23.872 and 23.329, respectively) was 1st and 3rd according to Interjournal Impact Factor (IIF) values being 5,852 and 5.460 (which means that the articles published in *Science* were over 5 times more cited in other journals than citing articles from others). Among mathematics journals for instance *Topology* ranked 15th by IF values (0.942 and 0.915) in both 2000 and 2001 appeared 1st and 2nd on the IIF ranked lists being twice as much cited than citing other journals. Again – the title being 1st on the IF ranked lists in 2000 and 2001 for social sciences (table 2) - *Behavioral and Brain Sciences* was less a "giver", but twice as much a "receiver" of citations from other journals - 14th in 2000 (IIF = 0.493) and 16th in 2001 (IIF = 0.519). Among the data collected for the individual journals one can find more examples, maybe less spectacular than those mentioned above, but also confirming the above presented observations.

Discussion and conclusions

There is no doubt that IF value proves to be an important tool when selecting journals not only for ISI purposes, as it was designed, but also while selecting journals to be subscribed to, because otherwise some very important ones could be omitted when titles would be picked out from bibliographic databases by productivity counts. But such a tool can be deceptive when used for other evaluating purposes, what was pointed out by many other authors. In fact, as it is shown above, we do not exactly know what is "the target" of this impact and even more what means its "strength" represented by the value of journal IF, besides, what we can know for sure that in this particular journal, more often than in other journals, some published articles are later on very highly cited, and they work also for the renown of other articles, the whole title and a publisher.

Looking for the meaning of the highest and lower values of journals IF I considered two different approaches. Presenting the examples of IF values for some review journals vs. values for other journals from the same fields, I have shown that the value of IF of a particular journal cannot be considered the measure of its importance or influence on a discipline (on the example of immunology and biochemistry, and even more of biological psychology). It means that the progress in science reported in journals is not always stimulated by the top IF journals to such a degree as it could be judged from their IF value.

On the other hand introducing Interjournal Impact Factor I wanted to find out whether, as one could presume, journals of the highest IF values have the strongest impact on other journals (more exactly on what is published in other journals) and such an assumption also turned out not to be true. This does not suggest that journal self citation reduces its importance, it only proves that high IF value journals do not necessary have high influence on others. For that reason, I think that the name of this indicator should be rather something like "Relative Citation Coefficient" or "Relative Citation Index", which would not employ the meaning of impact or influence, and would not create temptation for evaluating anything but usefulness of journals.

It seems, however, that the magic of IF influences the most authors from all over the world and even some publishers – first of them being under the pressure of evaluation, the last ones under the pressure of publication profitability. The authors aiming at success strive to publish in high IF journals or at least in the titles from ISI list of "source publications" which makes the competition more difficult, elevates requirements, and as a result the quality of papers. It does not mean that all the journals that succeed to attain high IF or to join the ISI list of source publications represent higher scientific level than all the rest, but certainly due to this competition they achieve not only high quality but also prestige and renown.

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The ISI database and bibliometrics: using ISI data in national and institutional analyses

Nancy K. Bayers

Introduction

This presentation focuses on some of the approaches we in the Thomson ISI Research Services Group have used to analyse the world research environment, particularly in terms of comparing research performance among nations and institutions.

This discussion will concentrate on the recent research environment--1998-2002 – beginning first with comparisons among selected nations overall, in terms of publications—an indicator or research output and productivity; and citations—an indicator of research impact and influence. We will then turn to the German research landscape, and how it compares with other nations by specific fields. We will conclude with an analysis of specific German institutions are contributing to Germanys' research performance.

National comparisons

Overall, the most marked development in the past five years is the European Union overtaking the United States in terms of number of papers indexed by ISI. Of the approximately 3.6 million papers indexed in the past five years, 1.3 million came from EU member countries, or 37%, and 1.2 million from the US, or 34%. As the Table 1 below indicates, Japan ranks number 3 in terms of publications with 9.6%, followed by the UK at 9.3%, then Germany, at 8.8%. Germany thus ranks 4th overall in terms of research productivity as measured by publications. France ranks 5th at 6.3%, followed by Italy (4.2%), Spain (3.0%), Netherlands (2.6%), Sweden (2.1%), Switzerland (1.9%), and Belgium (1.4%).

COUNTRY	% papers in world		COUNTRY	% papers in world
EU	37.1		ITALY	4.2
USA	34.2		SPAIN	3.0
JAPAN	9.6		NETHERLANDS	2.6
UK	9.3		SWEDEN	2.1
GERMANY	8.8		SWITZERLAND	1.9
FRANCE	6.3		BELGIUM	1.4

Tab. 1: Percent papers in field by selected nations. Source: ISI.

This is the current picture in terms of overall publication output. In order to obtain a trend analysis – whether these has been a significant increase in publication output over time, let us compare the earlier 1981-1985 period with the 1998-2002 period. Note that the world average increase in all papers was 60% over this period.

Country	1981-85 papers	1998-2002 papers	% increase
SPAIN	21,754	106,115	388
ITALY	53,269	150,417	182
JAPAN	148,060	343,733	132
NETHERLANDS	40,259	92,220	129
BELGIUM	22,027	48,572	121
SWITZERLAND	32,198	66,772	107
FRANCE	114,499	228,185	99
EUROPEAN UNION	692,345	1,336,393	93
SWEDEN	38,385	73,644	92
GERMANY	169,755	317,370	87
UK	199,156	334,676	68
WORLD	2,247,259	3,599,665	60
USA	890,932	1,229,994	38

Tab. 2: Percent increase in publication output, 1981-85 to 1998-2002. Source: ISI.

Germany: publication output

Germany overall experienced an 87% increase in publication output, compared with the European Union average of 93%. Size of country does not necessarily affect the degree of increase in publications. Sweden, with 38,000 papers experienced a 92% increase, while the Netherlands and Belgium, with 40,000 and 22,000 papers, respectively, experienced a 129% and 121% increase, respectively.

These statistics indicate overall productivity, but do not reflect which fields of research are experiencing the greatest growth. Let us turn specifically to Germany's productivity.

As mentioned, Germany experienced an 87% increase in publication output from the early 1980s to the present. Table 3 lists which fields showed the greatest increase.

Field	1985-85 papers	1998-2002 papers	% increase
Neurosciences & Behavior	3,487	13,180	278
Immunology	1,624	5,177	219
Computer Science	1,030	3,175	208
Geosciences	3,074	9,360	205
Space Science	2,339	6,339	171
Molecular Biology & Genetics	4,093	11,022	169
Physics	21,311	53,418	151
Ecology/Environment	2,428	5,727	136
Clinical Medicine	35,980	77,253	115
Psychology/Psychiatry	3,089	6,581	113
Microbiology	4,384	7,911	81
Materials Science	7,046	12,608	79
Engineering	10,521	17,934	71
Chemistry	30,147	50,148	66
Biology & Biochemistry	13,546	22,018	63
Mathematics	4,079	6,446	58
Plant & Animal Science	12,884	16,044	25
Pharmacology	5,880	5,903	0.4
Agricultural Sciences	6,820	5,824	-15

Tab. 3: Germany—percent increase in publications by field. Source: ISI.

This table indicates that the greatest increases were in the fields of Neuroscience and Immunology at 278% and 216%, followed by Computer Science (208%), Geosciences (205%), Space Science (171%), and Molecular Biology (169%). There was little increase in Plant & Animal Science, Pharmacology and even a decrease in the Agricultural Sciences.

However, as we learned from my colleague Jeff Clovis, relative measures, not just absolute counts or percentages, must be used since each field exhibits different growth rates and different citation rates. Thus, the relative increase in number of papers by field relative to the overall field average increase is a better indicator of growth. Table 4 indicates that four of the fields above that are among those with the greatest growth also had significant growth relative to their field: Neuroscience, Immunology, Geosciences and Space Science. However, the greatest growth was in the field of Psychology/Psychiatry, with an increase relative to the world average of 3.12—over 3 times the world average. Biology & Biochemistry in Germany also outpaced the field world-wide with a relative growth rate of 2.17.

FIELD	% increase in Germany	% increase in world	Increase relative to world average
Psychology/Psychiatry	113	35	3.23
Neurosciences & Behavior	278	89	3.12
Immunology	219	76	2.88
Geosciences	205	72	2.85
Space Science	171	77	2.22
Biology & Biochemistry	63	29	2.17
Microbiology	81	46	1.76
Physics	151	93	1.62
Clinical Medicine	115	73	1.58
Ecology/Environment	136	98	1.39
Molecular Biology & Genetics	169	129	1.31
Computer Science	208	181	1.15
Plant & Animal Science	25	24	1.14
Chemistry	66	59	1.12
Mathematics	58	60	0.97
Materials Science	79	110	0.72
Engineering	71	99	0.71
Pharmacology	0.4	20	0.02
Agricultural Sciences	-15	8	---

Tab. 4: Germany—percent increase in publications by field, relative to field growth rate. Source: ISI.

Growth rates relative to field have provided us with an indication of which areas have shown the greatest gain over the past 22 years. What is more illustrative of the research landscape is: In which fields is Germany showing the greatest concentration relative to the field size. Table 5 provides statistics for Germany in 19 broad fields.

Field	% papers in world	Field	% papers in world
Space Science	14.1	GERMANY	8.8
Physics	11.9	Immunology	8.1
Molecular Biology & Genetics	10.1	Biology & Biochemistry	8.1
Chemistry	10.0	Pharmacology	7.7
Mathematics	9.9	Computer Science	7.3
Microbiology	9.8	Plant & Animal Science	7.2
Neurosciences & Behavior	9.4	Agricultural Sciences	6.9
Materials Science	9.2	Psychology/Psychiatry	6.7
Geosciences	9.2	Engineering	6.7
Clinical Medicine	8.9	Ecology/Environment	6.2

Tab. 5: Germany—Percent papers in field. Source: ISI.

While Germany overall accounts for 8.8% of total publication output, in 10 fields Germany's output is greater than its average. At the top is Space Science, which produces 14.1% of the world's papers in that field, followed by Physics at 11.9%, and Molecular Biology, Chemistry, Mathematics and Microbiology each at approximately 10%,

Germany: citation impact

So far we have been analysing nations and Germany specifically in terms of publication output overall and in specific fields. The next question is: How influential are these papers? For this analysis we turn to citations – an indicator of impact and influence. Again, one cannot just look at overall numbers to make comparisons, but must analyse relative to world averages by field.
Table 6 shows that in 19 broad fields, Germany's impact less than the world average in only three. At the top are some of the fields that ranked the highest in terms of publication output, and now also rank high in terms of citation impact. At the top are Physics with a relative impact of 1.32, followed by Geosciences at 1.27, Space Science at 1.20, and Chemistry at 1.19. Interestingly, in 3 fields in which Germany's output is less than its overall average, its relative impact ranks high. These fields are Plant & Animal Science, with a relative impact of 1.24, ranking it third, Engineering at 1.18 and Ecology/Environment at 1.15.

Field	Relative impact	German impact (cites per paper)	World impact (cites per paper)
Physics	1.32	4.80	3.64
Geosciences	1.27	4.24	3.34
Plant & Animal Science	1.24	3.36	2.72
Space Science	1.20	9.24	7.72
Chemistry	1.19	4.41	3.70
Engineering	1.18	1.87	1.58
Ecology/Environment	1.15	3.59	3.12
Materials Science	1.14	2.39	2.09
Biology & Biochemistry	1.14	8.32	7.28
Microbiology	1.14	7.42	6.52
Mathematics	1.11	1.51	1.36
Immunology	1.09	10.86	9.98
Pharmacology	1.09	4.76	4.38
Neurosciences & Behavior	1.04	7.76	7.44
Molecular Biology & Genetics	1.04	13.45	12.95
Agricultural Sciences	1.03	2.22	2.16
Computer Science	0.99	1.32	1.34
Clinical Medicine	0.98	4.61	4.72
Psychology/Psychiatry	0.82	2.58	3.14

Tab. 6: Germany—citation impact by field relative to field averages. Source: ISI.

High impact papers

Now that we have analysed in which fields Germany is most prolific and most cited, it is time to look at the institutions whose papers underlie these statistics.
We prepared a database of the 200 most-cited papers per year by each of these 19 fields for the period 1998-2002. We selected BY YEAR so that the earlier papers from1998-1999, which have had a longer period to be cited, would not have an advantage over the newer papers. Because of this selection process, this analysis will be based on NUMBER of papers appearing in this highly cited papers database, rather than citations.

National comparisons

The chart below shows the percentage of highly cited papers by country, compared with each country's overall percentage of papers. As we can see, Germany has a higher percentage of papers that are highly cited compared with its overall output. Other countries whose participation in highly cited papers ranks higher than its overall percentage output are the US, UK, Netherlands, Sweden, and Switzerland. Those ranking slightly lower are France and Italy.

COUNTRY	% papers in world	% highly cited papers
USA	34.2	67.0
JAPAN	9.6	5.5
UK	9.3	14.6
GERMANY	8.8	9.1
FRANCE	6.3	6.2
ITALY	4.2	3.8
SPAIN	3.0	1.7
NETHERLANDS	2.6	3.8
SWEDEN	2.1	2.2
SWITZERLAND	1.9	3.5
BELGIUM	1.4	1.4

Tab. 7: Percentage of highly cited paper by country. Source: ISI.

Germany—high impact papers

Within this highly cited database of papers, 1998-2002, with 1000 papers per field, Germany's main representation is shown in the following chart. Not surprisingly, in each of these fields Germany's citation impact ranks above the world average by field.

Field	Papers	Field	Papers
Space Science	187	Immunology	119
Geosciences	150	Plant & Animal	113
Physics	146	Chemistry	109
Materials Science	127	Neuroscience	103

Tab. 8: Germany. Number of highly cited papers by field.

Germany--institutional comparison

We have been looking at Germany overall in terms of publication output and citation impact, in order to determine in which fields Germany is showing the greatest concentration, and in which fields Germany is showing the greatest influence and impact. But of course, it is not Germany but its institutions and scientists that are behind these statistics. We conclude this presentation with a list of those institutions who have contributed 25 or more papers to that group of Highly Cited Papers from 1998-2002. Note that these are raw statistics based on the primary institutional name.

Institution	Papers		
Technical University of Munich	81	Technical University of Berlin	36
University of Munich	78	German Cancer Research Ctr	33
University of Kiel	65	Ruhr University of Bochum	33
University of Freiburg	61	RWTH Aachen	31
University of Hamburg	60	MPI Chemistry	29
University of Heidelberg	56	MPI Colloids & Interfaces	29
University of Tubingen	51	University of Karlsruhe	28
University of Mainz	49	University of Bayreuth	27
MPI Extraterrestrial Physics	46	University of Dusseldorf	27
University of Frankfurt	45	University of Munster	27
MPI Astrophysics	43	DESY	26
Humboldt University	41	Research Centre Juelich	26
University of Bonn	40	MPI Molec Cell Biol & Gen.	25
University Erlangen Nurnberg	37	MPI Psychiatry	25
University of Wurzburg	37		

Tab. 9: Institutions contributing 25 or more highly cited papers, 1998-2002.

For most of these institutions, the number of highly cited papers are scattered among three or more fields. For others, there was a specific field concentration, particularly the Max Planck Institutes of Extraterrestrial Physics and Astrophysics, whose papers were primarily in the field of Physics; and the Max Planck Institute of Chemistry was in the field of Geosciences.

Conclusion

Preparing these lists of top nations and institutions, and German performance overall and by field, is in a sense the relatively easy part. The harder part is the analysis. What does this all mean? As mentioned earlier in discussion of uses and abuses of ISI data – quantitative analysis using publication and citation statistics is not mean to supplant expert review or to be the only measure of research performance. Multiple measures must be used for a complete, accurate picture. These statistics are a guideline and can alert analysts to anomalies that may require further investigation. One must also ideally analyse the underlying papers to determine what makes one institution's or scientist's papers more highly cited than another's. These data also require review by those who are intimately familiar with the research environment and system of a nation, institution or scientific field.

It is hoped that this presentation has provided some interesting statistics and rankings, and some useful examples of the many ways in which the ISI data can be used for evaluating research. I welcome any comments, questions or insights concerning these data.

Application Studies

Bibliometric mapping of selected research fields

H. Peter Ohly

Introduction: value adding for scientific reviews

State-of-the-art reports can be seen as specialised overviews, summaries and evaluations of the research situation in selected scientific fields. Such reports were published by the Social Science Information Centre Bonn in the fields of Nutrition Sociology (Bayer et al. 1999), Migration (Santel & Schock 2001), and Elderly Workers (Herfurth et al. 2003).[1] Each report was based on extensive discourse between scientists of different schools together with documentation specialists. It proved very helpful in introducing into this discourse scientometric analyses of relevant literature data bases, i.e.: not only listing bibliographic information but also aggregating and visually highlighting the large quantity of bibliographic data. Herewith, new topics, unknown scientists, undiscovered information sources, or unexpected dynamics and gaps of scientific parts can be taken into consideration.

Distributed retrieval and cumulation

If as basic information source a literature search is performed, we should have in mind that often there is a variety of data bases available. Taking the search outcome of more than only one data base prevents less relevant literature from being lost while guarantying enough diversity. On the other hand, data cleaning will be much more extensive. Enough recall (perform test searches!) and precise query adaption (make test analyses!) should be cared for. By cumulating the results, skewness of single database retrieval can be avoided and the data basis will be more representative - though never complete nor representative in a statistical meaning. Checking for duplicates (13 % of the literature search in four data bases were duplicates in the field of Elderly Workers) and detecting incorrect versions will be time-consuming but necessary. From this point on no exact interpretation with regard to the data bases can be given, as the selection might be data base specific (Fig. 1). Who ever tries to incorporate all information distributed over different data bases (e.g. different keywording) should also consider bringing in quantifiers for kind of publication, size of literature, number of authors, kind of citations etc., or rather leaving it out. A knowledge unit for the analysis should be comparable with the unit the user takes into account and that is usually a title and not the content of the literature with all its implicit background (A short summary can be more informative than a big monograph).

[1] If not indicated the examples are taken from this field.

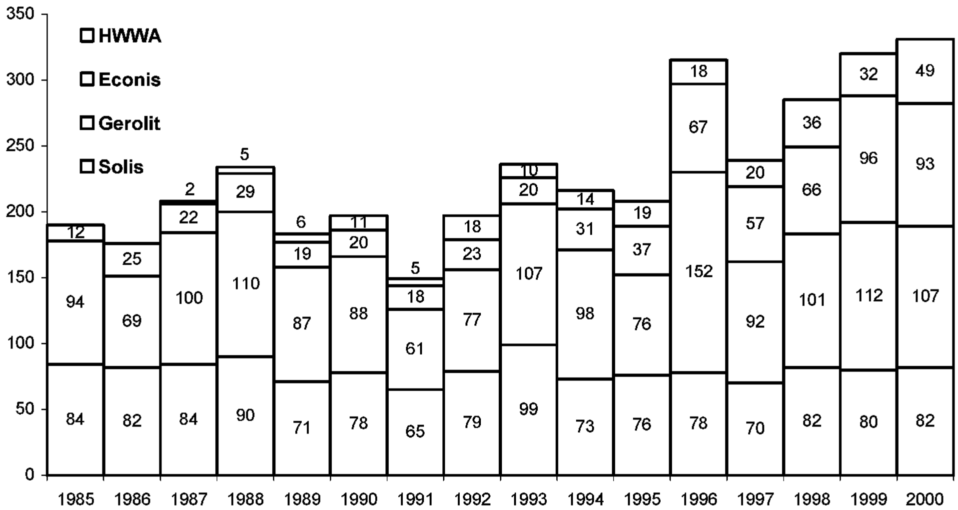

Fig. 1: Distribution of literature by year and data base.

Multivariate structures

Frequencies give meaning to single subjects only in comparison to other subjects in the investigated field. Nevertheless internal dependencies might occur (e.g. multiple authors), and these should be considered as a team. The frequencies of co-occurrences are the means of plotting associations of subjects into an at least 2-dimensional co-operation space. It proves that already very low thresholds (here: 7 publications and more) for the association frequencies reduce the great number of authors in the data basis very quickly to only some components of connected persons and others that are productive but standing alone (Fig. 2). Co-authorship will reveal clusters of persons that work together and should cognitively be influenced by these ties. The quality of willingness to co-author seems to be more important than absolute quantity. By regarding the network diagram, we can easily see that some of the authors have central positions within their networks and some have key positions (In Fig. 2: Nägele, Kohli, Schmähl) as a bridge to other author groups (In Fig. 2: Voges, Jacobs, Guillemard).

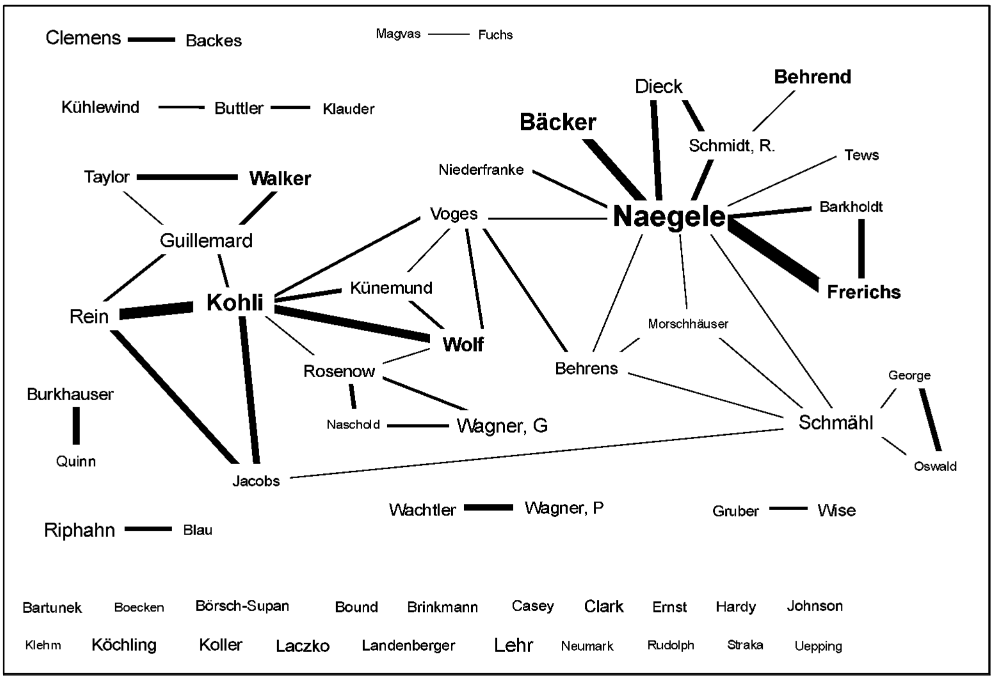

Fig. 2: Co-authorship network 1985-2000.

Concepts can also be regarded as networks if we use the co-occurrence of descriptors (Fig. 3). Equivalent terms are then not direct neighbours but are tied together by a third term with which they are often used (e.g. *Older Worker* and *Older Employee* with *OLD PEOPLE*). Instead of using co-occurrences as linking measure, it seems more appropriate to use a kind of association coefficient (here: Jaccard-coefficient) that describes the relative importance of that connection. Word clusters can have different meanings: indexing language peculiarities, semantic nearness, research thesis. Non-tied concepts are more general in a sense that they are not associated at all or to all others in the field of interest. Introducing more general categories (derived from the descriptors; written in capital letters) into the semantic web will result in more structure, so that descriptors with minor frequencies have a chance to be expressed by them. On the other hand, working only with categories without more specific concepts might be too flat.

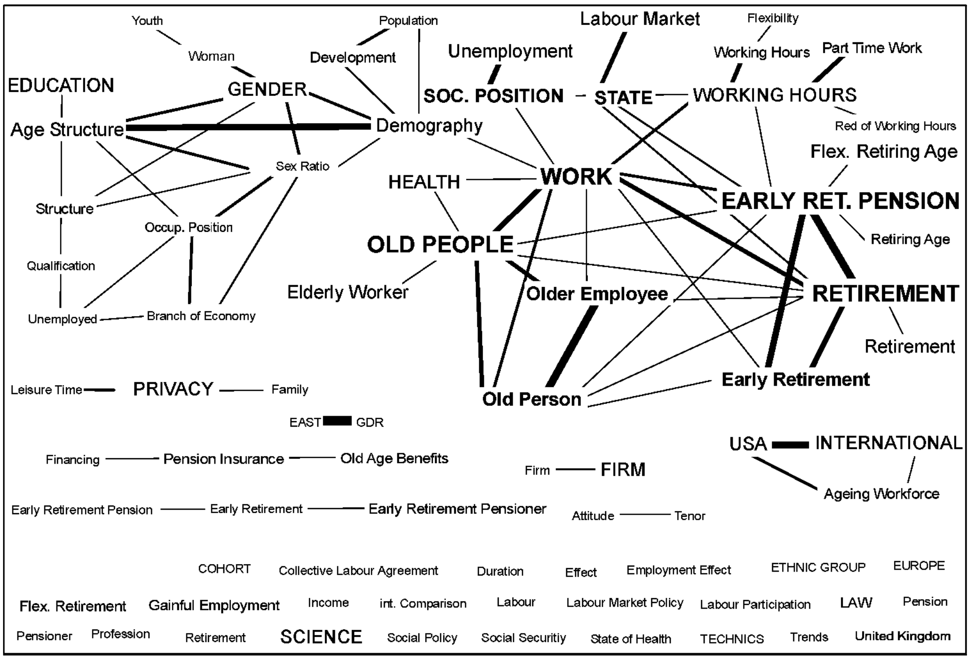

Fig. 3: Concept network (descriptors and classifications) 1985-1988.

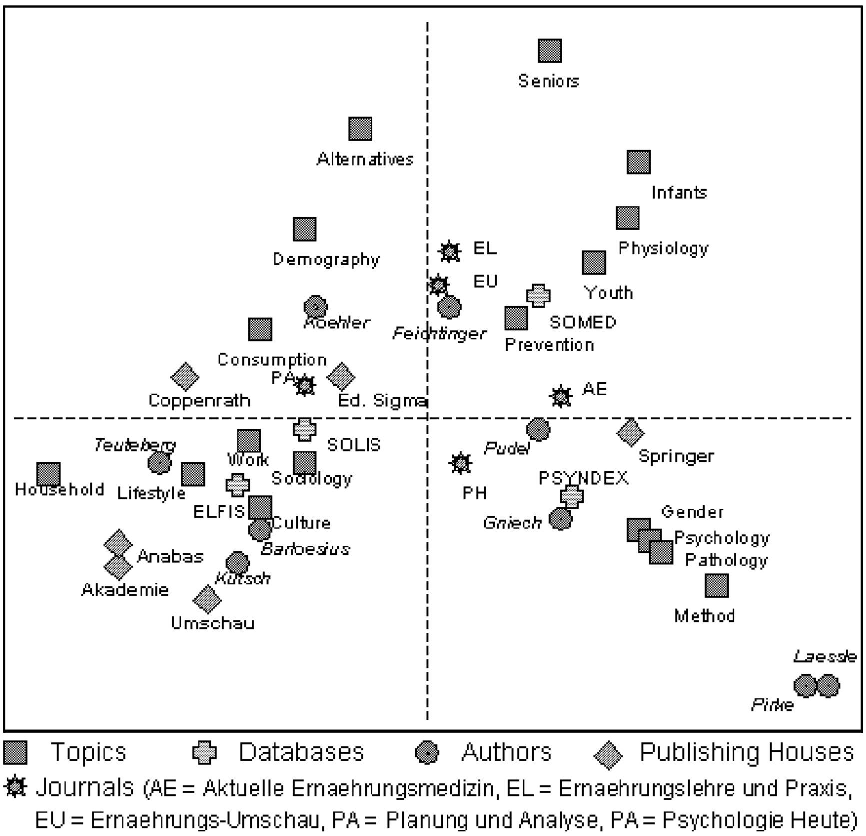

Fig. 4: Correspondence analysis of topics with centroids of authors, publishing houses, data bases and journals (example: Nutrition Sociology).

Analysing the structure of key subjects such as authors, publishers, journals, or even data bases together with the semantic space will lead to multidimensional scaling or correspondence analysis (Ohly 2000). A simple correspondence analysis of categories (derived from title keywords) with plots of centroids of other subjects for the field of Nutrition Sociology showed the semantic closeness of these subjects without having necessarily direct ties among them (Fig. 4). E.g. the authors Kutsch and Barlösius are located in the same socio-economic semantic subspace (defined by the axes) though never having published together.

Author	Period				Total
	1985-1988	1989-1992	1993-1996	1997-2000	
Dieck, M.	14	0	1	2	17
Laczko, F.	5	6	0	0	11
Kuehlewind, G.	5	6	1	0	12
Wolf, J.	10	6	6	0	22
Schmidt, R.	9	1	3	2	15
Voges, W.	2	6	2	0	10
Kohli, M.	13	18	12	2	45
Buttler, F.	1	8	2	0	11
Rein, M.	2	10	2	1	15
Wagner, G.	5	8	5	3	21
Backes, G	3	2	4	2	11
Burkhauser, R.	2	4	6	1	13
Baecker, G.	7	8	15	4	34
Lehr, U.	4	6	5	4	19
Guillemard, A.	1	9	7	2	19
Schmaehl, W.	5	4	3	6	18
Naegele, G.	22	13	26	22	83
Clemens, W.	3	3	3	6	15
Wise, D.	0	5	2	4	11
Rosenow, J.	1	3	6	4	14
Clark, R.	1	3	3	5	12
Kuenemund, H.	1	1	5	3	10
Behrens, J.	0	3	3	5	11
Behrend, C.	3	1	5	11	20
Walker, A.	0	4	7	11	22
Koechling, A.	0	1	5	5	11
Wachtler, G.	0	0	6	5	11
Wagner, P.	0	0	6	6	12
Koller, B.	0	1	3	6	10
Taylor, P.	0	0	5	5	10
Frerichs, F.	0	0	9	18	27
Riphahn, R.	0	0	1	14	15

Fig: 5: Distribution of authorship over time periods (sorted by a concentration measure; shaded by distance from mean to minimum/maximum).

Dynamical aspects

Topic	Period				Total
	1985-1988	1989-1992	1993-1996	1997-2000	
ETHNIC GROUP	37	48	39	28	152
TECHNICS	21	27	23	20	91
RETIREMENT	393	311	375	385	1464
PRIVACY	85	62	89	80	316
WORKING HOURS	129	87	98	135	449
GENDER	109	138	160	121	528
EARLY RETIREMENT	361	269	346	394	1370
INTERNATIONAL	118	111	117	143	489
SOC. POSITION	181	147	222	219	769
WORK	613	576	747	820	2756
EDUCATION	118	141	171	165	595
HEALTH	146	115	168	191	620
DEMOGRAPHY	136	178	212	206	732
OLD PEOPLE	405	404	645	644	2098
SCIENCE	114	147	208	202	671
STATE	224	198	283	380	1085
EAST	26	81	117	64	288
COHORT	36	19	38	59	152
LAW	57	79	80	141	357
FIRM	86	82	166	230	564
EUROPE	22	25	56	64	167
PUBLIC SERVICE	5	2	3	18	28

Fig. 6: Distribution of topics (classification) over time periods (sorted by a concentration measure; shaded by under/over 5% distance from mean).

Science is not stable: it changes personnel and foci within the course of time. Though publications can not perfectly represent this - as there is always a time lag to the underlying research - we should try to show the authorships differentiated for certain periods (Fig. 5). It can easily be seen, who is leaving (most of his works were published in the first period) and who has recently entered (most published in the last period) this scientific playground. Other authors will be turned out as constant players (bold names in Fig. 5: publishing always within half distance from their mean frequency) – for statistical and social reasons often the more productive.

Even concepts have a kind of career - although difficult to be expressed by descriptors of a controlled indexing language. Brought categories might never vanish though some ups and downs are always present (Fig. 6). If a 5 % deviation from mean is taken as threshold only some topics (in bold letters) seem to be constant in time. Changing constellations of descriptor co-occurrences often have a real background as can be shown by the shift of *EDUCATION* from demographic context in 1985-1988 (Fig. 3) to private activities in 1997-2000 (Fig. 7). Other concepts are changing from a specific role to a general role (*WORKING HOURS*) or are present only in some periods (*PRIVACY*) – depending on the threshold (here: the most frequent 80 terms).

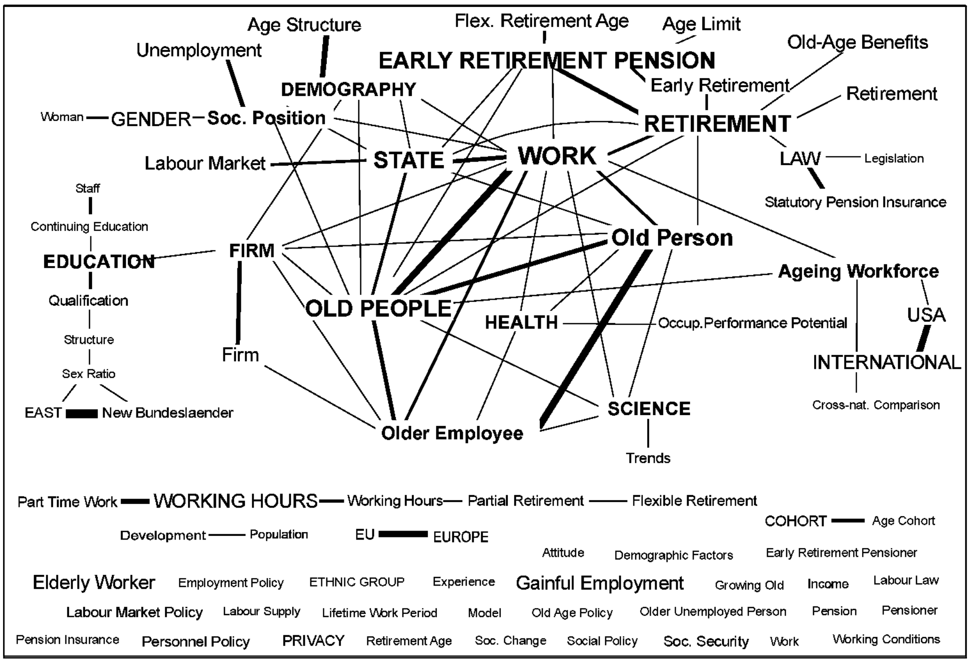

Fig. 7: Concept network 1997-2000 (descriptors and classifications).

Final considerations

Scientometric analyses of literature outcome are worthwhile for the overview of specialised fields – at least if statements on the scientific system and communication are aimed at. But there might be a different chance in highlighting certain fields. New heterogeneous fields can easily be described by very rough patterns. Established fields must be described in more detail to find specific structures and developments. Also multidisciplinary material might lead to simple discipline dependent representations and otherwise cause confusions of concepts. Nevertheless, data should be cumulated from different sources to get a less biased bibliographic corpus. Mere inspections of frequencies might be misleading as internal stratification and structures are disguised. Multivariate analysis helps to find grouped subjects in the data basis. Another way to clarify frequencies are time comparisons. Nevertheless quantity measures must be adopted to the specific research thesis, e.g. individual actors are not quantifiable such as concepts or other more timeless subjects (Ohly 2003).

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Bibliometric indicators and their use for research evaluation: an analysis of highly productive biomedical teams

Frank Havemann

Introduction

One feature of modern science is that researchers collaborate in teams. Research teams appeared sporadically already during the 19th century; now they are so common that on various occasions scholars in science studies have stipulated using teams as the basic units of investigation instead of individual researchers. Quantitative analyses of teams are often tedious because their memberships fluctuate and their boundaries tend to be fuzzy. An invariant of many teams is the dominance of one highly productive researcher. Teams need stars, but stars also need teams: in many fields researchers without teams cannot keep step with the development at the research front.

Since the beginning of modern times science has been in a state of permanent change. Now it has entered a period, which many observers characterise as a radical transformation (cf. Havemann 2002 and references therein). Ziman (1994) views science reaching a "steady state" after centuries of exponential growth. Gibbons et al. (1994) see a "Mode 2" of scientific knowledge production arising in addition to the more traditional academic "Mode 1". Etzkowitz and Leydesdorff (1995) have suggested a "triple helix" model, which is designed to map the new relations of university, government and industry in research and development. Scientometrics is challenged to prove empirically theses regarding the transformation of the science system (cf. Hicks & Katz 1996b). I have aggregated bibliometric indicators of German biomedical research, which can be useful when the following theses are discussed:

1. Successful research teams have to be larger now than some decades ago.
2. Their collaboration with partners from abroad, and from other sectors of national science systems has increased.
3. Highly productive groups can nowadays be found less often at universities than some decades ago.

There is a general trend towards a more competitive granting of funds for research, which can be seen as one feature of the undergoing transformation of the science system (Ziman 1994, Cozzens 1995). The frequency of external evaluations of projects, institutes, and research programmes has increased dramatically. Highly qualified researchers spend a lot of time on evaluation. Bibliometric methods (if used properly) can help to make research evaluation more efficient and objective–that is the hope.

The secular tendency toward more collaboration in science has lead to a situation where research results often cannot be attributed clearly to only one single researcher, to one team, or to one institute. Therefore Hicks and Katz (1996a) demand a new general definition of evaluative methods. Larédo (2001) appreciates that the European Commission has given an adequate answer to this situation with a research policy that accounts for the collective character of modern science. In my opinion one method to make bibliometric indicators used in evaluation more adequate to the distributed knowledge production is counting not whole publications or citations but giving all contributing researchers, groups or institutes only a fraction of a credit point for them. This fractional counting method is used extensively by Computer Horizons Inc. for the Science & Engineering Indicators[1] and also by the Observatoire des Sciences et des Techniques (OST, cf. Zitt & Teixeira 1996) but seldom used in evaluation. Exceptions have been communicated by Vinkler (2000), by Colman et al. (2000, 56) and by Frohlich and Rester (2001, 706).
Many studies of groups and their publication performance can be found in the literature. They cannot be reviewed here. To mention only some recent papers: Rey-Rocha et al. (2002), Bordons et al. (1996), and Kretschmer (1987).

Method and data

I confined the analysis to two samples of highly productive biomedical researchers and their teams, which were affiliated at an institution in the western states of Germany. I have selected those team leaders, which mostly contributed to research papers in biomedical core journals in the two five-year periods 1980 – 1984 and 1994 – 1998, respectively. I have chosen biomedicine, because this is a discipline where a strong tendency towards more collaboration can be observed (Havemann 2001a). So in this field significant changes in the last two decades of the 20th century could be expected. I have confined the analysis to teams working in the western part of Germany (the former Federal Republic of Germany, West-Berlin excluded) because the results should at least as possible be affected by the disturbances of the science landscape following the German unification in 1990. I have limited the number of team leaders to some top performers because accurate bibliometric analyses of teams are tedious.
The analysis is based on rankings of highly productive researchers obtained from all biomedical journals indexed in the Science Citation Index (SCI). Only the SCI document types *articles*, *letters*, and *notes* (not to *reviews* et cetera) have been taken into account, because only those documents are published to communicate new research findings. In the two periods mentioned above West German biomedics contributed, respectively, to 11,460 and 30,297 research papers (Havemann 2001b). This huge increase was achieved partly by doing more work in collaboration with

[1] <http://www.nsf.gov/sbe/srs/seind>.

colleagues working outside West Germany, but surely also with West-German colleagues working mainly outside biomedicine. The mean number of authors rose from 3.0±1.7 in the early eighties to 4.6±3.1 at the end of the nineties (Havemann 2001b). The rankings were therefore not based on normally counted paper numbers. This would have favoured those stars, which were outriders of this trend toward more collaboration in research. Instead I measured their scientific productivity by estimating their contributions to their papers using the fractional counting method, i.e. each of a paper's k co-authors gets a credit of $1/k$ (cf. Egghe et al. 2000).

As Bordons et al. (1995) I define a research team as a group of those people which in a given period of three or four years do most of their work together with a highly productive researcher, the star. The authors cited choose a critical value of 2/3 of all (normally counted) papers a researcher has published in the period to consider her or him as a team member. So members of a team must not be affiliated to the same institute. This team definition seems me to be appropriate in an era where collaboration between different institutes becomes more and more common (cf. Hicks & Katz 1996a). As a consequence, a researcher can be a member of more than one team during the same period. The papers a team member has published without the star are not counted as papers of the star's team. So team members as defined here are researchers the star can convince or engage to do most of their research together with the star.

The productivity of a researcher can be characterised not only by one but by several indicators. The (normally counted) number of papers is one of them. A second one is the fractionally counted paper number that estimates his or her contribution to the papers studied, as mentioned above. Fractionally counted paper numbers of team members can be added; the sum, here denoted by f, estimates the contribution the team as a whole has given to all its n papers. If f/n = 100% the team did not collaborate with other researchers. By f^* the fraction the star contributes to his or her papers is denoted. The ratio f^*/n estimates the expectation value of the fractional credit the star can get for one paper. Therefore $c = 1 - f^*/n$ estimates the collaboration coefficient of the star's bibliography as defined by Ajiferuke et al. (1988).

Here I can present results of comprehensive studies of only five teams of stars in the early eighties, and four in the period 1994 – 1998. Further teams will be analysed in the future. This will increase the statistical significance of the results. Thus, from findings presented here only preliminary conclusions can be drawn. Their presentation may be useful, however, to discuss improvements of the methods used for the extraction of relevant bibliometric indicators of group performance. The bibliometric analyses are based on all research papers (mainly articles, but also some letters and notes) the stars together with their teams have published in the twenty-year period 1980 – 1999 in journals filed by SCI. Here I do not confine the study to biomedical journals. Thus the ranks obtained here can differ from the initial rankings because some stars have more papers in multidisciplinary journals (such as Science or Nature) than others. After downloading the star's bibliography and feeding it into a database I select from his (or her) co-authors those with research papers in this bibliography in at least three different years (after identifying synonym names). These co-authors are candidates for team membership. This selection rule excludes sporadic co-authors as well as those students, which only shortly contribute to the team's research output. To see whether the above given critical value of 2/3 of research papers published together with the star is fulfilled for a candidate I have to search for her or his papers published without the star in SCI journals during the periods of mutual collaboration. The main problem to be solved here is to distinguish homonym authors. Because the SCI does only record the initials of first names an address analysis has to be made which can be tedious especially in the cases of very common surnames and of papers with many authors where the address cannot be assigned to authors (if only the SCI and not the original paper is inspected). In some cases the CV and the publication list of a researcher published in the Internet are helpful for identifying their SCI records.

All results of team performance presented here have been obtained from studying running three-year periods. In each period members of a team are specified according to the 2/3 criterion mentioned above. Membership starts in the year the member has published the first research paper as a co-author of the star. It ends in the year of the last common paper. So we get full, two or one third memberships in the three-year periods. This procedure should be more realistic than counting a co-author for the whole period as a member but it has the disadvantage to produce edge effects at the end and at the beginning of the twenty years under consideration. With m I denote the mean number of members in the periods.

There are team members not affiliated to the stars institute or department; their share should be determined. A test exploration revealed only occasional occurrence of members from outside but quite a few cases have been found where colleagues with the same address as the star are not team members. It would be of interest to compare the lists of team members obtained by this bibliometric method with historical descriptions of teams. Both tasks have to be left to future.

Results

If we compare the top twenty of the rank list 1980 – 1984 of highly productive West-German biomedics with those 14 years later, there are 14 of 20 stars affiliated to universities in the first period, and only 7 in the second. This decrease is statistically significant. The probability that both sets of authors behave as random samples from one and the same population is less than 5 percent. Thus, the third of the hypotheses mentioned in the introduction seems to be validated, but keep in mind that ranking differences are often not statistically significant. To be at the top can partly be a result of chance. The comparison of the whole distributions of university and non-university biomedical researchers, however, would be tedious, so we must restrict the analysis on the top. At least, the result backs up the theses, that highly productive groups can nowadays be found less often at universities than some decades ago.

In the early eighties 5 of the 20 most productive biomedical researchers lead groups at institutes of the Max-Planck-Gesellschaft (MPG), in the years 1994 – 1998 this number was 7. Then three stars were at the European Molecular Biology Lab (EMBL) in Heidelberg and two at the German Collection of Micro-organisms and Cell Cultures (DSMZ) in Braunschweig. In both periods 12 of 20 top stars worked in the south of West Germany.

The other two hypotheses, regarding size and collaboration of highly productive teams cannot be validated or rejected with data of the 9 teams studied until now (Table 1 and 2). The general tendency toward more collaboration in biomedical research however is so strong that it is also observable on the level of groups and individuals. The collaboration coefficient *c* of nearly all stars is higher at the end of the 20-year period than at its beginning (Table 3). All stars start with *c* between 60 and 70 percent. Only one star ends up with a lower value (c = 52%). The increase (or decrease) of *c* is not a monotone one. In most cases the linear regression model explains less than half of the variation (Table 3, last column).

The collaboration coefficient indicates the level of co-operation of individuals. That of teams is also rising for nearly all teams. Only one team contributes more to its papers in the last period than in the first, i.e. finally it collaborates less (Table 4, last line). The trend of decreasing team contributions f/m, however, is even more affected by fluctuations than that of increasing collaboration coefficient *c*. All stars have a bigger share of papers together with colleagues working at other institutes in the last years considered than in the early eighties, but not in all cases this trend is so clear as in the case of KS starting with 1/3 institutionally co-authored papers, ending up with 93% (Table 5). Similar findings have been obtained about the subset of internationally co-authored papers (here KS started with a share of 13% and reached 46%, finally). As an example, Fig. 1 displays time series of collaboration data of one star (RH, see also Fig. 2).

star	inst. sector	year of retiremen t	period of max(*f**)	max(*f**)	rank of max(*f**)	*n* in same period	rank of *n*	*c* (%) in same period (range all periods)
KW	gov.	?	1980-82	33.7	1	101	2	67 (67-75)
FL	univ.	1990	1980-82	15.3	8	42	8	63 (63-82)
JK	gov.	2001	1981-83	24.5	2	72	3	66 (58-77)
KS	univ.	2004	1982-84	12.4	9	42	9	71 (67-83)
GB	gov.	1986	1987-89	18.8	5	61	6	69 (64-70)
ES	gov.	2009	1992-94	17.4	7	62	5	72 (68-77)
DM	gov.	?	1995-97	22.6	3	44	7	49 (49-65)
RH	gov.	2002	1995-97	18.9	4	105	1	82 (60-84)
HS	univ.	2007	1996-98	18.2	6	67	4	73 (60-74)

Note: n - normally counted number of papers, $c = 1 - f^*/n$ is the collaboration coefficient. The first five stars are on the top of ranking in 1980 – 1984, the last four in 1994 – 1998. Retirement years are those where stars are 65 years old.

Tab. 1: Data of stars ordered by the period of maximum fractionally counted paper number f^*.

team	period of max(*f*)	max(*f*)	rank of max(*f*)	*n* in same period	rank of *n*	*f/n* (%) in same period	*m* in same period (range all periods)
KW	1980-82	70.8	1	101	2	70	13 (10-17)
FL	1980-82	34.3	6	42	9	82	18 (4-18)
JK	1981-83	56.8	2	72	3	79	13 (10-13)
KS	1991-93	30.3	8	45	7	67	17 (6-19)
GB	1987-89	41.4	4	61	6	68	13 (12-18)
ES	1993-95	32.5	7	64	5	51	11 (6-11)
DM	1995-97	28.3	9	44	8	64	6 (3-7)
RH	1995-97	45.2	3	105	1	43	36 (3-36)
HS	1996-98	39.3	5	67	4	59	13 (4-14)

Note: n - normally counted number of papers, f - fractionally counted number of papers, m - rounded mean number of members.

Tab. 2: Data of teams (same order as in Tab. 1).

Tab. 2: Data of teams (same order as in Tab. 1).

star	*c* (%) 1980-83	*c* (%) 1997-99	*c* (%) range all periods	*c* (%) p.a. (slope of regression line)	R^2 (correl. coeff.)
KW	67	71	67 - 75	0.4	0.36
FL	63	82	63 - 82	1.7	0.36
JK	63	73	58 - 77	0.8	0.36
KS	67	83	67 - 83	1.0	0.61
GB	64		64 - 70	–	–
ES	70	77	68 -77	0.3	0.22
DM	61	52	49 - 65	– 0.6	0.21
RH	60	83	60 - 84	1.5	0.64
HS	67	74	60 - 74	0.5	0.30

Note: $c = 1 - f^*/n$, linear regression done with yearly values of *c*.

Tab. 3: Collaboration coefficients *c* of stars (same order as in Tab. 1).

Team	*f/n* (%) 1980-83	*f/n* (%) 1997-99	min(*f/3m)*	corresp. Period	max(*f/3m)*	corresp. period	range of *f*/f* (%) all periods
KW	70	61	0.39 = 15.1/38	1994-96	1.86 = 70.8/38	1980-82	41 - 54
FL	82	30	0.15 = 1.8/12	1997-99	0.67 = 32.2/48	1982-84	40 - 59
JK	74	70	0.49 = 14.7/30	1989-91	1.54 = 56.8/37	1981-83	33 - 57
KS	57	26	0.29 = 8.6/30	1995-97	0.85 = 17.9/21	1986-87	34 - 66
GB	69	–	0.69 = 32.6/47	1984-86	1.09 = 41.4/38	1987-89	44 - 51
ES	49	37	0.59 = 11.7/20	1984-86	1.21 = 30.2/25	1995-97	47 - 64
DM	68	57	0.61 = 12.8/21	1983-85	2.13 = 21.3/10	1997-99	56 - 89
RH	56	40	0,31= 34.3/109	1994-96	0.71 = 7.1/10	1981-83	39 - 79
HS	49	55	0.62 = 26.2/42	1994-96	1.35 = 20.3/15	1981-83	46 - 72

Note: *n* - normally counted number of papers, *f* - fractionally counted number of papers of all team members including the star, f^* - fractionally counted number of papers of star, *m* - mean number of members in 3-year period (3*m* - person years).

Tab. 4: Collaboration of teams, papers per person year, and star's contribution f^*/f (same order as in Tab. 1).

star	$n(a > 1)/n$ (%) 1980-83	$n(a > 1)/n$ (%) 1997-99	n 1980-83	n 1997-99	$n(a_f > 0)/n$ (%) 1980-83	$n(a_f > 0)/n$ (%) 1997-99
KW	44	66	101	32	23	31
FL	5	83	42	6	2	17
JK	33	69	60	32	30	66
KS	33	93	30	28	13	46
GB	58	–	48	–	35	–
ES	71	73	24	60	38	50
DM	58	62	19	37	32	59
RH	44	79	16	107	25	36
HS	33	65	21	57	10	26

Note: n - normally counted number of papers, a - number of addresses, a_f - number of foreign addresses.

Tab. 5: Institutional and international collaboration of stars.

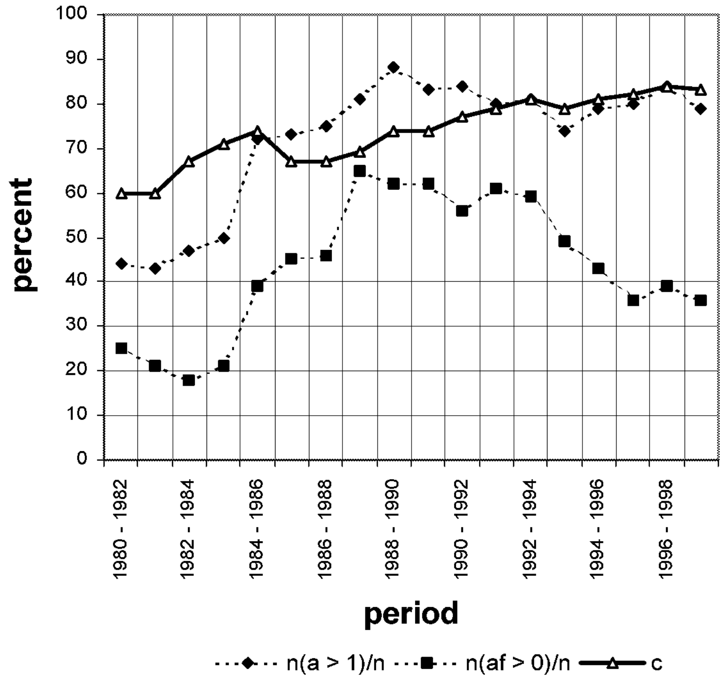

Fig. 1: Percentage of papers of star RH written in institutional (number of addresses a > 1) and in international collaboration (number of foreign addresses af > 0) and collaboration coefficient in running 3-year periods.

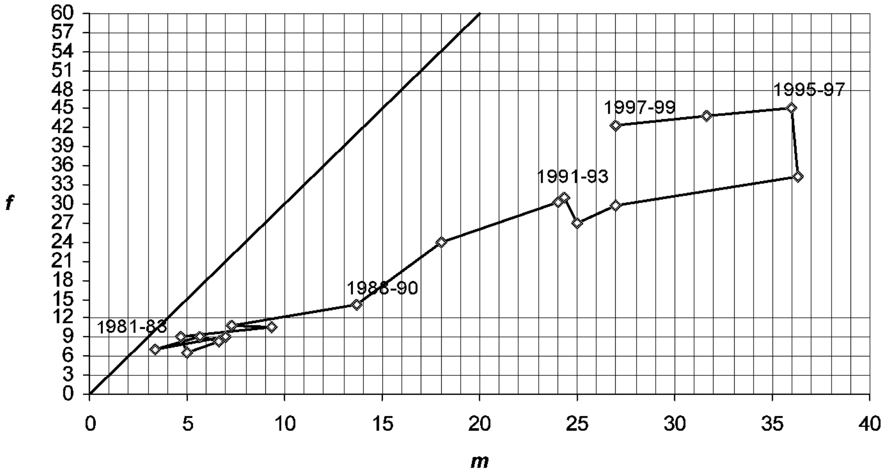

Fig. 2: Scatter diagram: mean number of members *m* and fractional score *f* of RH's team in running 3-year periods. The straight line displays a productivity of one paper per member per year.

In general, all bibliometric indicators of teams considered here reflect different research situations of the teams in different phases of their development and cannot be understood in detail without insider knowledge. Some groups get smaller in the years before and after the star's retirement (FL, KS). Two teams show a dramatic decrease of fractional score *f* despite stable member numbers (JK, KW). RH started with a small group with about 4 to 8 members producing relatively few papers until he together with two co-workers got the Nobel prize in 1989. After this he was able to engage many collaborators. The team grew to extreme size (maximum 36 members, Fig. 2).

I found huge differences between different periods regarding the ratio f/m that indicates publication efficiency of teams. The number $f/3m$ gives the yearly output per member (Table 4). Note, however, that stars contribute a big share f^*/f to the fractional score of their teams (Table 4, last column).

Discussion

The results presented here can be affected by differences in publication behaviour. Suppose a star tends to sign as a co-author only if he has done some work or writing for the paper. Another one could feel that he should also be an author if he gave the idea, the intellectual background or the money to a project. The first star would have smaller scores than the second one. Member numbers could also differ. This must be taken into consideration when looking on the data presented here. Time series analysis of a team is also affected if the publication behaviour of its leader changes with time. So, studies of this behaviour and its changes would be worth to be done. Within the framework of this study the differences can be taken into account by also analysing the papers the team members publish without the star. This has to be left to future. A question to be answered will be how to treat researchers who are members in more than one team.

The main result regarding evaluative bibliometrics is, that the teams' performance should be measured with fractionally counted publications, because there is a strong tendency towards collaboration with other groups. Therefore teams tend to contribute less and less to their papers. This casts some doubts on the usefulness of citation data for measuring a group's impact within its scientific community. The citation numbers of published results obtained together with other groups should be shared between all contributors, i.e. as papers citations should be counted fractionally.

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Webmetrics

Measuring scholarly communication on the web

Mike Thelwall

Introduction

The web has changed the face of scholarly publishing. Journals are now often available in both print and electronic form, with both usually requiring a subscription for access. In addition, researchers can use the web for a wide range of information seeking, from publishers' digital libraries to meta-indexes such a the ISI Web of Knowledge, and the vast quantity of less formal online publishing. Both producers and consumers of research can also participate in informal publishing, including personal web pages, course pages, and research group pages. In line with these changes come new challenges for researchers and for those who study or catalogue research: to ensure that mechanisms developed for print media are adapted or replaced to cope with change, and to exploit any new opportunities that have arisen.

A key task for researchers, librarians, research managers and funders is to evaluate the importance of bodies of research, a very difficult task. A second task, mostly of interest to researchers and research managers is to understand the research process itself, including patterns of collaboration. Traditionally, evaluative bibliometrics has addressed the first issue and relational bibliometrics the second, primarily using citation information from databases of journal articles. In the era of the web a logical question to ask is whether web publications can be exploited in any way to aid traditional evaluative and relational bibliometrics. In other words, two important questions are as follows:

1. Can information from the web be used to help evaluate the importance of bodies of research?
2. Can information from the web be used to reveal patterns of online communication that will help understand the research process.

Before addressing these questions it will be useful to give some background information about citation analysis bibliometrics. The underlying theory of citation analysis is Merton's (Merton 1973) belief that references in journal articles tend to show cognitive connections, the citing article typically having used the results of the cited article. Based upon this (simplified) idea, an article that has been cited many times is important because much subsequent work has needed it. An article that has not been cited may well be irrelevant to progress the overall scholarly knowledge base. Scholars in some countries routinely report citation counts of their articles as evidence for promotion decisions or research funding applications. Moreover, journals can be ranked by the average citation counts of their articles (e.g. the

Institute for Scientific Information Journal Impact Factor). Whole departments or universities are also sometimes ranked using citation information.

In fact Merton's theory has been recognised as being far too simple. Citations are made for many reasons that are unrelated to the importance of the cited work, for example, to refute it, to show that other researchers are working in the same area, or because the author is personally known (Borgman & Furner 2002). Nevertheless, numerous studies have shown that citation counting is still a valuable exercise, but care should be taken in interpreting results and avoiding known pitfalls (e.g. disciplinary differences in citations mean that researchers in different areas should not be compared).

A number of researchers made the connection between citations and web hyperlinks and suggested that counting the number of links to a web page (or a set of web pages) could provide a useful indicator of online impact (Almind & Ingwersen 1997, Rodríguez Gairín 1997). A web page that many others linked to would surely be more important that one that was apparently ignored. The online impact or web impact of one or more pages could therefore be estimated through inlink counts. Since many scholars, departments and universities publish extensively on the web, this opened the door to a new type of bibliometric study. The challenge was to assess how well hyperlinks could live up to expectations. Could link counts yield useful information about research or would they be found wanting? In this article we will outline methods used to collect and analyse data and then review a series of published results.

Data collection methods

To obtain hyperlink counts there are essentially two main alternatives: a personal crawler and a commercial search engine.

Early webometrics research tended to use commercial search engines for link count data. AltaVista was the most common choice, but AlltheWeb has also been used. AltaVista's Advanced Search feature allows users to execute a search for link pages rather than the standard key word search. For example, to find out how many pages at the University of Wolverhampton (www.wlv.ac.uk) link to Jülich Research Centre (www.fz-juelich.de) the AltaVista command is:

link:fz-juelich.de AND host:wlv.ac.uk

This should give a list of web pages in the Wolverhampton University Website (which all have domain names ending in wlv.ac.uk) that contain at least one hyperlink to a page in the Jülich Research Centre Website (which have domain names ending in juelich.de). This search yielded zero results, suggesting that no such links exist.

Note: The results only cover pages indexed by AltaVista and so there may be many links in the Wolverhampton site, but in pages that have not been found.

Another example serves to illustrate a more powerful use of the same commands. In the UK, all universities (and some other education and research organisations) have domains ending in ac.uk. As a result one command can search for all links to Jülich Research Centre from all these organisations:

link:fz-juelich.de AND host:ac.uk

This produced "About 68" results (Figures 1-3). As an example, the first one was from the Job Submission Description Language Working Group, hosted in Edinburgh University, Scotland (http://www.epcc.ed.ac.uk/~ali/WORK/GGF/JSDL-WG/) linking to a Scheduling Dictionary Working Group page, a multi-institution group (http://www.fz-juelich.de/zam/RD/coop/ggf/sd-wg.html).

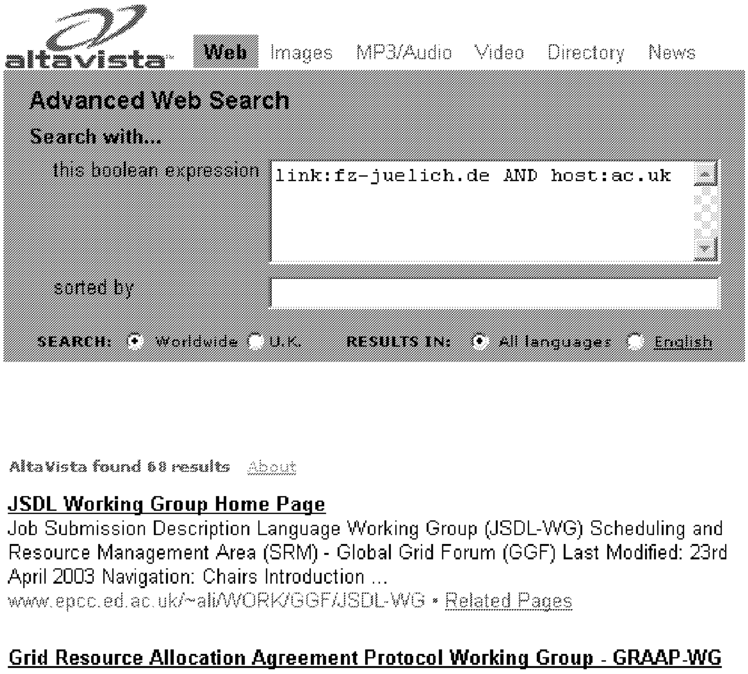

Fig. 1: An AltaVista search results page (top half).

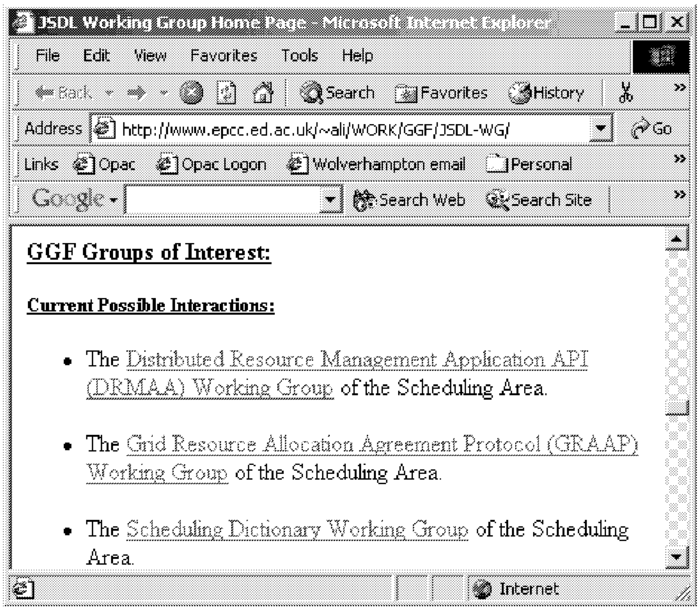

Fig. 2: The source of the first link found by AltaVista.

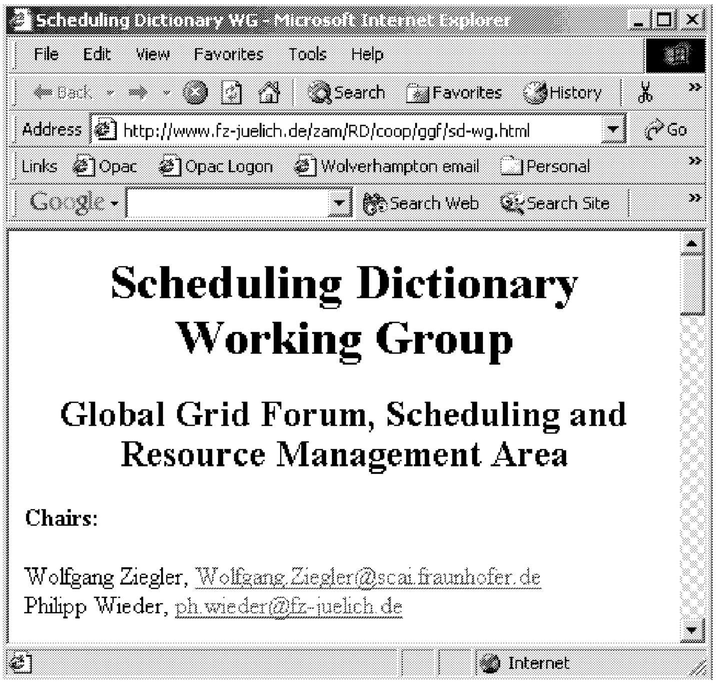

Fig. 3: The target of the first link found by AltaVista.

Note: Some of the results may be incorrect for two reasons. First, the link: command matches any occurrence in the hyperlink and not just the domain name, so in the (unlikely) event that a UK university linked to a URL such as www.a.com/fz-julich.de/info.html then this would be recorded as a match. Second, the host: command matches any occurrence in the domain name, so in the (unlikely) event that a non-UK academic domain name included ac.uk and linked to fz-juelich.de then it would be a false match.

Commercial search engines such as AltaVista are an attractive data source because they are free and cover hundreds of millions of pages. They are not ideal, however, because they do not publish detailed information about their coverage and crawling strategy.

Early studies showed that search engine results could be unreliable. In particular, the counts of matching pages could be inaccurate and the matching page sets could contain mistakes (Rousseau 1997, Bar-Ilan 1999, Mettrop & Nieuwenhuysen 2001). Rousseau suggested the use of averaging multiple identical queries to minimise the effect of fluctuations in results. AltaVista seems to have become relatively stable since 2001 (Thelwall 2001a, Vaughan & Thelwall 2003) and so this no longer seems necessary. Nevertheless, researchers should take care to check the accuracy of the results.

Personal crawlers are a more inherently scientific tool because they are more fully under the control of the researcher. These are computer programmes that can be instructed to download websites so that their links can be extracted. The disadvantages of a personal crawler are: more effort and resources are required for data collection; and potential coverage is more limited because it would be impractical for most researchers to manage the crawling of thousands of websites. A free link crawler and tools is available at http://cybermetrics.wlv.ac.uk/socscibot/ and there are many other general purpose web crawlers freely available on the web.

Associations with research productivity

When a new data source is discovered, such as link counts, it is important to use a variety of techniques to assess whether the values have any meaning, and, if so, how they should be interpreted (Oppenheim 2000). A logical test for counts of links to research organisations, such as universities, is for a relationship with existing research measures. Early results in this regard were negative (Smith 1999, Thelwall 2000, Thomas & Willett 2000), but then one study found a significant result. The scope of this research was a set of 25 UK universities and for each one the number of links to it from the other 24 universities was counted (Thelwall 2001b). These link counts divided by faculty numbers correlated significantly with the research ratings of the universities: 'better' universities tended to attract more links per researcher.

Subsequent research confirmed this finding on larger scale studies in the UK (Thelwall 2002a), Taiwan (Thelwall & Tang 2003) and Australia (Smith & Thelwall 2002). A study of mainland China gave inconclusive results, however (Thelwall & Tang 2003). In summary, it seems likely that, at least in the richer nations, universities that conduct more and better research will attract more links from other universities in the country (and internationally (Thelwall 2002b). This does *not* imply that links are created to link to research or as a result of research, only that link creation is related to research, perhaps very indirectly.

Motivation studies

In order to find out why link counts correlate with university research, link pages have been randomly sampled to identify potential creation reasons for individual links. The results of a classification of a sample of 412 links between UK university websites (Wilkinson et al. 2003) were that whilst over 90% appeared to be created for reasons connected with scholarly activity, less than 1% directly targeted online copies of journal articles. Links typically occurred in the context of teaching pages or general research information pages, typically owned by individuals, research groups or departments.

A consequence of this finding is that hyperlinks should not be regarded as direct analogies of citations: they represent a range of *informal* types of scholarly communication. A more in-depth analysis of inter-university linking revealed that the major cause of high inlink counts for universities with higher research productivity was the production of more web content, rather than the quality of the content produced (Thelwall 2004). In other words, more productive researchers tend to publish more on the web, but what they do publish does not individually attract significantly more links.

Disciplinary research

The above reported findings all concerned entire university websites. In 2000, Thomas and Willett[1] investigated library and Information Science Schools in the UK, opening up a disciplinary avenue of research. No evidence was found for a correlation with research, but later studies found significant correlations for UK Computer Science departments (Li et al. 2003), US and Canadian Library and Information Science departments (combined) (Chu et al. 2002) and US Chemistry and Psychology departments (Tang & Thelwall 2003). The trends found were not as strong as for whole universities, probably because of the smaller size of the websites covered.

[1] Thelwall & Harries 2004, to appear). IBID.

Journal websites

Perhaps the most logical question for a bibliometrician to ask about hyperlinks is whether the number of links to a journal website correlates with the number of citations to its articles. For example, does the Journal Impact Factor of the Institute for Scientific Information correlate with hyperlink counts? The first answers to this question were negative (Smith 1999), but two subsequent positive results can be reported.

Vaughan and Hysen (2002) discovered that counts of links to Library and Information Science journal websites correlated significantly with Journal Impact Factors. The same was found for Library and Information Science and also Law later (Vaughan & Thelwall 2003). It was additionally found that older journal websites tended to attract more links, as did those that published more information. Both of these latter findings seem to match common sense. Nevertheless it can be seen that hyperlinks are a potentially valuable data source about the online impact of journals. It remains to be seen, however, what effect the proliferation of publishers' digital libraries and meta-libraries such as SwetsNet have on this result. These complicate the issue because many journals will have several different websites on the web in different kinds of digital libraries and meta-indexes.

Other research

Factors affecting the numbers of hyperlinks between university websites have been further investigated in various contexts. Two important but unsurprising findings are that close universities tend to interlink more than distant universities (Thelwall 2002c) and that universities in different European countries tend to interlink more if they share a common language (Thelwall et al. 2003). Additionally, English is a very common language for internationally linking pages throughout the EU, except in Greece.

Conclusion

The evidence now points to the fact that link counts can provide a valuable source of new information about informal scholarly communication, but caution should be exercised when interpreting results. This caution is needed because of potential problems that can affect the reliability of the link counts as well as the range of factors that can influence their creation, including geographic and linguistic.

It would be too strong to claim that hyperlink counts can be used to measure to online impact of an academic website and they certainly do not measure the impact of the site owners' research. Nevertheless, owners of websites can now easily use search engines to report link counts for their site and if these were found to be much lower than other similar sites then the question of effectiveness of the site should at least be questioned.

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Measuring website activity: about the difficulties of obtaining performance indicators

Simone Fühles-Ubach

Starting point

The strong recession of the New Economy has lead to an increasing need of justification for expenses in the internet field, expenses which a few years ago still had been considered as a matter of course. In the sphere of the new basic conditions, "Web Metrics" or "Web Measurement" has been developed as a new discipline with the function of measuring the success of a web site.
Also for the library sector it gets more and more important to obtain reliable and above all standardised data on the use of electronic services. This need is also pointed out by initiative projects like "Counter" (**C**ounting **O**nline **U**sage of **N**e**T**worked **E**lectronic **R**esources), which deals with the use measurement of electronic magazines and databases. (Mundt 2003)[1]
This lecture's principal topic is the measurement of general website activities of libraries. Generally, website activity in this context means the internet presence, which represents the library and its services and products to the internal and external users. The applied measurement method is a server-based measurement on the basis of log files, for these data normally can be automatically ascertained by any library server and are therefore at the library's disposal without problems. Furthermore, this method is one of the so called **"nonreactive measures",** which means that the user is not able to notice that his or her "behaviour" is automatically logged.

What is to be measured and what can be measured?

The analysis of user behaviour by means of log files is a quantitative method of usability evaluation, i.e. it is an appraisal of the general ease of use and operation on the basis of numerical values. The easiest way of analysing is **the method of mainly statistical frequency enumerations of page impressions**. By this method it can be ascertained which web pages the user hits – when, how long and how frequently. An important aspect in this context is the question, how many of the visits are based on search engine efforts. Because search engines and robots cannot be considered as real visitors, it is the attempt of log file analysis work to ascertain these occurrences and to eliminate them so that in the end the number of real users remains.
In addition, the intention of this method is not only to receive user-orientated results, but also to get **technical information** concerning the own web presence. For

[1] <www.projectcounter.org>.

example, it is possible to ascertain the amount of correctly transmitted pages as well as defective transmissions (Error 404 – Link does not work) and other server specific information. These data serve the link management. Log file analysis is also able to specify the technical equipment the users work with. In the **"Agent Entry"** you find detailed data on the software equipment of the client. These kinds of information are important to include also the users' hardware and software environments in the course of the technical implementation of the website.
Moreover, **contents-related information** can be obtained by the log file analysis. The analysis of the **"Referrer Entries"** states the address of the page containing the link to the website demanded last by the browser before entering the website. So, the user's track through the website's pages can be reconstructed since any log file entry is connected to the page before. These **"Path Analyses"** show how users move within the website. Also the first and last page the user enters within a website show how he or she gets along with the program. The analysis of these pages makes clear if the entry page and the exit page of the website are reasonable or if there are usability problems. The analysis of the **"Query Strings"** allows conclusions concerning the questions of what the users are looking for in the program (expectations of contents) and which search terms they associate most with the website. The sum of these data is an important groundwork for the assortment of **Metatags** and **Search Engine Marketing**.

Log file generation [2]

Every webserver records log files to make traceable the accesses to the provided websites. Every access activity is recorded, i.e. each connection of the server with the internet that is transmitted via Hypertext Transfer Protocol (http). Normally, what is recorded are text files in the so called Common Log File Format (CLF Format), which themselves are recorded by different computer platforms with different operating systems and different servers (programs!). The following table shows the field names and their meaning:

[2] A good introduction to the topic is given by: Janetzko, Dietmar: Statistische Anwendungen im Internet: Daten in Netzumgebungen erheben, auswerten und präsentieren. – München : Addison-Wesley, 1999.

Field name	Meaning of field name
Host	IP-Address / Domain name of the accessing server
Ident	Identification (if there is one, otherwise there is a hyphen)
Authuser	Authentication of the user (if necessary)
Date	Date and time of the access in dd/mm/yyyy
Time Zone	Deviation from Greenwich Mean Time in h
Request	Method, document and protocol of the access (often: GET/...); inquiry command of client, demanded file
Status	Answering status as code number (e.g. 404 – Page cannot be found)
Bytes	Total number of the transmitted bytes
Expanded CLF (ECLF) includes additionally:	
Referrer	URL of the page that contained the link of the requested page
Agent	Name and version number of the requesting browser

Example for a log file entry:
123.456.78.9 - - [08/May/2003:13:45:56=D500] Get XY.html HTTP/1.0 200 2050 Z.html Mozilla /5.0 [Win95]

- This entry shows the request of a client, who accesses via the IP address 123.456.78.9 on 8th May 2003 the page XY.html.
- The page transmission was successful (Code 200) and 2050 bytes were transmitted.
- The user followed a link on the page Z-html and used the Microsoft Internet Explorer in connection with Windows 95.

Indicators concerning website activity

The following illustration shows the different indicators of website activity:

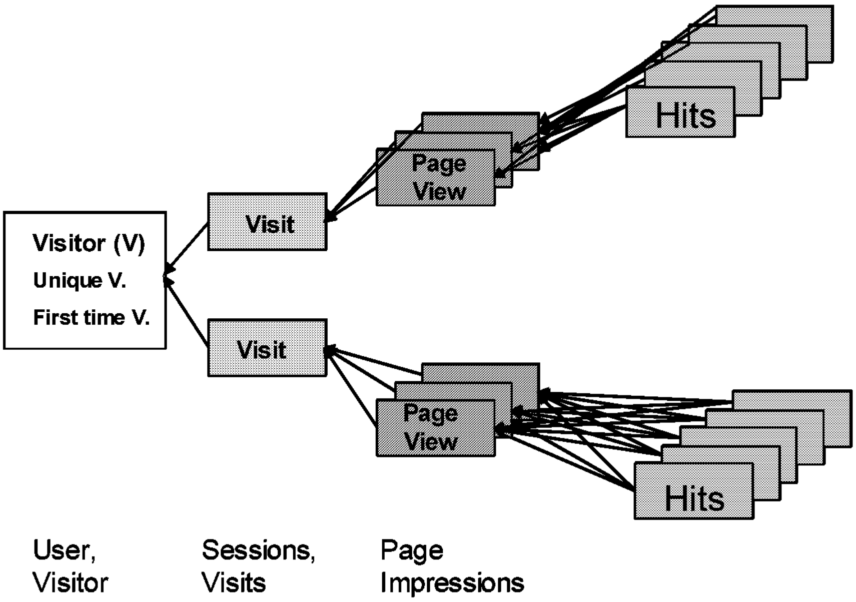

Fig. 1: Indicators of website activity.

In the beginning of log file analysis the number of "hits" was often used to measure the popularity of a website. The failure of this measure is considerable because a log file logs each file that is being requested during the access to a server in one line. This meant that every element integrated in the HTML-page, for instance pictures and graphics, had been registered as a "hit", which lead to the wrong idea, that websites with many multimedia elements were particularly high in demand.
The *Information Community for The Establishment of The Circulation of Advertising Media in Germany* (IVW = Informationsgemeinschaft zur Feststellung der Verbreitung von Werbeträgern e.V.), whose task it is among others to establish for providers of online advertising the shown accesses to the website's offers, has therefore chosen two indicators for the performance measurement which leaves layout and graphic features of a HTML-site out of consideration.

These indicators are **Page Impressions** or Page Views and **Visits**. Since the 1st of September 2002 the company InfOnline is executing the online measurements for the IVW.[3] At present, a *scaleable central measuring technique* (SZM = Skalierbares Zentrales Mess-verfahren) is used to measure page impressions and visits according to a standardised procedure. New measurement variables are to be developed in the future.[4]

Page impressions / page views

Page impressions indicate the number of times a HTML-page with potential advertising features is seen or requested by a user. They give a measure for the use of single pages within one website.[5]
However, the logging of websites which are produced by "Frame" technology, needed to be defined separately. In the case of frames, it is possible to initiate several page impressions by only one "click", which is not desired. The definition has therefore been extended correspondingly by the following passage: When a website contains pages that are put together by several frames (frameset), only the contents of one frame is considered as contents. The second indicator for performance measurement is called the **"Visits"**.

Visits / sessions

A visit indicates a connected group of transactions between an IP address and a website in the WWW. The visit defines the contact with the advertising medium. A group of transactions is called a successful page access of an internet browser to a current website, when it is effected from an external place.[6]
Though, the identification of visits is not trivial. In order not to overload the net, the connection is cut off after each request/response interaction. Thus, log files basically do not know connected groups of transactions. A visit is defined a visit when an IP address occurs repeatedly in short intervals in the log file. Then it is assumed with the utmost probability that both entries can be ascribed to the same user. Aren't there further requests by this IP address within a certain period of time (default setting 30 minutes, the timeout can be customised), the next session of this IP address is registered as new user session. It is important to mention that the identification of

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[3] Partners in equal shares are: Bundesverband Deutscher Zeitungsverleger e.V. (BDZV), Deutsche Multimedia Verband (dmmv) e.V., Organisation der Media-Agenturen im GWA e.V. (OMG), Markenverband e.V., VDAV – Verband Deutscher Auskunfts- und Verzeichnis-medien e.V., Verband Deutscher Zeitschriftenverleger e.V. (VDZ) and Verband Privater Rundfunk und Telekommunikation e.V. (VPRT).

[4] <http://www.ivwonline.de/news/pm_2002-08-06.php>.

[5] <http://www.ivw.de or www.infonline.de>.

[6] l.c.

visits does not yet allow definite conclusions on the visitors and that the number of visits should always be lesser than the amount of page views.

Users / visitors

It is the aim of the online market research to ascertain and to identify the "real" user (consumer). A visitor or user is a natural person who accesses to a website. However, the identification or the conclusion on exact amounts of users is complicated for several technical reasons. Possibilities of identification are offered by access controls and cookies. Cookies are little programs, which are automatically saved on the hard disc of the visitor's computer, so that the computer can be clearly identified when the access to the server is repeated. In case cookies are used, it is even possible to distinguish different types of users: (Sterne 2002, 144)

- First Time Visitors – Persons who visit a website for the first time
- Return Visitors – Visitors who return to a website several times
- Repeated Visitors / Users – Visitors who frequently return to the website and really use the website and its offerings

With the use of cookies it is also possible to personalise web presences, for what the online bookseller Amazon can be taken as an example. To execute objective visitor reckonings beyond cookie technology, there are only the possibilities of password logins and registrations, what, however, mostly leads to a decrease in the number of visitors. The website of "Hot-wired" for instance had to record a severe diminution of frequency after the introduction of a password login system (Werner 1999, 219). However, the case of libraries is a little different. Especially in university libraries the primary user group is already captured and therefore a registration or identification in the web by password is not necessary for services like book reservations and prolongations. The implementation of a general registration would certainly be easier for universities as it would be for other institutions.

Limits of log file analysis

Despite of the many possibilities to ascertain data and facts, it has to be pointed out that the results of log file analyses should not be considered as absolute values but as tendency values. During the server-based measuring some falsifying elements arise, which influence the data of the actual use in a different way. The following illustration shows how it comes to falsifications during the data collection process:

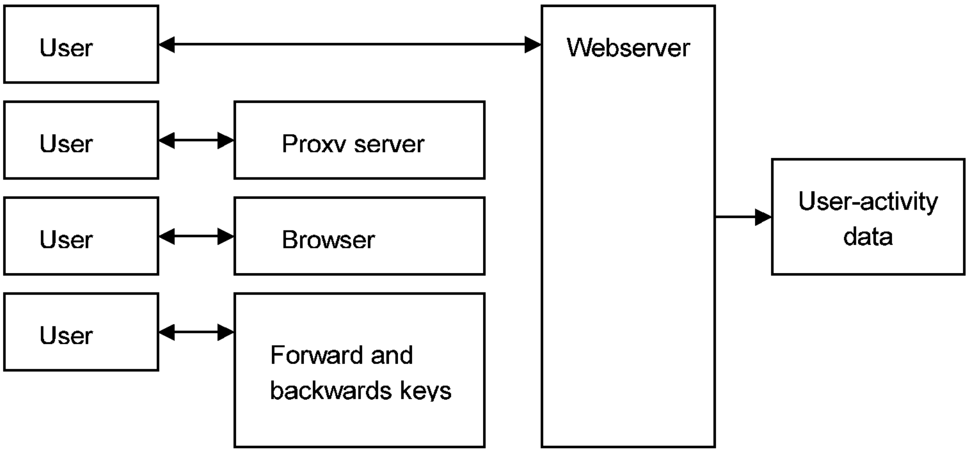

Fig. 2: User activity data collection by server-based measurement (Inan 2002, 179).

Proxy servers[7]

In order to exploit the whole scope of the internet optimally, proxy servers are used to minimise the volume of data transfer by latching information that is frequently used, so that these data do not have to cover the whole distance through the net again and again. When a user then requests such a page from the proxy server, the server on which the original page is situated does not receive any page request and therefore the data of this server do not appear in the log file. A regular entry only occurs when the page is not available locally. But in this case, the entry on the source server logs the web address of the proxy server which again leads to data falsifications.

Browser caches

Local caches of the browsers that run on the computers of individual users work in the same way proxy servers do. In order to accelerate the page setup, single pages are being latched and appear only once in the log file, although the user accesses to the pages several times. Consequently, the falsification of log files affects the field of contents or more exactly the question of which contents are requested how many times.

[7] Detailed information on proxy server discussions are found on the website of the Informationsgemeinschaft zur Feststellung der Verbreitung von Werbeträgern e.V. (IVW) at www.ivw.de and there particularly in an article on „Messung der Werbeträgerleistung von Online-Medien" at <www.ivw.de/verfahren/caches.htm>.

Back and forward button of the browser

When a user clicks on the back or the forth button of the browser, the pages are being kept in the main memory (RAM) and therefore these pages are not recorded as a request in the server log file, too.
A subsumption of the explained elements is shown in the following table:[8]

Falsifying element	**Proof of effective user requests**	**Identification / elimination**
Demanded graphics	Too high	Consider extensions (gif,...)
Proxy Server, Cache function	Too low	Enforce updates
Dynamic IP addresses	Too high or too low	Browser, Cookies, Registration
Company firewall	Too low	Browser, Cookies, Registration
Several persons – one PC	Too low	Registration
Robots, Spiders ...	Too high	Consider browser entry

Tab. 1: Falsifying elements

Dynamic IP addresses

Because of the limited supply of IP addresses online services like AOL or t-online as well as other internet service providers allocate their IP addresses dynamically (Janetzko 1999, 91). This procedure has two different effects: One is that an online provider is able to serve a great number of users by only few addresses. The consequence is that there can only be few addresses found in the log file, but behind these few addresses a multitude of users can hide. The same user can be allocated to different IP addresses at different times. The result: two different addresses appear in the log file which actually belong to only one user.

Firewall systems

Often, companies use firewall systems for safety reasons. Firewalls change internal IP addresses into one single external IP address which is then recorded in the log file, even if many different persons within the company have accessed to the website. If additionally proxy servers are used, the log files receive distorted information concerning the amount of visits and so make exact analyses of the users or user groups impossible.

[8] Hippner et al. 2002, <http://www.ecin.de/technik/webminingprozess/print.html>

Robots / spiders

Even though, log file recorded visits by robots and spiders are visits, they are not visits by information searching visitors, but by machines. As robots and spiders can be identified by agent entries, the real data on user amounts can be separated easily from this kind of distortions.
Regarding the indication and comparison of usage data on the basis of log file analysis it is important to know these facts in order to be able to argue correctly and competently when it comes to discussions on these specific data. Since these errors generally occur at any log file analyses at least to a certain extent and since they result in a constant error when regarding a single server, a comparability of values is nevertheless given.

Web mining as advanced method

If you are interested in further aspects concerning the users' behaviour, it is possible to record the sequence in which pages of a website are requested during a visit. The records of these paths are called **Clickstreams**, their analysis is called Path Analysis. The individual visits, separated in individual page impressions, can be saved in a database to be available for further analyses. This is where web mining starts out.
The term web mining has derived from the general term of "data mining". Data mining tools (Bager et al. 1997, 290) are specialised to find unknown coherences within company records. In contrast to classical query tools the user does not need to know at the outset what he or she is actually looking for. Rather, the user is lead to the interesting information. Web mining is characterised as the branch of research that has been adapted to the special requirements of the internet. The aim of Web mining (Zerr 2001, 22) is the analysis of log files in comparison with regularities and patterns of the users' behaviour. As large data masses are mostly administrated in databases, Web mining is often used by computer scientists and business data processing specialists.
However, the methods applied in data mining as well as in web mining are often classical statistical procedures which are also used in market research. The most important examples to mention are Cluster Analysis, CHAID, association measures or neural networks. With the aid of these methods many market-related data on internet users are to be gathered.
Concretely, web mining is to answer questions on visitors and profitable clients in order to help optimising customer relations and to increase market potentials. Due to this fact, web mining is mainly used by business enterprises with the intention to optimise their distribution. At present, official institutions still have little experience with it.

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Why and how people are visiting websites

Andrei I. Zemskov and Michael V. Goncharov

The goal of the study

The goal of the study is to analyse the user behaviour and the motivation of website visitors for further improvements of user services. According to governmental statistics there are 6 mill. regular Internet users in Russia at beginning 2003 (which stands for 4% of total population) and Internet activity has been growing rapidly.

Methodology

We did not carry out direct questioning but have performed comparative analysis of statistical data produced by OPAC module and by website statistics. Data collected refer to 15.12.02-15.01.03 period and previous samplings demonstrated the same or similar trends. One could easily understand difficulties of indirect comparative analysis:

1. Content of the website and content of printed collection essentially differs.
2. There are monitored different data, namely requests on printed items for traditional services and hits or visitor sessions for the website.
3. Generally speaking, there are different subjects and objects. Library reader's community and website users community does not coincide; there is some overlapping, but mostly the audience is not the same.

Which information is produced?

National Report "Russian Information Resources"[1] indicates that basically (more than 90%) information is produced for internal use. Less than 5% is produced for public application. There are more general data:

25 TB	of newspapers;
10 TB	of periodicals (ca. 1 mill. issues);
2 TB	of books (1 300 000 titles);
195 TB	of internal information.

Tab. 1: Annual global production of information.

[1] "Russian Information Resources" National Report 2001 at <www.inforeg.ru>.

Russian reader general preferences

Russian reader general preferences (Il'nitskij 2002) are given in the (Table 2).

Detectives	31 %
Professional publications	22 %
Textbooks	20 %
Literature for youth and children	19 %
Dictionary, Vocabulary	14 %
Love stories	12 %
Encyclopedia	11 %
Cooking recipes, housekeeping advises	11 %
Science fiction	8 %
Tales	8 %
Foreign poetry	1,5 %

Tab. 2: Russian reader preferences 2001, % of reading audience.

The library resources

Library collection comprises 8 mln. items, mainly on pure and applied sciences, engineering, economics and so on.

Books	2.0 mill.
Periodicals	3.8 mill.
Other materials	1.9 mill.
including microforms	1.6 mill.
Unpublished translations	0.3 mill.
Digital documents	6.2 thousand (less 0.1% of total collection)

Tab. 3: Traditional statistics (items).

Books	2,0 TB
Periodicals and other materials	3,0 TB
Digital offline resource	0,6 TB (ca. 10 % of total)

Tab. 4: Library collections in terms of information resources available.

Website of the Russian National Library for Science and Technology

Website of the Russian National library for Science and Technology (www.gpntb.ru) has been opened since 1995. Until that date we had X.25 packet communication technology. During 1995 – 1997 total content was ca. 700 MB, of which 95% are OPAC and Union Catalogue of SciTech publications. At beginning 1999 total information was increased up to 1.2 GB by addition of bibliographical DB and full text materials. In 2001-2002 we expanded technical Internet line capacity to 2Mb/s. We have 4 servers: communication, firewall, applications and file server. Nowadays site content annual growth rate is ca. several per cents. We have 358 PC, of which 324 are LAN connected. There are 83 PC for users, of which 45 are Internet connected. Comparative analysis of expert evaluations of libraries' websites features positioning of the Russian NPLSaT website amidst another library sites.

1. Russian State Library <http://www.rsl.ru>
2. Russian National SciTech Library <http://www.gpntb.ru>
3. Library of Siberian Medical University <http://www.medlib.tomsk.ru>
4. SciTech Library of Siberian branch of RAS <http://www.prometeus.nsc.ru>
5. Russian National Library <http://www.nlr.ru>
6. Moscow Open Ecological Library <http://www.ecoline.ru/library>
7. National Library of Karelia Republic <http://library.karelia.ru>

Tab. 5: Expert evaluation of library sites. Number one corresponds to the highest appreciation.

Basically, our site is like other federal (or national) level library sites, in particular, Russian State Library, Russian National Library, Library of Natural Sciences, Central Agricultural and Central Medical Libraries and so on. Essential difference is Union Catalogue of ST publications at our site. Nevertheless, we are sure that findings of our study could be applied to evaluations of other special library user behaviour.

Which documents prefer our readers?

While registration readers declare subjects of interest; at reader's choice registration could be permanent or temporary.

NN	Subject	Total number	Provisional registration	Stability coeff. (ratio columns 3 to 4)
1	2	3	4	5
1	Physics, Math.	986	771	1.28
2	Economics	918	793	1.16
3	Chemistry, Chemical Technology	779	646	1.20
4	Electronics, Radio	563	439	1.28
5	Informatics, STI	553	443	1.25
6	Mechanical Engineering	483	390	1.24
7	Transport	371	303	1.22
8	Ecology	332	296	1.12
9	Power Engineering, Communications	292	231	1.26
10	Construction, Architecture	240	188	1.28
11	Metallurgy	236	192	1.23

Tab. 6: Declared subjects of interest (January – April 2002).

One could see that stability coefficient for Physics, Math., (1.28), Construction and Architecture (1.28), Electronics, Radio (1.28), Power Engineering, Communications (1.26) features better coincidence of permanent and provisional requests if compared with Ecology (1.12), Economics (1.16), Chemistry, Chemical Technology (1.20). As a rule, people are coming to solve one certain problem. In any case more than 2/3 registered readers need reference service but not permanent library work.

How subject distribution of library collection satisfies user requests?

Table 7 presents 11 major (the most numerous) subjects of State STI Subject Heading Tables (SH numbers) and circulation data for April – December 2002

NN	STI SH numbers	Subject	Number of OPAC records	Circulation
1	2	3	4	5
1	06	Economics	26 819	4 919
2	29	Physics	20 511	553
3	55	Mechanical Engineering	18 691	2 043
4	50	Automation, Telematics, Computer sciences	15 333	1 064
5	27	Mathematics	9 605	560
6	47	Electronics, Radio	9 201	716
7	38	Geology	8 970	435
8	67	Construction, Architecture	8 748	861
9	31	Chemistry	7 274	516
10	10	Legislation	6 319	423
11	87	Ecology	6 092	1 400

Tab. 7: Major subjects of book collection.

Ratio of subject part of collection to circulation (lending) could be referred to as a completeness of subject collection. This parameter indicates range of choice for reader; it varies from 5.5 (economics) to 37 (physics). For further analysis we consider an aggregated data on several subject groups.

Aggregated group of subject headings	Circulation	Completeness of subject collection
1	2	3
1. Power Engineering, Mining, Mechanical Engineering, Metallurgy, Chemical Engineering, Construction and Architecture, Transport (SH numbers 44, 52, 53, 55, 61, 67, 73)	5 733	9.0
2. Economics (SH number 6)	4 919	5.5
3. Ecology and General Problems (SH numbers 38, 81, 82, 87)	3 318	7.3
4. Math., Cybernetics, Physics, Chemistry, Mechanics (SH numbers 27, 28, 29, 30, 31)	2 532	18.2
5. Electrical engineering, Electronics and Radio, Communication, Automation and Telematics, Computer Technology (SH numbers 45, 47, 49, 50)	2 357	12.9
6. Culture, Mass media, LIS, Informatics (SH numbers 15, 19, 20)	262	23.3

Tab. 8: Circulation referred to subject groups.

Findings of subject analysis

Readers of this specialised library require access to pure and applied sciences. Theirs needs of LIS documents (group 6) are fairly behind in priorities, despite relative completeness of this subject collection, readers could get 23 times more titles than they really took.

Declared requests in general do not differ from really asked. Strikingly high priority of Informatics and STI could be explained by certain misunderstanding. At registration people suppose that STI means publications on metallurgy, engineering, etc., and have no pronounced interest to LIS problems as a science.

Does activity of requests depend on stocks?

This is a fundamental question; term «critical mass» usually defines some threshold, which marks change in behaviour of system. Common sense supposes something like «dose – dependent» relations between stock and requests. But at monotonous growth of total number of OPAC records, requests varied different way, see (Table 9). So we failed to find correlation between stock and requests, much stronger are seasonal variations of library visits.

Month	Total number of records	Number of requests
1	2	3
May	287 820	11 614
June	291 420	7 679
July	295 129	8 548
August	297 767	5 689
September	300 358	3 982
October	304 328	17 479
November	307 594	11 338
December	310 789	10 760

Tab. 9: Requests versus total number of OPAC records.

Is there dependence of publication year on requests?

Website pages are accessible starting from year of publication, i.e. last opening or modernisation of site. That is why we have analysed activity of requests as a function of publication year and of subject.

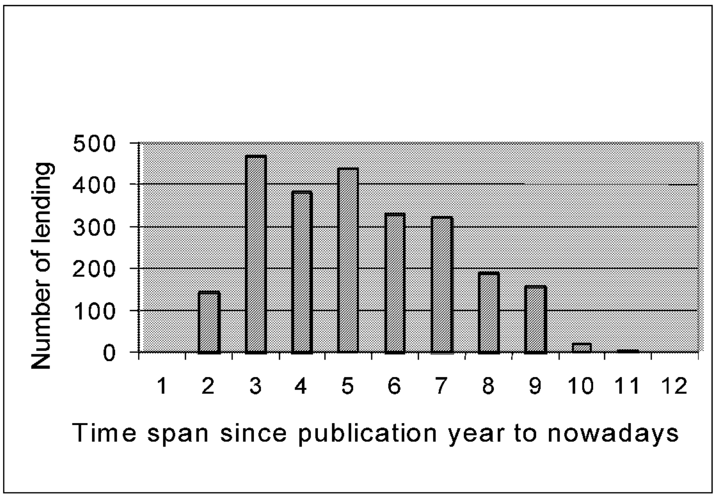

Fig. 1: Requests on books. Group 4: Mathematics, Cybernetics, Physics, Chemistry, Mechanics (SH numbers 27, 28, 29, 30, 31).

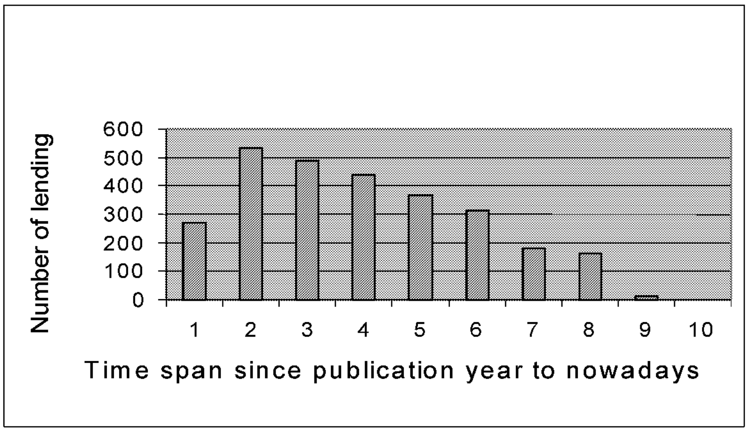

Fig. 2: Requests on books Group 3: Ecology and general problems (SH numbers 38, 81, 82, 87).

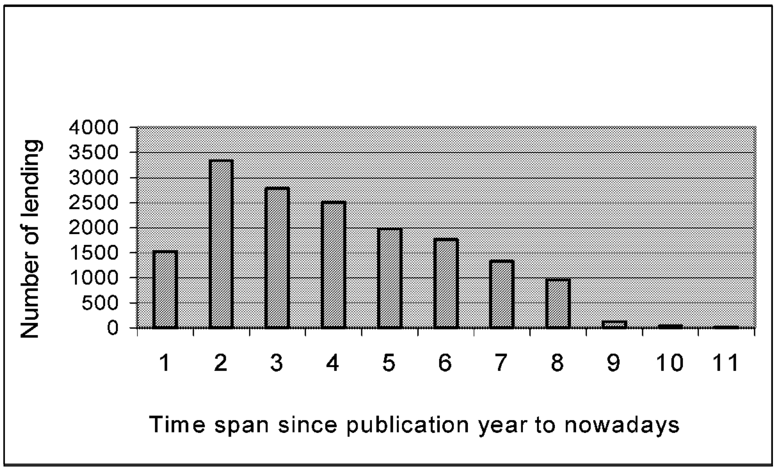

Fig. 3: Requests on books in general.

Findings of request activity analysis

All studied profiles feature 4 stages of activity. The first stage features the development of the request activity from initial zero level to the maximum value, which takes approximately 1.5 years. This process usually is not supported or accelerated by advertising campaign. Besides, under monitoring were pretty large collections. Contribution to time lag due to the in-library processing should be taken into account as well.

The second stage corresponds to maximum request activity and duration of this period is from 3 to 7 years depending on subject group. We could only notify that documents of group 6 (informatics and so on) keep readers interest for 7-9 years.
The next stage demonstrates decrease of readers' interest during 2-3 years. Again, universal character of averaged reader behaviour is shown.
The final stage corresponds to stable and small activity: 1 - 2 items per year are requested for our subject collections. Empirical formula (in relative units) for dependence of requests activity (Y) on books publication age (x): $Y = x^2e^{(1-x)}$
What is the reason of request decrease on pretty wide spectrum of subjects? For overwhelming majority of monitored subjects there was not any developments or discoveries and nobody has cancelled old facts. The main reason is a strive for a new information, and expectations of:

1. New facts and information;
2. New interpretation of old facts;
3. Preferences of new publication.

So, actualisation is very important factor and website designer (system administrator) should take care of the regular updating .
Unfortunately we could not find any correlation of requests activity on publication age for periodicals.

Comparison of library visits and website visits

These data are the grounds of statistics, see Fig 10. One could see certain growth after 1998 crisis, but in general this curve features some fluctuations around average 240-270 thousand visits per year. As for website visits, one could see monotonous growth during 6 years.

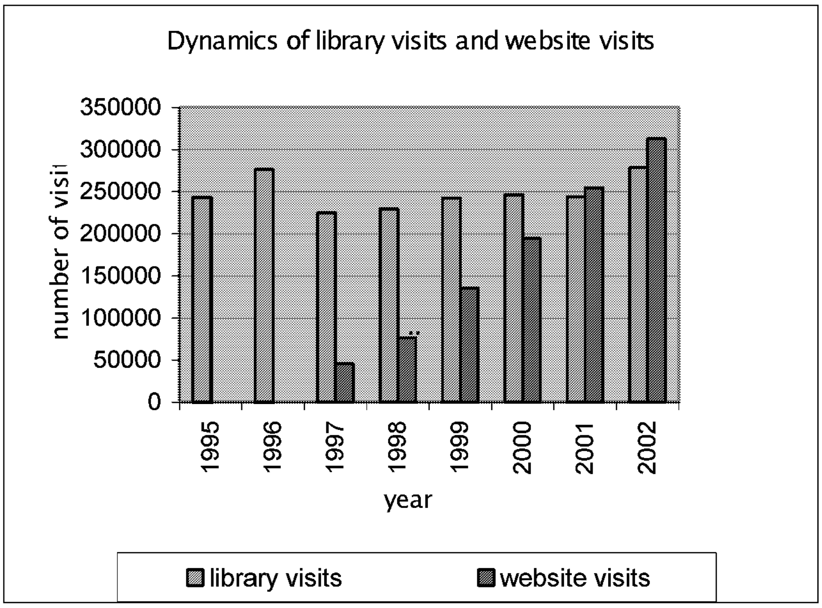

Fig. 4: Dynamics of the traditional library visits and website visits.

Visitor Sessions profiles

Year	Visits
2000	998
2001	1180
2002	1450
2003	1700

Tab. 10: Average website visits per day.

(100 sessions of the same visitor are counted as one). Profile by number of visits is an important category for user satisfaction evaluations; 2.18% of all visitors are visiting our website 10 times per month or more.

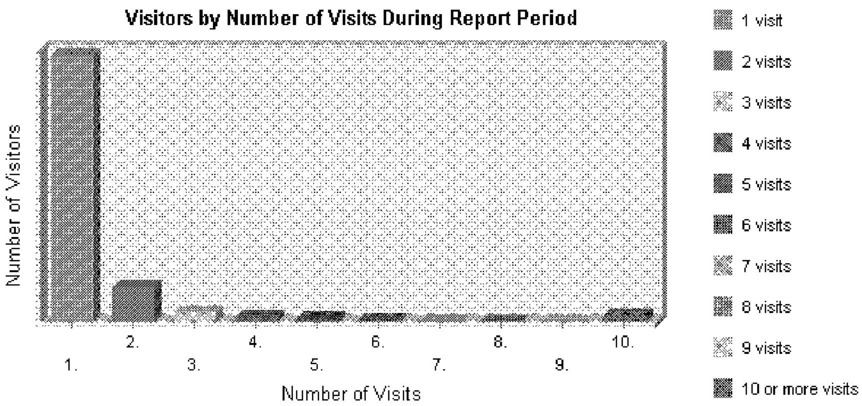

Fig. 5: Distribution by number of visits during one month.

More 22% visitors come directly to known pages, in particular to OPAC, Union Catalogue, doctoral theses. Just the same way a majority of visitors are quitting site from the search pages. Ratio of total number of visits to full text pages visits is 6.
With respect to content of pages website visitors' priorities are as follows:

1. Search pages;
2. Pages with full text news (information on international events, conferences, etc.);
3. Pages with stable full text content (conference proceedings, library journal)

Overwhelming majority of our readers are citizens of Moscow and suburbs. Total population of this region is approx. 15 mill. and that is our potential audience. Services for remote users via ILL stand for 1% of service in library premises. Therefore geographic distribution of users presents narrow function with conventional half width 150-200 km.

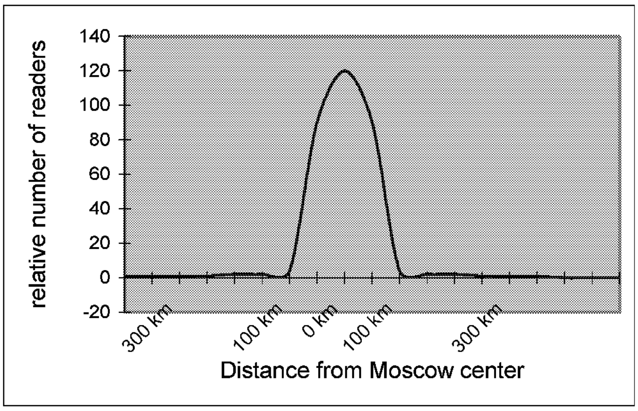

Fig. 6: Conventional distribution of library readers.

Regional distribution of remote users (in terms of Internet visits) presents all continents, regions, and countries (including 7 users from Polynesia).

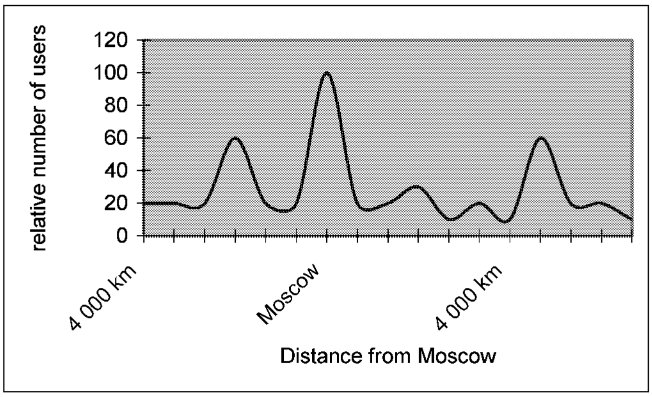

Fig. 7: Conventional website visitors' distribution.

The most active external referring sites are Yandex, Aport, Rambler, Google. Library's website is indexed by 300 search systems and directories.

Distribution of requests on seasons, days and daytime

Monthly and daily distributions of library visitors are presented at (Fig. 8 and Fig. 9).

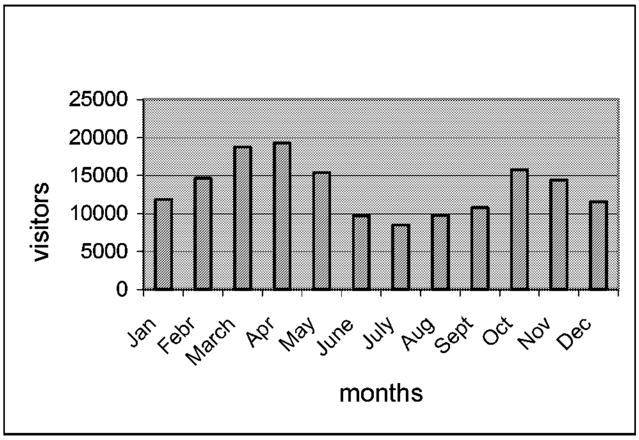

Fig. 8: Library visits by months in 2002.

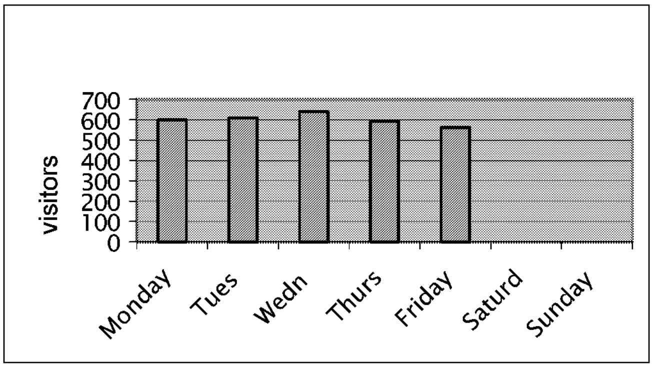

Fig. 9: Library visits by days.

Activity of website users by day of the week and by hours of the day is presented at (Fig. 9 and Fig. 11). The busiest day (20% of total visits) is Thursday, the least busy - Sunday. Website traffic by months has no seasonal variations.

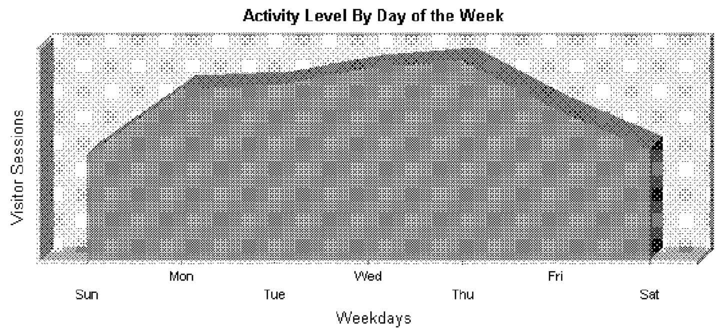

Fig. 10: Activity of website users by day of the week .

Website is visited without seasonal or daily gaps.

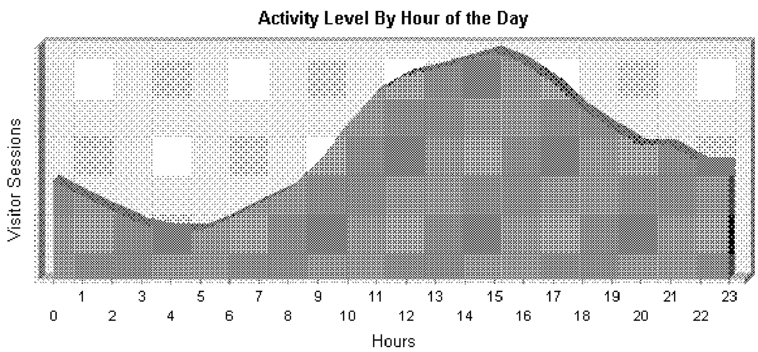

Fig. 11. Activity of website visitors by hour of the day.

Maximum website visits fall on 11.00-17.00 (Moscow local time). Notice non stop service around the clock: the difference between activity level as function of hours is not high.

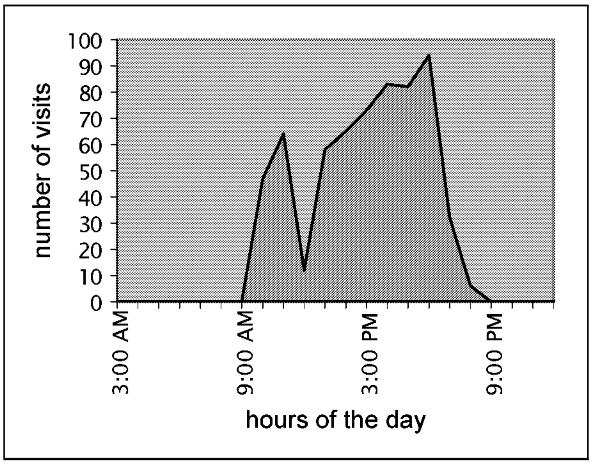

Fig. 12. Activity of library visits by hour of the day.

A gap of activity at lunchtime corresponds to appreciation of library visit as a work.

Local users of remote digital resources

We have statistical data on requests from our library readers' to digital documents (more 1200 scientific journals) of Russian Foundation of Basic Research (RFBR) Electronic Library.

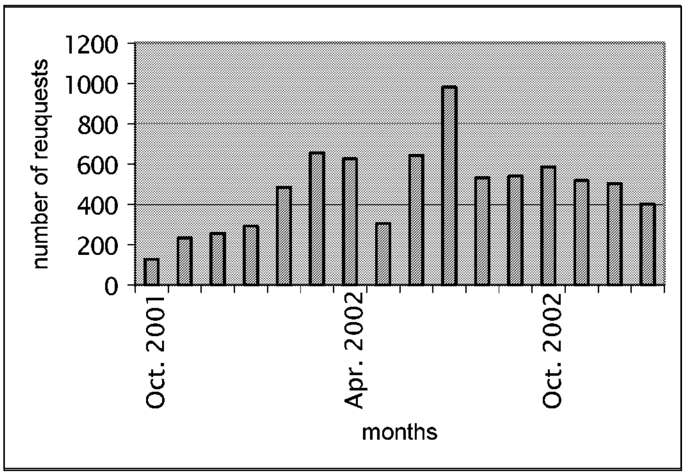

Fig. 13. Requests on digital full text documents of RFBR Electronic Library.

A majority of users (80%) prefer Microsoft Internet Explorer and 97% prefer Windows platform, Cyrillic-coding chart cp-1251. Average duration of website session is 14 minutes, which is equivalent to browsing (reading) 7 printed pages. Average reader (700 - 900 readers daily) session duration is 3 hours, which includes search and waiting of order time.

For the year 2002 there were 260 000 visits to our library and circulation (lending in reading rooms) was 2 300 000 items, or 9 items per visitor. Having assumed 300 pages for an item, it corresponds 2 700 pages for each reader. Keeping in mind average human ability to read no more 100 pages for 3 hour, we get pretty low efficiency of work.

In total readers have ordered 1725 GB information (less 30% of total collection content), of which they could read less than 65 GB. For 2002 there were downloaded from website 6 370 000 files, another words all content of website was browsed 15 times.

Conclusion

1. Telecommunication technologies provide 10-fold supremacy over traditional ones in public communication, in social inclusion.
2. Regional coverage of traditional library and its website differs essentially. Traditional library services are local; it serves pretty limited regional community. Distribution function of website visitors covers all Internet – connected (and, in our case, Russian speaking) part of the world (USA, Germany, Israel, Kazakhstan, Ukraine and so on).
3. Website features higher coefficient of practical operation availability 24/7/365 if compared with library services.
4. Rather weak dependence (if any) on site content volume demonstrates motivation of web visits. People are coming to well known place and if they fail to find immediately required material, they will surf to other sites.
5. Despite monotonous increase in website visits and overwhelming majority of searches to see, there is no adequate increase in ILL orders. So library catalogues are used as a bibliographic tool, and not as the better availability instrument
6. In general, website looks like a referring service, but not as an independent publication of subject collection. Visitors are coming to get advice or reference and not for long lasting reading work.

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Case Studies in Germany

Authorised bibliometrics for faculties of medicine in North Rhine-Westphalia: controlled indicators of institutional research performance

Matthias Winterhager

Introduction

Bibliometric indicators, based on publication statistics and citation analyses, have been used to measure research performance at the institutional level for some 20 years now[1]. It is only in recent years however, that the application of these indicators may have dramatical consequences for the institutions under evaluation. In a situation of more and more restricted financial resources it is obvious that public money will be directed by science policy primarily towards those units that show up with best performance indicators. Where in earlier times competition was more or less limited to the yearly increases of science budgets, today we face severe budget cuts that can hit institutions at their life nerve. As science policy decisions are more and more influenced by indicator rankings, it is of vital interest to show up with best indicator values – permanently. At the level of departments, in the long run it is possible that only those with continuously good rankings will survive.

Regarding research performance, two types of indicators currently play a dominant role in most kinds of institutional evaluations: third party funding and bibliometrics. While data on third party funding can be gathered easily or are already available[2], the production of valuable bibliometric indicators is a rather complex and time-consuming task. Some data can be purchased as a commercial standard product ("ISI Essential Science Indicators®")[3] from the producer of the Science Citation Index, and some are even available in public domain (e.g. the "Champions League" of research institutions compiled by CEST).[4] However, there is a lack of data going below the institutional top level of organisation down to detailed indicators for departments, sections, institutes and laboratories. Also, standard products like Essential Science Indicators®(ESI) and the Champions League are normally built without systematic control by the research institutions themselves; therefore the institutions under evaluation remain being object of study of others and do not have any chance to check and verify the databases that the rankings are based upon. This may lead to various kinds of errors, inaccuracies and artefacts.

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1 cf. Moed et al. 1983, Martin & Irvine 1983.

2 cf. for Germany: Deutsche Forschungsgemeinschaft 2003.

3 <http://www.isinet.com/demos/esi/>.

4 <http://adminsrv3.admin.ch/cest/en/produkte.htm>.

To change this situation, within a joint project some larger German faculties of medicine decided to engage in bibliometric indicator production by themselves. The German state North Rhine-Westphalia (NRW) hosts seven faculties of medicine, closely linked with the university hospitals at Aachen, Bochum, Bonn, Düsseldorf, Essen/Duisburg, Cologne and Münster. These seven faculties wanted to establish a calibrated database for the regular production of research performance indicators by measuring their visibility in the leading international scientific journals. Comprehensive analyses of publication output and impact (citation rates) for all institutional units of the faculties should be available. In the past, some of the faculties occasionally had operated with a "quick and dirty"-approach of combining publication data from Medline with so-called journal impact factors. This approach, although widely used at faculties of medicine in Germany, has many shortcomings and disadvantages[5]. Seglen lists 22 problems associated with the use of journal impact factors[6]. Three important issues here are:

- impact factors are based on a very short time window;
- impact factors poorly correlate with actual article citedness (because the distribution of citations to any journal is extremely skewed: a rather small number of articles regularly account for the majority of citations to the journal)
- impact factors are highly field-dependent (e.g. biochemistry journals are cited four times as much as those in orthopaedics).

The use of impact factors as a proxy measure to predict real citation counts of scientific articles is unacceptable for purposes of research evaluation.[7] After investigating new empirical data for their own journal, the editors of *Nature Neuroscience* concluded that a journal's impact factor "is almost useless as a predictor of the likely citations to any particular paper in that journal" and "Journal impact factors cannot be used to quantify the importance of individual papers or the credit due to their authors, and one of the minor mysteries of our time is why so many scientifically sophisticated people give so much credence to a procedure that is so obviously flawed".[8] The NRW medicine faculties decided to focus their analysis on measuring actual citations for each publication instead of using impact factors.
The aim of the project of the NRW medicine faculties is to provide valuable bibliometric information as an additional input into local and state-wide peer review processes. The project is governed by a committee of the research deans of the faculties and is designed as a "bottom up" procedure: the faculties generate the

5 cf. Amin & Mabe 2000, Opthof 1997.

6 Seglen 2003, p.146.

7 cf. Seglen 1997.

8 cf. Anonymous 2003.

bibliometric indicators for themselves on a regular basis in a co-ordinated and controlled manner. The process is controlled by an independent (external) bibliometric research team to guarantee common methodical standards. Based primarily upon bibliographic data and actual citation counts from the Web of Science, the publication database of the project is thoroughly verified inside the clinics and institutes - *before* any indicators are built. This leads to a high degree of transparency of results; detailed information on the validity of the data as well as the possible shortcomings of the method is available to all involved researchers in the faculties. As the scientists themselves are the first to see any results for their own unit, they can use information from the project as an in-house early warning system, alerting them on critical indicator values before they get confronted with rankings from anywhere else. This is a major benefit of the approach and enforces the acceptance of the project within the faculties.

Method

The project relies primarily to the *Science Citation Index Expanded*® and its sister databases *Social Sciences Citation Index (SSCI)*® and *Arts & Humanities Citation Index* (A&HCI)®, which can be searched through the integrated portals *Web of Science* or *Web of Knowledge* as offered by the Institute for Scientific Information (ISI)[9]. Some of the faculties additionally use Medline(PubMed)[10] to include a few more publications from journals that are not covered by the Web of Science[11]. This is for reasons of completeness; these "Medline-only" publications are included only into some publication indicators, but excluded from any of the citation indicators. One of the difficult tasks of the project at this stage is to identify and mark duplicates (publications covered both in Web of Science *and* Medline) in the database to prevent any double counting.

The analysis is performed annually for the actual period of the five most recent years (publication time window). Consequently, the citation time window is varying, depending on publication dates: articles published in earlier years generally have a greater chance (more time) to attract citations than those of most recent years[12]. This adjustment of publication and citation time windows is a compromise between two conflicting goals: immediacy vs. reliability of the citation indicators. Citation indicators

9 <http://www.isinet.com/ISI/>.

10 <http://www.ncbi.nlm.nih.gov/pubmed/>.

11 In some fields this approach seems to be more appropriate than in others: dentistry and history and philosophy of medicine are examples where coverage of Medline is better than Web of Science, regarding publications from Germany.

12 To show the extremes: articles published in January of the earliest year have a citation window of up to five years; for articles published in December of the most recent year this window is less than one month.

for publications from the most recent two years only are in many cases not reliable (since these publications will attract a substantial volume of citations only in forthcoming years). On the other side, citation indicators for five year-old publications only may be much more reliable, but somewhat outdated when used to evaluate the current performance of a research institute. As all indicators are calculated for the total period as well as for each of the five publication years separately, data of high immediacy are available at least with respect of publication indicators.

In a first step, for the period of study all publications carrying at least one address of any of the faculties are extracted from Web of Science and PubMed. For the NRW faculties of medicine, these are a total of some 5.000 scientific articles per year. The extracted data are moved into a relational database system for further coding and indicator building tasks. Next, all records are scanned for valid address information which can be assigned to the relevant institutional units of the faculties. Since there are thousands of spelling variants for address data in the databases and even in the journals themselves, the task of address checking, cleaning and assigning is huge. It is one of the most time-consuming parts of the project. In a number of cases, it is impossible to assign a record to any unit of a faculty (e.g. if the authors of a publication give just "UNIV XYZ" as their address, without any further specification). Any address record is assigned as precise as possible to one of the institutional units, and marked with a corresponding code.

Based on these coded address data, complete lists of publications (as covered in the Web of Science and Medline/PubMed) are generated for each institutional unit (clinic, centre, institute, section, lab, research group) within the faculties. The listings are sorted by publication year and first author to enable fast checking of completeness and correctness by the scientists.

In the next step the lists are brought to the attention of the heads of the relevant units. Each unit gets its own publication list and instructions for the checking and correcting process. The scientists have the opportunity to correct and, if necessary, to supplement the list. Copies of the front pages of the original articles have to be provided for any corrections in assignment to institutional units and any additions to the publication list. The external bibliometric research team will check all these changes independently. Valid corrections and additions from the faculties then are integrated into the publication database. This process of verification is another very time-consuming task of the project, but it is essential for establishing a calibrated database in which all participating units can have trust.

Since every publication is assigned exactly to the relevant unit(s) during the verification process, valuable bibliometric indicators can be drawn afterwards from the database on various levels of institutional aggregation. All indicators are generally calculated and delivered in two versions: one for English language publications only and a another one for all publications, regardless of the language in which the original article has been written. This is to control the influence of language upon indicator values: a higher proportion of language-language publications may lower the citation rates for a given institute, because these publications generally have a much lower potential to receive citations than those written in English. Regarding the type of publication the analysis is restricted to substantial contributions in scientific journals as articles, letters, notes and reviews. Meeting abstracts, book reviews, corrections, editorial material etc. are generally excluded from the calculation of indicators (non-journal items like monographs, handbooks etc. are not counted as well). In very few cases, where unexpectedly high numbers of citations have been detected for special publications of these types (e.g. some editorials), the type has to be corrected or an additional indicator set is prepared with inclusion of those publications.

The indicators are generated for all levels of institutional aggregation, from the bottom of each institutional unit up to the top, the faculties in total. 'Full counting' is applied for publications written in co-authorship between different institutions: each involved institution gets a full count rather than split ones for the publication. Consequently, citations to these publications are not split but fully counted for each participating institution. From the verified database, the following basic indicators are calculated:

	publication activity
P	number of publications (Web of Science only)
P_+	number of publications (Web of Science + PubMed)
	citation impact
P_{uc}	uncited publications (absolute and percentage of P)
C	sum of citations
C_{self}	self-citations (absolute and percentage of C)
C_{max}	citation maximum (number of citations to most highly cited publication)
JCS_m	journal citation score mean
FCS_m	field citation score mean

A comparison of sum of citations (C) with citation maximum (C_{max}) can be very helpful to determine whether the citation impact of a given institutional unit is driven mainly by a single 'citation star'. In such a case the star can be identified and its bibliographic details will be provided as an addendum to the indicator set.

Mean citation scores (JCS_m and FCS_m) can be used to normalise the observed actual citation counts (C/P) against the relevant expectation values on two communication channel levels: journal and field. This enables comparisons between institutional units despite their (possibly) different disciplinary profiles.

To address relevant science policy-related questions, the following set of advanced indicators is built from the basic bibliometric indicators:

P_+		publication output
CR	$= (C-C_{self})/P$	absolute citation rate (non-self citations per publication)
RCR_f	$= CR/FCS_m$	relative citation rate (field level)
RCR_j	$= CR/JCS_m$	relative citation rate (journal level)

These four indicators, representing different dimensions of research output, can be used to evaluate scientific activity and impact of institutes. The faculties may combine the four, giving them different weights with respect to their specific characteristics:
publication output (P_+): quantitative, dependent from size of institutional unit (number of scientists);
absolute citation rate (CR): measuring the actual citation impact directly, without normalisation; success rate dependent from disciplinary profile of the unit (average citation rate in molecular biology is much higher than in orthopaedics);
relative citation rate, field level (RCR_f): actual observed citation rate is normalised against average (i.e. expected) value of the discipline, based upon a journal-to-field classification system; however: field averages may be determined through a heterogeneous mix of different journals;
relative citation rate, journal level (RCR_j): actual observed citation rate is normalised against average (i.e. expected) value of the communication channel that the authors themselves have chosen for their publication; normalisation is determined directly by the scientific community of the journal.
Obviously there is no "ideal" indicator, best fitting for every task of research evaluation. Rather, each has its own advantages and disadvantages, and faculties get the most valuable information when looking at the complete panel of all indicators.

Results

Results of the project are twofold: first, the faculties get a verified database of their publication output covering the most recent five years. This can be used to generate detailed publication lists for each institutional unit (or at any higher level of institutional aggregation). Second, different tableaux of bibliometric indicators are provided, also on various levels of aggregation. A few examples shall demonstrate the kind of information that the faculties get from the analysis.
First, basic and advanced indicators are built at the faculty level to enable comparisons between the project partners in total (Table 1 and 2). Differences in size of publication output as well as in absolute and relative citation rates can easily be determined.

Faculty	P	P_{uc}%	C	C_{self}%	C_{max}	JCS_m	FCS_m
F1	2431	41.3	11552	10.8	375	4.46	5.77
F2	2942	40.3	10868	17.4	225	3.51	4.74
F3	3148	36.1	16939	13.4	304	4.86	5.62
F4	3430	38.2	16819	14.6	255	4.49	5.41
F5	3597	35.4	18352	14.1	193	4.67	5.38
F6	3938	30.8	24435	15.6	230	5.38	5.97
F7	4776	36.3	27736	14.5	897	5.04	5.58

Tab. 1: Basic bibliometric indicators – faculty level 1997-2001.

Faculty	P	CR	RCR_j	RCR_f
F1	2431	4.75	1.07	0.97
F2	2942	3.69	1.07	0.87
F3	3148	5.38	1.13	1.09
F4	3430	4.90	1.11	1.04
F5	3597	5.10	1.12	1.05
F6	3938	6.20	1.16	1.13
F7	4776	5.81	1.18	1.17

Tab. 2: Advanced bibliometric indicators – faculty level 1997-2001.

To control the influence of publication language, the faculties also get the indicators in a second version, based exclusively on their English language publication output. As non-English publications generally show lower citation rates, citation indicator values are higher for all faculties in this case.
Next, disciplinary and journal profiles are generated for each faculty (Table 3 and 4). These profiles show which fields and journals the faculty members are most active in. Moreover, the tables reveal how far the publications in the respective field or journal contributed to the faculty's citation performance.

Field	P	C	C_{max}	CR	RCR_j	RCR_f
HEMATOLOGY	435	2481	95	5.70	0.50	0.73
BIOCHEMISTRY & MOLECULAR BIOLOGY	417	3885	797	9.32	1.04	1.17
CARDIAC & CARDIOVASCULAR RESEARCH	397	2132	95	5.37	0.87	1.13
PERIPHERAL VASCULAR DISEASES	344	2124	95	6.17	0.65	0.83
ONCOLOGY	318	1429	44	4.49	0.78	0.67
DERMATOLOGY & VENEREAL DISEASES	291	767	47	2.64	0.39	0.81
CELL BIOLOGY	282	2669	797	9.46	0.97	0.92
CLINICAL NEUROLOGY	260	1368	65	5.26	1.08	1.03
NEUROSCIENCES	252	1227	57	4.87	0.79	0.79
RADIOLOGY, NUCLEAR MEDICINE	242	667	30	2.72	0.89	0.80

Tab. 3: Disciplinary profile – faculty F7 top 10 fields 1997-2001 (P-ranked).

Journal	P	C	C_{max}	CR	RCR_j	RCR_f
JOURNAL OF INVESTIGATIVE DERMATOLOGY	168	315	31	1.88	0.19	0.52
BLOOD	167	783	71	4.69	0.33	0.59
INTERNATIONAL JOURNAL OF LEGAL MEDICINE	82	520	151	6.34	1.42	1.25
ANESTHESIA AND ANALGESIA	82	272	35	3.32	0.66	0.74
GASTROENTEROLOGY	80	60	40	0.75	0.04	0.12
EUROPEAN HEART JOURNAL	79	266	50	3.37	0.74	0.97
NAUNYN-SCHMIEDEBERGS ARCHIVES OF PHARMACOLOGY	76	37	19	0.49	0.09	0.10
CIRCULATION	71	857	95	12.07	0.72	1.77
JOURNAL OF BIOLOGICAL CHEMISTRY	67	839	87	12.52	0.94	1.63
JOURNAL OF HYPERTENSION	55	163	59	2.96	0.63	0.48

Tab. 4: Journal profile – faculty F7 Top 10 journals 1997-2001 (P-ranked).

As mentioned, a comparison of C to C_{max} can show if there are specific publications that dominate the faculty's citation impact ('citation stars'). The faculty members upon request can see bibliographic details for these.

The indicators shown here on faculty level are available down to the level of institute/clinic in every faculty (there are 80 institutional units and more in some cases). This is the main resource that the partners get from the project, together with the verified publication database.

Conclusion

Authorised bibliometric indicators can be a valuable information resource in the context of science policy decisions. In contrast to unauthorised standard products, they offer higher degrees of validity, transparency and acceptance inside the institutions under evaluation, because the scientists themselves participate directly in the verification process. Evaluated units no longer need to remain just objects of studies of others, but can have control over indicator construction down to every single publication. A major benefit of this approach is that the researchers are the first to see any results for their own unit. Thus they can use it as an in-house early warning system that will alert them on critical indicator values before they get confronted with rankings from outside.

Exact citation counts, normalised against discipline- and journal-specific expectation values provide far more insights into the scientific impact than any simplified use of proxy measures like impact factors.

However, even the best verified, thoroughly checked indicators cannot replace qualified peer review processes. Uncritical use of indicators at least in the long run may have inadvertent consequences. From experiences in Flanders comes the warning, that with permanent linking of indicators directly to funding decisions a situation may emerge, where even "the productivity of the system as a whole may decline".[13] Formula-based funding policies should in any case be tested very carefully and their consequences should be controlled on a regular schedule.

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Bibliometric short-term analysis of the medical faculties of Germany's public universities 1993-1999

Johannes Stegmann and Günter Grohmann

Introduction

Although peer review certainly is essential for quality assessment of scientific work, the bibliometric method may give rich supplementary information on research output, acceptance, and importance. Counting publications and reference citations may even be the initial point of a thorough evaluation of research facilities and programs (Kostoff 1998, van Raan 2000). In addition, bibliometrics is a powerful method for tracking, mapping, visualisation of science, especially when combined with more advanced techniques as, e.g., co-word and co-citation analysis (White & McCain 1997, He 1999, Qin 1999, Small 1999, van Raan 2000, Small 2000).
With the exception of the studies by Spiegel-Rösing (1975) and Lehrl (1997) which focus on publication output of German medical faculties, there was - as to our knowledge - no comprehensive study of German university medicine until recently when Tijssen et al. (2002) published the results of a bibliometric study of Germany's medical research system between 1982 and 1998. Although publication and citation windows and the level of aggregation differ from those in our study the general outcome - how the standing of Germany's university medicine in the world is - should be comparable between their and our study.
In this communication we present some general results on publication output and citation impact of the public German medical faculties in the nineties. Our study is named "short-term" due to the small sliding publication and citation windows (two years and one year, respectively) which are processed separately in order to be able to track in more detail the developments of the German research system located in the medical faculties.

Methods

Online searches were performed via telnet connection to the german host DIMDI (Deutsches Institut für Medizinische Dokumentation und Information). Counts of "research-relevant" papers (document types: article, review, note) were retrieved from multiple databases using search profiles specific for each of the 35 German public medical faculties. Productivity was measured by dividing the number of published papers by the number of scientific staff, the latter taken from data published by the Wissenschaftsrat (1998). Citation counts were retrieved from the databases SCISEARCH and SOCIAL SCISEARCH using DIMDI's CALL REFS command. Mean observed citation rates (MOCR) were calculated according to the synchronous method used for the calculation of ISI (Institute for Scientific

Information) defined journal impact factors, i.e. the number of cites received in one year by papers published in the two preceding years were divided by the total number of papers published by a medical faculty in these two years. Mean expected citation rates (MECR), i.e. assumptive citation rates derived from journal impact factors, and normalised mean citation rates (NMCR), i.e. citation rates normalised by field-specific impact factors, were determined according to standard procedures (Schubert et al. 1988, Braun & Glänzel 1990, Glänzel et al. 2003). Cumulated normalised citation rates were determined for each faculty according to the formula where $P_{subfield}$ denotes the number of papers published in the subfield.

$$NMCR_{cumul} = \sum (P_{subfield} \times NMCR_{subfield}) / \sum P_{subfield}$$

Journal impact factors and categories ("subfields") were taken from ISI's Journal Citation Reports (JCR) (ISI 1995-1999). For a couple of journals not listed in the JCR impact factors were constructed and included in calculation of field-specific citation rates (Stegmann 1999, Stegmann &Grohmann 2001).
The large amount of data downloaded were processed using JAVA-based software packages developed by us. For graphical displays standard software was used.

Results and Discussion

For our analyses, all papers are taken into account, whether being indexed in ISI databases or not. We find about 117,000 uniqe papers published by German medical faculties in the investigated period (1993-1998).
Figure 1 shows the yearly paper production which increases from about 17,000 in 1993 to almost 23,000 in 1998. The growth rate is - on average - nearly 6 % per year. A more or less constant fraction of circa 22 % of the papers are not included in ISI's databases SCISEARCH or SOCIAL SCISEARCH but were retrieved from other databases, including MEDLINE and EMBASE. Comparison with other data sources (Lehrl 1997, National Science Board 2000, van Leeuwen et al. 2001) and results of online retrieval for global biomedical research and its German fraction performed by us allow the conclusion that the numbers of papers retrieved by our search profiles are fairly correct (data not shown).

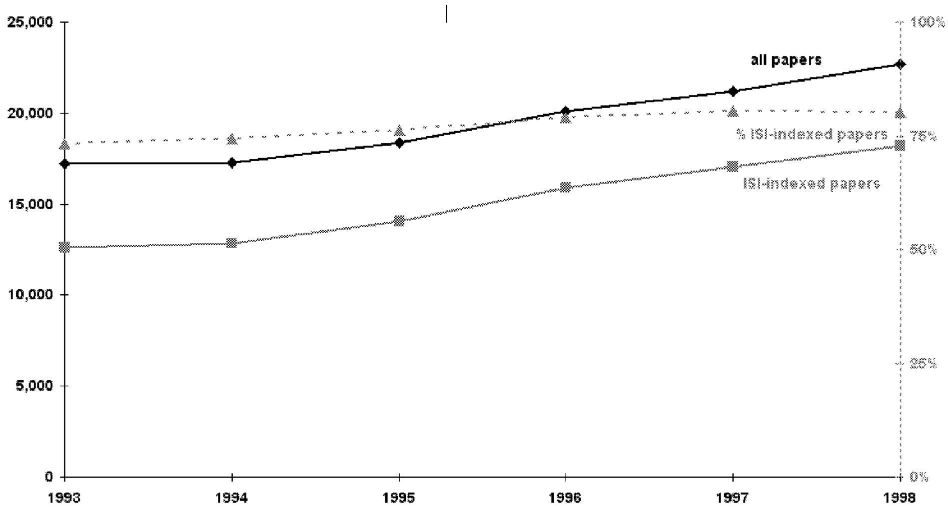

Fig. 1: German medical faculties: yearly output of published papers 1993 - 1998. (unique papers only, i.e. papers shared by two or more faculties were counted once).

Figure 2 shows productivity and impact (observed and expected) for all faculties during the period investigated. Productivity raises from 1.4 papers per two years per person in 1993-1994 to 1.8 in 1997-1998. The observed number of cites received range from nearly 61,000 in 1995 to more than 100,000 in 1999 (data not shown); accordingly, the MOCR value raises from 1.6 (1995) to 2.0 (1999) (Figure 2). The expected citation rates (MECR values) parallel the observed ones (Figure 2) with Pearson's R being higher than 0.9 (not shown).

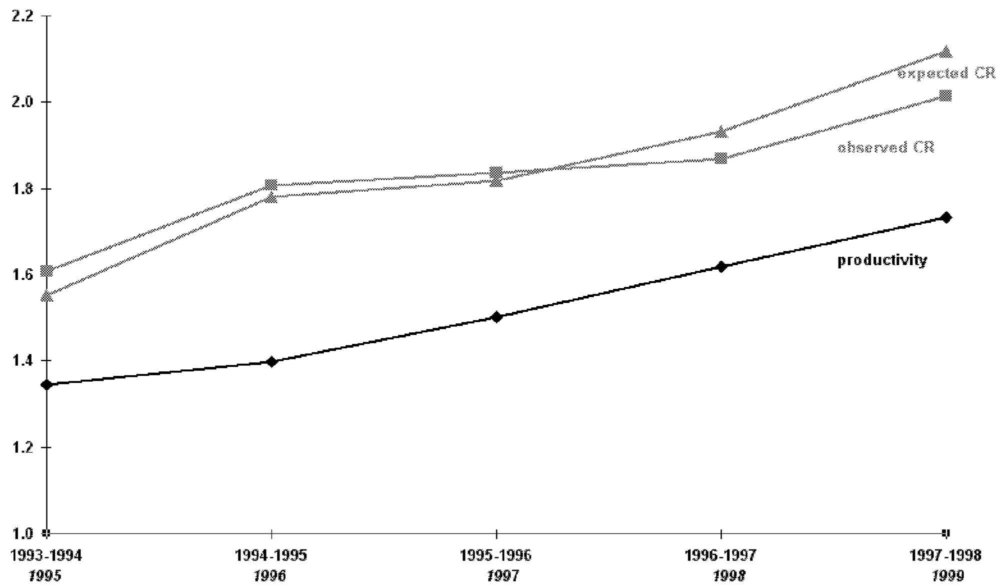

Fig. 2: German medical faculties: productivity 1993-1998, impact 1995-1999. Productivity was measured by dividing the sum of papers published by all faculties (multiple counting of shared papers) by the sum of staff personnel. Citation rates (CR) were calculated by diving the sum of cites of each faculty by the sum of papers.

A closer look at possible differences between "East and West" (Figure 3) reveals that the bibliometric increase is more prominent for the medical faculties in the *Neue Bundesländer*. Their impact doubles (from 0.8 to 1.6), thus approaching the initial values of the faculties located in the *Alte Bundesländer* which show impact ratios raising from 1.6 to 2.1. However, although the *Neue Bundesländer* treble their productivity (from 0.3 to 0.9) they do not reach the initial productivity of their counterparts in former West-Germany which raises from 1.6 in 1993-1994 to 1.9 in 1997-1998 (Figure 3).

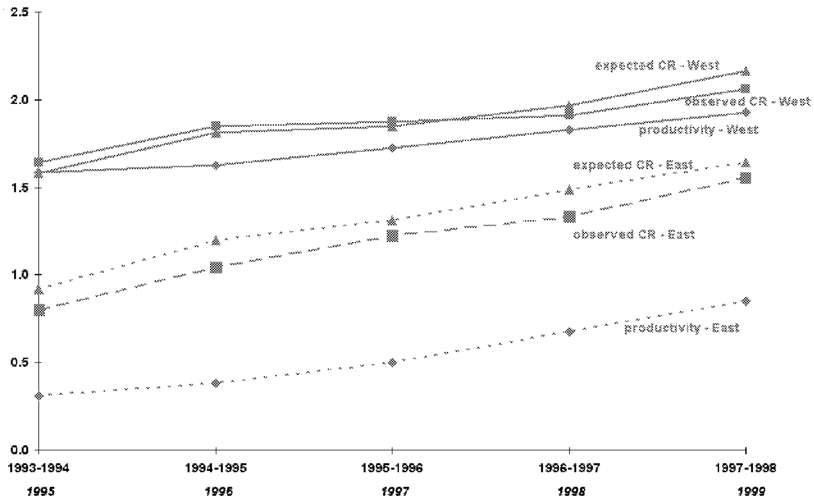

Fig. 3: German medical faculties: productivity 1993-1998 and impact 1995-1999. "Alte Bundesländer" (West) vs. "Neue Bundesländer" (East) (excl. Berlin).

The situation in Berlin (which was excluded from the data set used for Figure 3) is shown in Figure 4. Initially, Berlin had three medical faculties and university hospitals, two belonging to the Free University in "West-Berlin" and one (the Charité) belonging to the Humboldt University in "East-Berlin". In 1995 one of the Free University's medical faculty and hospital ("Rudolf Virchow") was assigned to the Humboldt University and merged with its medical facilities under the common name "Charité". The other faculty and hospital ("Benjamin Franklin") was now the sole medical facility of the Free University. This development can clearly be deduced from Figure 4. At the end of our observation period productivity (1997-1998) and impact (1999) of the two medical faculties are of (more or less) equal magnitude.

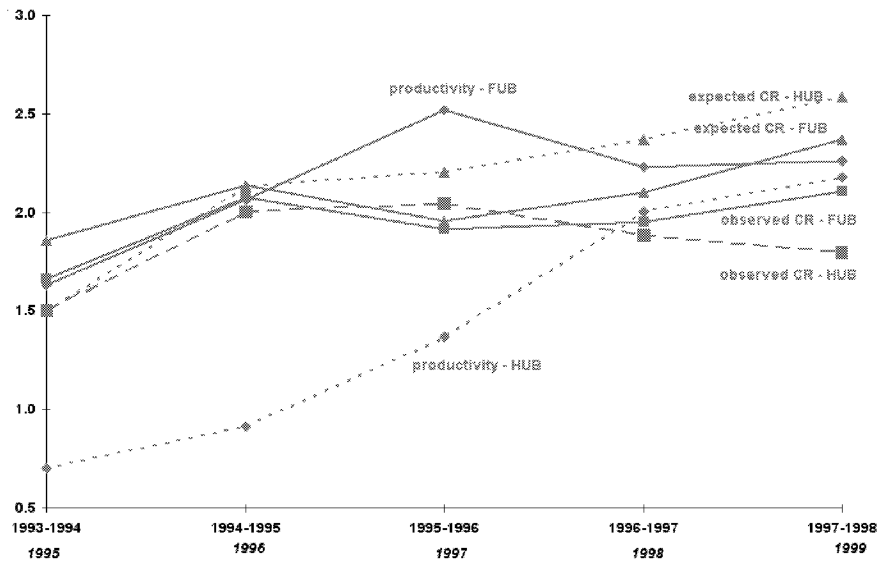

Fig. 4: Berlin medical faculties: productivity 1993-1998, impact 1995-1999. FUB: Free University Berlin; HUB: Humboldt University Berlin.

Figures 5 a and 5 b give a closer look at impact and productivity of each medical faculty. There is a sharp "productivity-border" between the "Eastern" and "Western" medical faculties in 1993-1994 (Figure 5 a) which is partially still present (but much more less expressed) in 1997-1998 (Figure 5 b). With respect to impact, the differences between "East" and "West" are not so distinct. Individual faculties have a comparably high impact level already in 1995 (Figure 5 a) and perform much better in 1999 (Figure 5 b). Please, note that the axes' origin is 0.0 / 0.0 in Figure 5 a and 1.0 / 0.5 (ordinate / abscissa) in Figure 5 b.

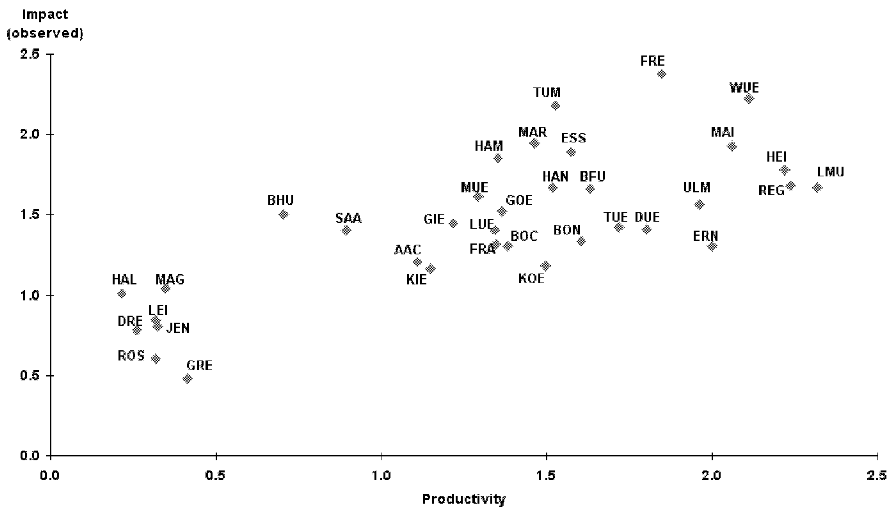

Fig. 5a: German medical faculties: productivity 1993-1994 vs. impact 1995.

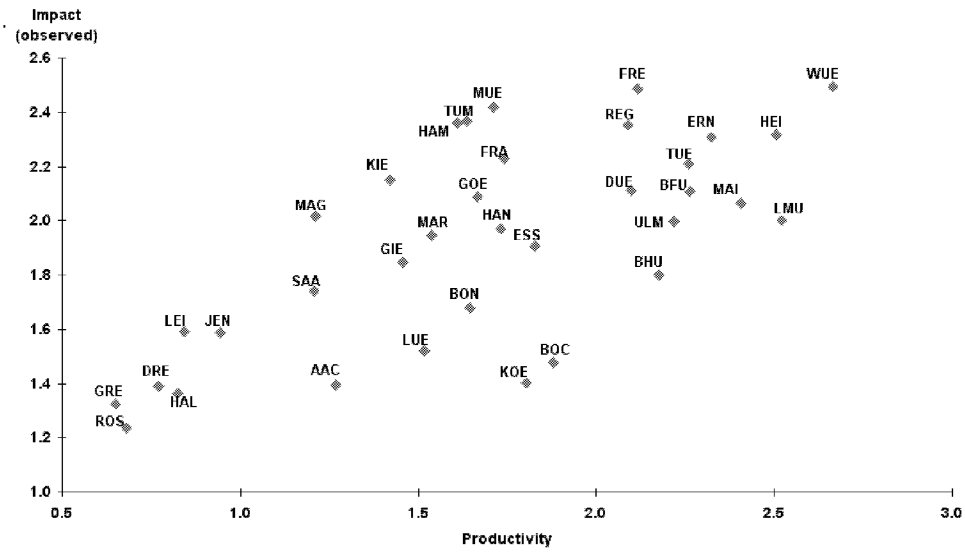

Fig. 5b: German medical faculties: productivity 1997-1998 vs. impact 1999.

Legend to Figures 5 a and b:

AAC: Aachen
BFU: Berlin Free University
BHU: Berlin Humboldt University
BOC: Bochum
BON: Bonn
DRE: Dresden
DUE: Düsseldorf
ERN: Erlangen-Nürnberg
ESS: Essen
FRA: Frankfurt am Main
FRE: Freiburg
GIE: Giessen
GOE: Göttingen
GRE: Greifswald
HAL: Halle-Wittenberg
HAM: Hamburg
HAN: Hannover
HEI: Heidelberg
JEN: Jena
KIE: Kiel
KOE: Köln
LEI: Leipzig
LMU: München Ludwig-Maximilians-Univ.
LUE: Lübeck
MAG: Magdeburg
MAI: Mainz
MAR: Marburg
MUE: Münster
REG: Regensburg
ROS: Rostock

To compare the impact of larger institutions with a wide variety of research activities one must take into consideration the impact characteristics of the different research specialities. We use the categories ("subfields") supplied by ISI (1995-1999). There are large differences between the faculties regarding single subfields (not shown). However, the cumulated field-normalised citation rates show a remarkable evenness for all faculties in 1999 (Figure 6 b). In the early citation period (1995) there are considerably larger differences between the faculties also after field-normalisation (Figure 6 a). Although there is a fairly good correlation between observed and field-normalised impact, the data in Figures 6 a and 6 b clearly suggest to use field-normalised citation rates whenever large institution like medical faculties are compared with respect to citation impact.

Figures 6 a and 6 b give also an impression of the international standing of Germany's medical faculties because the category-specific impact factors rely on all journals included in the categories, thus representing the "world-average". We see that Germany's medical faculties do perform (more or less) according to that world-standard, a result also found by Tijssen et al. (2002).

For any intra-faculty decisions regarding the strength and weakness of individual subfields, more detailed analyses or our data are necessary (in preparation). In addition, the international and inter-faculty co-operation behaviour of the medical faculties need to be investigated using our downloaded data (in preparation).

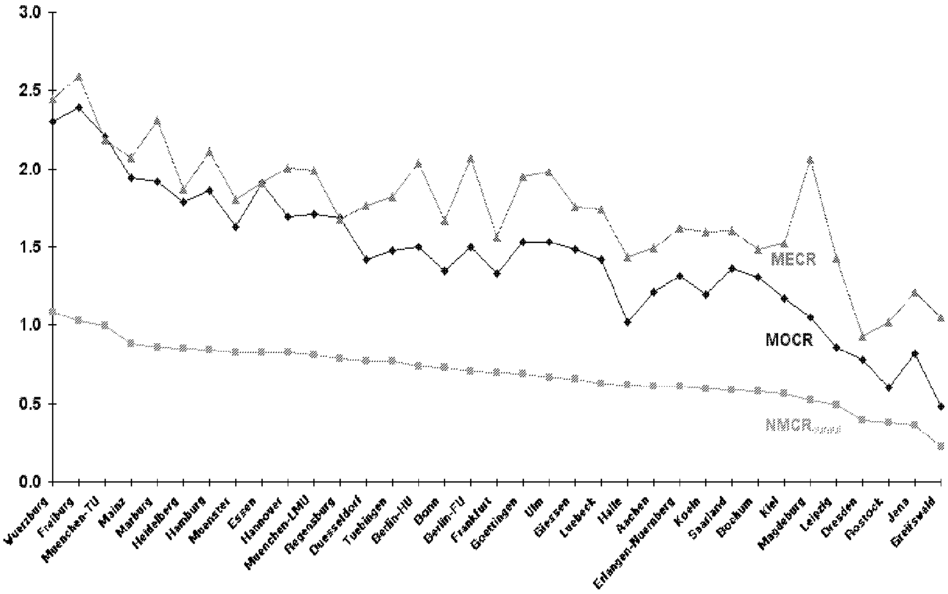

Fig. 6a: German university medicine: observed (MOCR), expected (MECR), and cumulated field-normalised citation rates ($NMCR_{cumul}$) 1995.

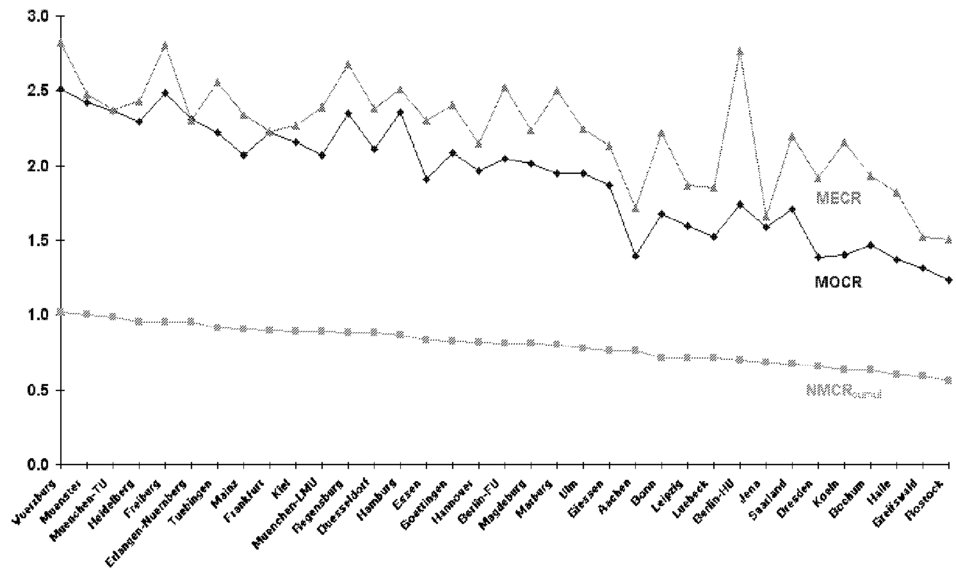

Fig. 6b: German university medicine: observed (MOCR), expected (MECR), and cumulated field-normalised citation rates ($NMCR_{cumul}$) 1999.

Conclusions

Our investigation gives a bibliometric description of the research performance of German medical university faculties in the more recent past which may serve as origin of closer individual inspections and as addition to peer-review based evaluations. An important general result is that all faculties have developed, also on an international scale, to a comparable level, provided field-specific normalisation is taken into account, thus representing a coherent well performing research system.

Acknowledgements

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Cocitation analysis - a tool for monitoring interdisciplinary research fronts. A case study on nanoscience

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Introduction

Cocitation cluster analysis is a very different bibliometric method compared to the computation of bibliometric indicators for institutional entities. The main difference is, that the structure of the analysed cocitation network is formed by the authors of the scientific publications themselves. By each single act of citing, which is a fundamental element of the formal scientific communication, links between important pieces of previous scientific work are indicated. The cognitive connection of these aspects of knowledge (theories, methods, techniques, instruments, problem solutions etc.) as represented by the cited publications is given in the argumentation of the current citing work. Even though the single link between two such items supplied by a single cocitation can be very weak, the computing of a very huge amount of cocitations will reveal significant density regions in the cocitation network. These groups of relatively strong co-cited publications can be seen as the shared intellectual cores of recent research themes, problem areas or specialities, which are represented by the respective co-citing publications. Because the resulting structure is based only on the citing patterns of the analysed publications, it reveals an inherent socio-cognitive structure of science, which is independent from external pre-configured classifications like thesauri or disciplinary categories. If based on a large interdisciplinary database like the Science Citation Index, the method of cocitation cluster analysis is appropriate for detecting very recent interdisciplinary research areas which are not reflected in the more inert institutional and classificatory systems of science and politics. The entities of the found inherent structure can be analysed afterwards with regard to institutions and disciplinary categories. Especially in the case of recently booming interdisciplinary research areas like Nanoscience and -technology, Neuroscience or Climate Research the method should be able to show the proportion of intertwining, overlapping or mixing of disciplinary categories in certain central research areas. In a research project focussed on the changes in the role of scientific disciplines we have chosen the field of nanoscience for a case study. Some results of the cocitation cluster analysis performed in this context will be given in the last section (of this talk/contribution) after a more detailed description of the method.

Method

The cocitation analysis uses the indirect linkages between jointly cited publications as indicators of their similarity. The most basic assumption is therefore that the citation marks a relation between the cited work and the citing article which is given in the context of the article.[1] The references to older publications given by the author and documented in the reference lists of the scientific articles can be seen as the cognitive resources which are of relevance for the reported work. They are all related to the cognitive contents of the citing article and therefore indirectly linked among themselves. From these direct relations between citing and cited articles the indirect links between the jointly cited pairs of publications are deduced: the cocitations.[2] In figure 1 this basic principle of the cocitation analysis is shown.

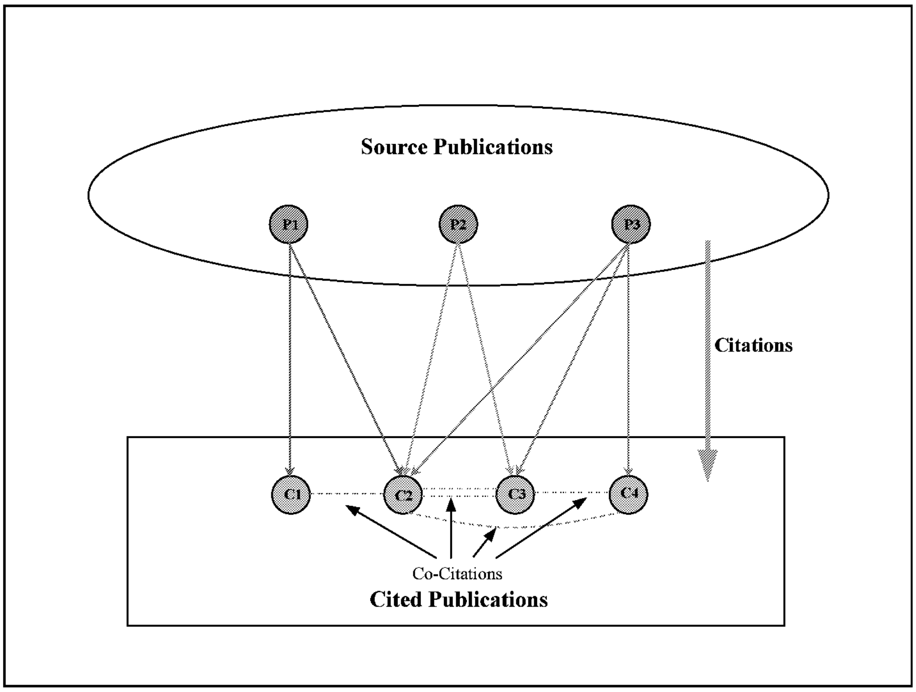

Fig. 1: Basic principle of co-citation analysis.

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[1] Special types of relation and the different functions of citations have been critically discussed by several authors. See for example Cozzens 1989, Edge 1979, or MacRoberts & MacRoberts 1986.

[2] The cocitation as an indirect link between cited publications was independently introduced by Small 1973 and Marshakova 1973.

The references from the source publications P1 – P3 to the cited publications C1 – C4 are shown as arrows. They establish cocitation links between the cited publications marked by dotted lines. In this schematic depiction C2 is the most frequently cited Publication, co-cited with all others (and two times with C2), whereas C1 is co-cited only with C2. Through the citations each of the recent source publications P1-P3 leaves individual connecting patterns in the huge amount of older publications which can be theoretically cited. The cocitation as a relationship between older publications is recognised and maintained by the analysed recent publications.
Another more implicit but important principle of the cocitation analysis is the assumption of a correlation between citation frequency and importance. The frequency of citations is seen as an indicator of the importance of the cited publication. Therefore the analysis is limited to the most highly cited publications.[3] The third basic assumption is related to the cocitations: The frequency of cocitations is proportional to the similarity of two cited publications and can be used - after normalising[4] by the single citation counts - as a measure for their similarity. The actual significance of a single cocitation link can be very weak in some cases, but a relatively large number of cocitations of a pair of cited publications can be seen as a meaningful indicator for a link between the co-cited publications and there cognitive contents. Cocitations which are rather contingent, at least in relation to the cognitive dimension, will probably not be frequently repeated by other authors.
The more citing publications are analysed the more differentiated and extended the cocitation network becomes. Because of their relative coherent citation pattern larger areas of thematically connected publications will add their cocitations forming relatively dense regions of the cocitation network which are representing the shared intellectual resources of the coherently citing publications. These networks can be identified by clustering the highly cited and heavily co-cited publications. With the clustering procedure the most dense parts of the complex cocitation network are grouped into clusters representing the included frequently cited and co-cited publications. A group of co-citing source publications – the research front - corresponds to each cluster. The cluster cores represent the broad range of cognitive aspects regarding research problems, methods, phenomena or artefacts referenced through the cited publications in the analysed source articles. The research fronts on the other side are the set of source publications in which these aspects are one of the important points. They mark the recent research areas with a relatively coherent referencing pattern.

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[3] We used integer citation counts to select the highly cited publications. Fractional citation counts proposed by Small & Sweeney 1985 were not necessary, because in the analysed fields the difference between the referencing behaviours of the involved research areas are small compared to the whole SCI.
[4] Normalising the absolute numbers of cocitation was proposed by Small 1976.

The found cluster structure can be aggregated through an iteration of the clustering procedure using the degree of the research fronts overlap as similarity measure.[5] The overlap of a pair of research fronts is defined as the number of source publications, which are citing articles from both corresponding clusters. The iteration of the clustering procedure results in a nested hierarchy of cluster levels. The entities of the cognitive dimension, which are represented by the clusters, become more and more general. On the lowest level the clusters can be seen as rather small specialities and on the more aggregated higher levels as subfields or much broader areas.
The cocitation cluster analysis is performed in the following main steps (Figure 2), starting from the data in the scientific literature database ending at the maps of science. Starting point of the analysis is a scientific literature database containing source documents with their references to other (older) publications. Usually this is the Science Citation Index, one of the most comprehensive multidisciplinary databases. If the technical requirements are not met to analyse a whole year's issue of the database, what is usually the case, if the online platform Web of Knowledge is used, the first step has to be the delineation of the research field. In case of nanoscience we have used a very simple search strategy as starting point. The publications of the database year 2002 with the pattern nano* in their title and in addition all publications from several relevant journals were downloaded. To improve this initial selection independently from document title or journals we used the most highly cited references as seeds for an extended search in the Science Citation Index.
If the first selection comprises a substantial part of the research field under examination, the highly cited references should be important pieces of its shared intellectual basis. The citing publications, which were not covered by the title word search, are added to the initial set, if they are citing a minimum of publications on the list of highly cited documents. About 5% of publications are added by this procedure, so that about 11300 publications build the field data basis for the cocitation analysis.
In the next step the downloaded data is organised to prepare the cluster analysis. For each cited publication the number of citations are count. For each actually co-cited pair of highly cited publications the absolute number of cocitations and the relative cocitation strength is computed. The relative cocitation strength - a normalisation of the absolute number of cocitations by the geometric mean of the single citation counts, known as Salton's Index - is used as the similarity measure for the cluster analysis. From the data set a total of 143.088 publications are cited, 76% of them only one time, the most highly cited publication has got citations from 632 of the "Nanoscience"-publications. In the cocitation analysis we used thresholds for the absolute number of citations and for the Salton-Index. From the total of cited documents only the 6,7% were analysed, which were cited four times or more. From these 9652 publications 136399 pairs are co-cited, which means that 0,1% of the triangular matrix cells can be filled with a value for the

[5] The clustering of cocitation clusters was introduced by Small et al. 1985.

similarity measure greater zero. But only about 44% of these cocitations are strong enough in terms of their relative strength to satisfy the threshold for the Salton-Index of 0.2. This should illustrate the significance of the analysed cocitations. The result of the process of data organising is a ranked list of cocitation pairs, which is the input for the cluster analysis

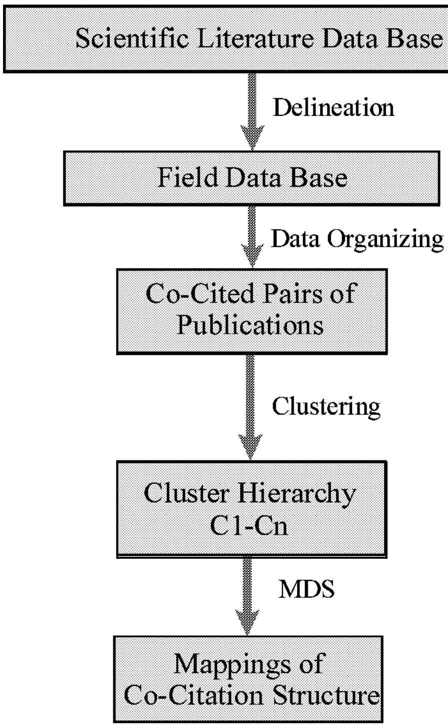

Fig. 2: Main steps of cocitation cluster analysis.

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The cited publications are clustered with a refined single linkage method. The result is a list of clusters each containing groups of heavily co-cited publications. For the nanoscience the cluster analysis results in 1055 clusters on the first level (C1). 70% of the analysed highly cited publications could be assigned to one of these clusters. The remaining publications are not connected to the network, partly because of the weakness of the existing links, partly because of their very general influence. Especially some of the very highly cited publications, show multitude of connections, all of them only moderate in their relative strength, so that it is difficult to assign them distinctly. This is sometimes seen as a problematic characteristic of the cocitation analysis. But it is not the aim of the method to assign the highly cited publications, or the recent citing publications on the other side exhaustively to clusters. The found clusters indicate a core of particularly dense areas of the whole scientific landscape or the analysed field of research. If the aim is a more comprehensive view of a certain region or aspect, the clusters can function as seeds for an extended analysis.

The last two steps, data organising and cluster analysis, can be repeated by taking the clusters as elements for the next clustering procedure. The iteration results in a sequence of aggregation levels from cited references up to the highest cluster level with only a few large clusters. In the case of nanoscience the procedure was carried out up to the third aggregation level. The 1055 C1-clusters were grouped in 99 C2-clusters, which were assigned to 9 C3-clusters. Inside the C3-clusters 38% of the initially selected highly cited publications can be found. Even if C1- or C2-clusters are not grouped on the next higher level, they are not lost for the analysis. All clusters on each level can be scanned for certain features or characteristics dependent on the guiding questions of the analysis. The regions of the whole cocitation network can be identified, in which selected authors, institutional actors, countries or themes are represented. The last step is a visualisation of the found structure in 2-dimensional maps using multidimensional scaling (MDS). In these maps the clustered elements of a selected cluster (detailed map) or the clusters of the highest cluster level (overview map) can be shown. The depicted elements, clusters or highly cited publications, are positioned in the map, so that the differences between their pairwise similarity measures (resp. their reciprocal values) and the corresponding distances in the map is minimised. The clusters or documents in the map are represented by circles. The size of the circle area is proportional to the size of the clusters research front in terms of publication number or, in case of mapped clustered publications, proportional to the number of citation. The descriptions of the clusters, which are given as annotations, are generated from the titles of the co-citing publications. Those phrases were selected, which are found in many of the most frequently co-citing front publications. The cluster titles have to be as short, concise and unambiguous as possible and therefore can not function as complete descriptions of the cognitive content, which is represented by the cluster. In the following some examples from the field of nanoscience are shown.

Results

The examples are presented from the field of nanoscience, because it was selected for a case study in a current research project on the changing role of scientific disciplines. The project is carried out at the IWT as a part of the research group "Science in Transition - Towards the Knowledge Society", funded by the VW foundation.

Nanoscience is postulated to be one of the most promising research fields with a broad scope of partly revolutionary applications. Not only most of the research problems around the various applications, but also the fundamental research on basic phenomena is seen as an interdisciplinary effort. In the United States and the European Union large funding initiatives have been launched, which are coupling their funding policies explicitly to the interdisciplinary of the programs and institutions. This strong external push on the field and important breakthroughs in instrumentation and techniques could be possible causes for the rapid growth of publications since 1990 (Figure 3). The strong increase in relative frequency of publications in the Science Citation Index can not be compared to any other booming field in the last decades. This outstanding development of an (at least postulated) interdisciplinary research field (by claim or by nature?) raises questions about the internal coherence of the research field, its cognitive development and the role and influence of the involved disciplines:

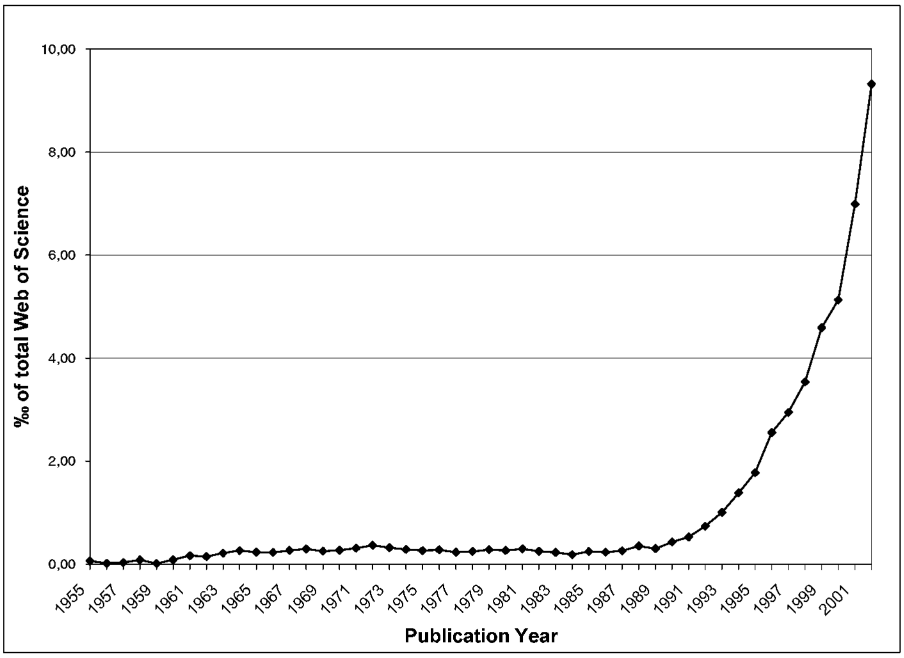

Fig. 3: Relative frequency of "Nano*" publications 1955-2002.

Is the field of nanoscience integrated by some central research problems affecting the work in various disciplines, perhaps even prevailing in interdisciplinary research teams, or is the field split into areas with a main focus on more disciplinary themes?
Is the work on the central themes and research problems really interdisciplinary? Are their significant differences between main research themes regarding the contribution of disciplines? Which are the most active institutional actors and what are the disciplinary profiles of the contributing institutions at central research fronts? Which are the most frequent combinations of distinct disciplines in the institutional cooperations on the research fronts? To answer these questions, the cocitation cluster analysis can supply information about the disciplinary and institutional structure of the main thematic regions in the field. Moreover the method can provide a tool for information retrieval. Based on

the cluster structure and the bibliographic information research fronts with certain characteristics can be identified and examined. Selected maps with additional information are presented in this chapter to demonstrate the potential of the method.
In the overview map of nanoscience (Figure 4) the 9 clusters on the highest aggregation level are depicted.[6]

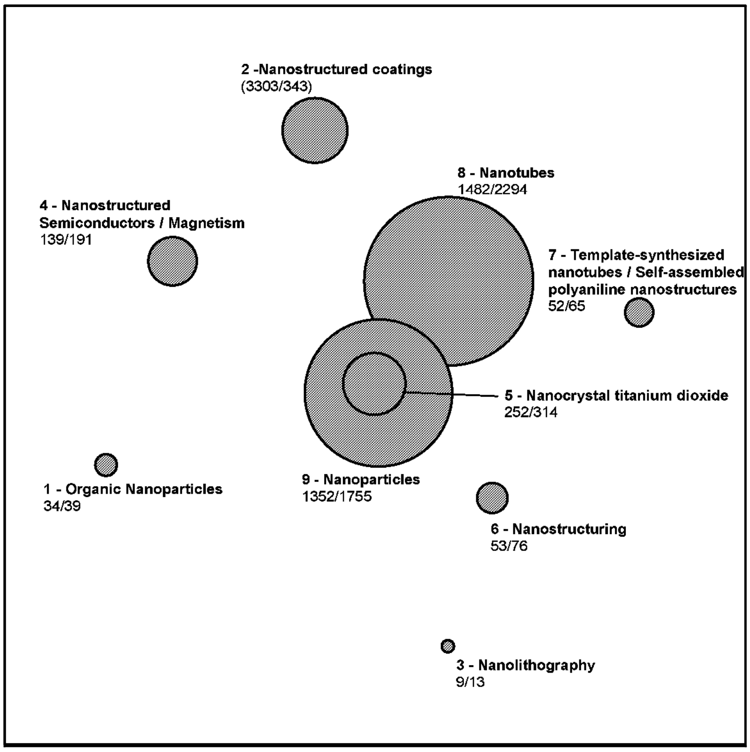

Fig. 4: Overview map of the field nanoscience 2002.

The most striking feature of the map on this level is, that two large and central areas are dominating the field: the C3-cluster Nanotubes with 2294 co-citing publications the largest strongly connected region in the field, and the cluster Nanoparticles, which is co-cited by 1755 publications. Both clusters share a huge part of their citing literature: about 500 nanoscience publications are citing at least one clustered publication from

[6] The circles symbolising the clusters are positioned in the map by MDS based on their cocitation strength, resp. the overlap of their research fronts. The size of the circle areas is proportional to the number of co-citing publications, which are forming the research fronts. Note that an actual overlap of circles in the map represents not their shared citing publications.

both cluster cores. Some much smaller areas, most of them surrounding the large central clusters can be seen on this level. To learn more about the mapped entities, we can look at the most active countries and institutional actors of the research fronts or their journal and disciplinary profiles.

The disciplinary profile on the basis of the journals, which were selected by the authors to communicate their results, should be an appropriate starting point for the exploration of the field.

In figure 5 the disciplinary profile of the whole field of nanoscience as represented by the filed data base is shown. To assign disciplinary categories to publications the ISI's classification system for journals was used. The dominating disciplines as indicated by the selected communication channels are "Materials Science, Multidisciplinary", "Physics, Applied", "Chemistry, Physical" and "Physics, Condensed Matter". From this profile we can conclude, that the selected "nano-" publications show a quite multidisciplinary scope, as reflected by the share of the large disciplines physics, chemistry and materials science (which for itself is more like a multidisciplinary research field, not fully established as an autonomous discipline). The multidisciplinarity of the field as a whole could be the result of the relevance of different nano-related research themes in different contributing disciplines or it could indicate a multi- possibly even interdisciplinarity inside the important coherent interconnected research areas of the field. The disciplinary profiles of the large and central cocitation clusters found on the overview map (Figure 4) will give a first insight in these regions.

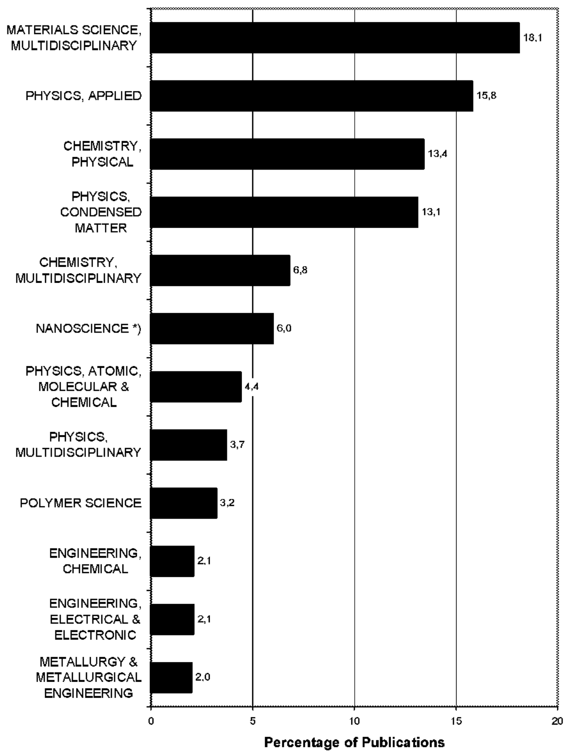

Fig. 5: Disciplinary profile of nanoscience 2002 (P>=2%).

For the co-citing publications of the cluster "Nanotubes" the relation of contributing disciplines (figure 6) is slightly different as compared with the whole field. The share of all contributing physical fields is higher and especially the field "Physics, Condensed Matter" ranks higher in the disciplinary profile. Besides these differences, which reflect the more special thematic orientation, the multiplicity of disciplines with a large proportion of publications on the research front is the same as for the whole field. For the other area, the cluster "Nanoparticles" the picture is somewhat different.

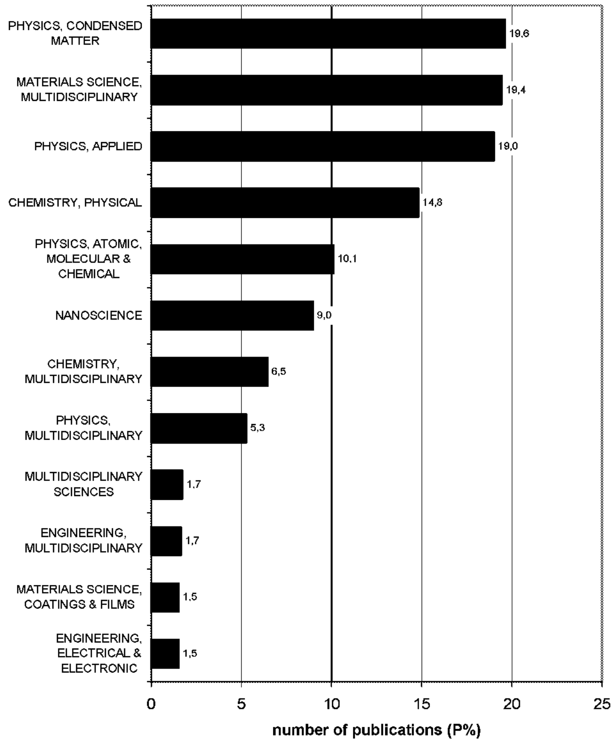

Fig. 6: Disciplinary profile for cluster C3-8 "nanotubes" (P >= 1,5%).

The disciplinary profile (figure 7) shows a much higher share of Chemistry, whereas the contribution of physical fields is significantly lower. But also in this large region the three main disciplinary areas Physics, Chemistry and Materials Science are represented within the fields on the top of the profile.
To examine if this multidisciplinarity can be found even inside the distinct cocitation clusters of the both large regions we can zoom into the cocitation structure.

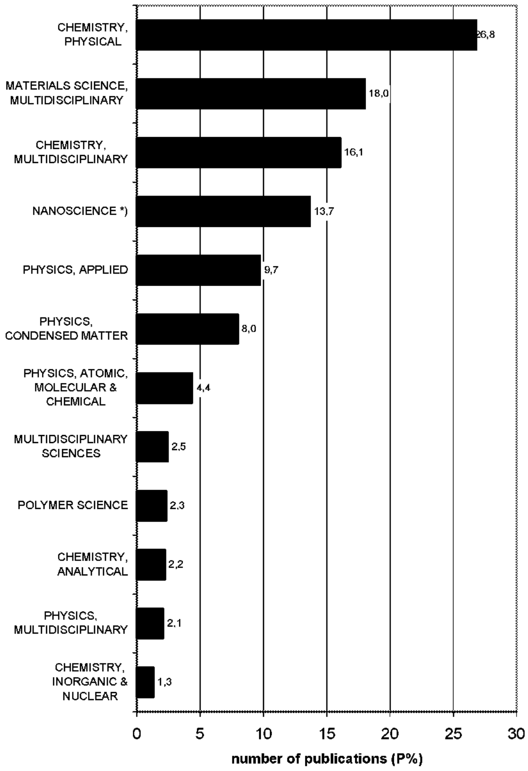

Fig. 7: Disciplinary profile for cluster C3-9 "nanoparticles" (P >= 1,5%).

In figure 8 the cocitation map of the cluster "Nanotubes" is shown. The largest coherent regions of the cocitation network inside this cluster can be found close together in the centre of the map. The cluster "Carbon Nanotubes/Hydrogen storage/field emission" is by far the largest cluster with more than 850 co-citing publications representing the research front. The 5 clusters of medium size (200 and 500 co-citing publications) like "Nanotube electronics", "Synthesis of nanowires" or "Non-carbon nanotubes" are positioned in the direct neighbourhood of the large central cluster. An exception is the cluster "CU nanowires/current carrying nanostructures" (C2-80) placed more apart from the centre on the upper right margin of the map. In the following figures we will compare the characteristics of this cluster with another one in the central area: the cluster "Synthesis of nanowires" (C2-94) including 125 highly cited publications, which are grouped in 15 C1-clusters and co-cited by 303 recent publications. The cluster C2-80 consists of 33 C1-clusters including 209 highly cited publications, which are co-cited by

221 recent publications. The central cluster C2-94 represents more central cognitive aspects of the mapped region as indicated by the average number of citations received from the analysed publications. The cited publications in the cluster C2-94 got 7,5 citations on the average, whereas the mean citation count for clustered publications in C2-80 comes to 3.8. The disciplinary profiles on the basis of the journal classification for the two clusters can be compared in figures 9 and 10. In case of cluster c2-94 the field "Materials Science, Multidisciplinary" leads the ranking of contributing research fields, followed by fields from Chemistry and Physics.

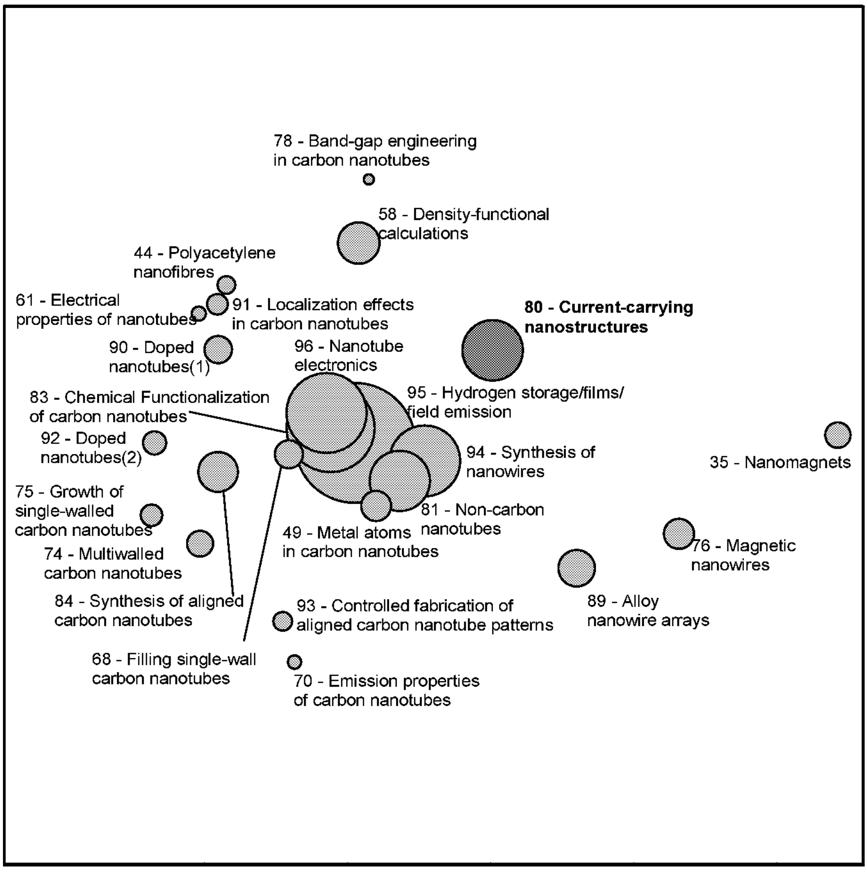

Fig. 8: Cocitation map of C3-8 "nanotubes".

More than 10% of the publications are published in "Nanoscience" journals, which are not classified by ISI (figure 9).

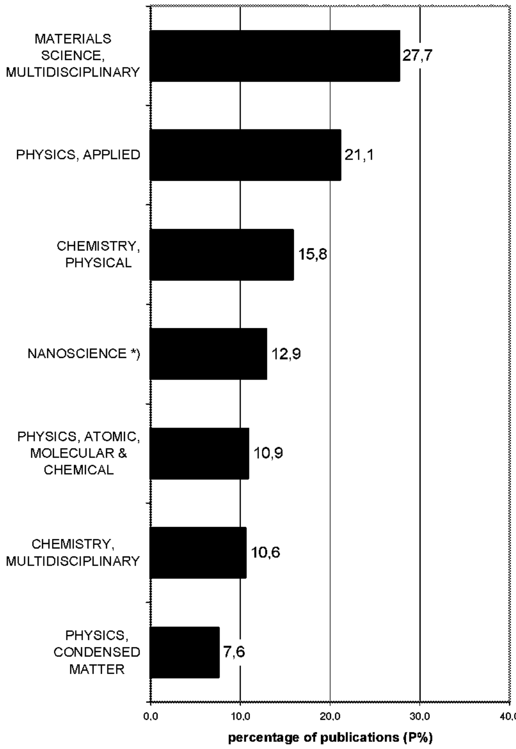

Fig. 9: Disciplinary profile based on journal classification for C2-94 "synthesis of nanowires" (P% >= 5).

The co-citing publications of the cluster C2-80 are published mainly in journals, which are affiliated to physical fields, primarily in the field "Physics, Condensed Matter", but fields from Materials Science and Chemistry are involved as well (figure 10).

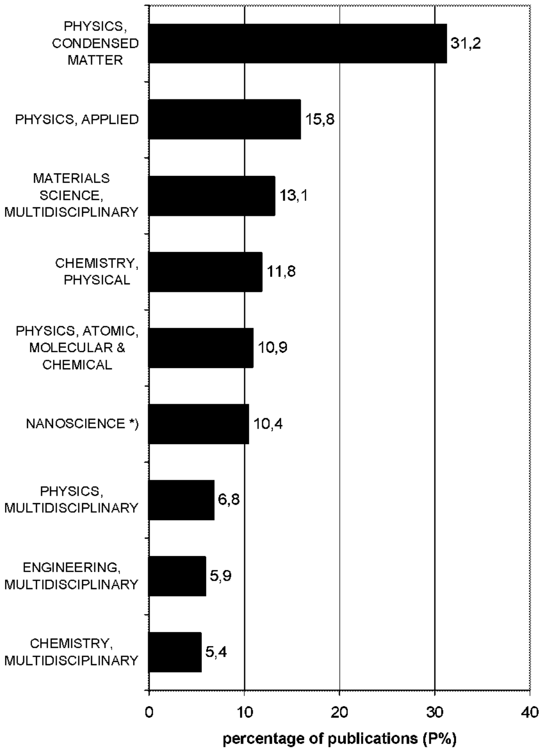

Fig. 10: Disciplinary profile based on journal classification for C2-80 "CU nanowires / current-carrying nanostructures" (P% > 5).

To examine, if the multidisciplinarity of the research themes represented by the compared clusters, which is indicated by the disciplinary orientation of the journals, results from a cooperation of researchers from different disciplines, we can look at the institutional addresses of the analysed publications. The most active institutional actors of the research fronts are listed in tables 1 and 2. Institutional addresses contain information about the disciplinary affiliation of the contributing researchers and therefore reflect the social dimension of multi- or interdisciplinarity.
For the cluster "CU nanowires/current carrying nanostructures" institutions from many countries are among the top actors, but each of them participating only at a relatively small proportion of the clusters co-citing literature (table 1).

N	Institution
10	Chung Ang Univ, Dept Elect Engn, SOUTH KOREA
9	Univ Calif Los Angeles, Dept Chem & Biochem, USA
6	Univ Liege, Dept Chim, BELGIUM
5	Calif NanoSyst Inst, Los Angeles, USA
5	Hebrew Univ Jerusalem, Fritz Haber Res Ctr Mol Dynam, ISRAEL
5	Helsinki Univ Technol, Phys Lab, FINLAND
5	Nanjing Univ, Natl Lab Solid State Microstruct, PEOPLES R CHINA
5	Penn State Univ, Dept Chem, USA
5	UNICAMP, Inst Fis Gleb Wataghin, BRAZIL
5	Univ Birmingham, Sch Chem Sci, UK
5	Tech Univ Denmark, Mikroelekt Ctr, DENMARK
4	Lab Nacl Luz Sincrotron, BR-13084971 Campinas, BRAZIL
4	Max Planck Inst Phys Complex Syst, D-01187 Dresden, GERMANY
4	McGill Univ, Ctr Phys Mat, CANADA
4	McGill Univ, Dept Phys, CANADA
4	Nanjing Univ, Dept Phys, PEOPLES R CHINA
4	Penn State Univ, Dept Elect Engn, USA
4	Univ Regensburg, Inst Theoret Phys, GERMANY
3	IBM Corp, Div Res, USA
3	Kyoto Univ, Inst Chem Res, JAPAN
3	N Carolina State Univ, Dept Phys, USA
3	Northwestern Univ, Dept Chem, USA
3	Osaka Univ, Dept Precis Sci & Technol, JAPAN
3	Univ N Carolina, Dept Phys & Astron, USA
3	Univ N Carolina, Kenan Labs Chem, USA
3	Virginia Polytech Inst & State Univ, Dept Phys, USA

Tab. 1: Institutions at research front of C2-80 by number of publications.

The large disciplinary areas chemistry and physics as well as materials science are represented by the contributing institutions, which are from many different regions. On the contrary the leading institutions of the research front "Synthesis of Nanowires" are almost exclusively from the Peoples Republic of China, and the United States are the only participating country outside the South East Asian region (table 2).

N	Institution
22	Chinese Acad Sci, Inst Solid State Phys, PEOPLES R CHINA
17	Univ Sci & Technol China, Struct Res Lab, PEOPLES R CHINA
16	Chinese Acad Sci, Inst Phys, PEOPLES R CHINA
15	City Univ Hong Kong, Ctr Super Diamond & Adv FIlms, PEOPLES R CHINA
14	Chinese Acad Sci, Ctr Condensed Matter Phys, PEOPLES R CHINA
14	City Univ Hong Kong, Dept Phys & Mat Sci, PEOPLES R CHINA
13	Nanjing Univ, Natl Lab Solid State Microstruct, PEOPLES R CHINA
12	Natl Inst Mat Sci, Adv Mat Lab, JAPAN
10	Univ Sci & Technol China, Dept Chem, PEOPLES R CHINA
9	Nanjing Univ, Dept Phys, PEOPLES R CHINA
8	Univ Calif Berkeley, Dept Chem, USA
7	Univ Washington, Dept Chem, USA
6	Georgia Inst Technol, Sch Mat Sci & Engn, USA
6	Univ Calif Berkeley, Lawrence Berkeley Lab, USA
5	Acad Sinica, Inst Solid State Phys, PEOPLES R CHINA
5	Nanjing Univ, Dept Chem, PEOPLES R CHINA
5	Natl Cheng Kung Univ, Dept Chem Engn, TAIWAN
5	Tsing Hua Univ, Dept Chem, PEOPLES R CHINA
5	Tsing Hua Univ, Dept Mat Sci & Engn, PEOPLES R CHINA
5	Univ Washington, Dept Mat Sci & Engn, USA
5	Yantai Univ, Dept Phys, PEOPLES R CHINA

Tab. 2: Institutions at research front of C2-94 by number of publications.

The disciplinary scope of the top institutions can be compared with the other example but the institutions affiliated to physics and materials science are a bit stronger represented at the research front of cluster C2-94. In the main this seem to confirm the results from the disciplinary profile which was computed through journal classification. To compare both dimensions, on the one side the more cognitive, based on the selected communication channels, which tells about the disciplinary scope of the reported research results, and on the other side the more social dimension of institutional cooperation, which indicates the different skills and perspectives brought together in the process of knowledge production, we computed a disciplinary profile from the institutional addresses by assigning the addresses to very general disciplinary categories.

The assignment had to be rough and incomplete because of the generality or unsharpness/indistinctness of some addresses. Nevertheless, the resulting profiles (figures 11 and 12) show a multidisciplinary scope for both clusters, each with a quite corresponding relation of the main contributing disciplines as compared to the journal based profile. Only the role of the institutions belonging to engineering disciplines and the share of special nano-related research institutions in case of cluster c2-94 as well as chemistry in case of cluster c2-80 is not equally reflected in the journal based disciplinary profile.

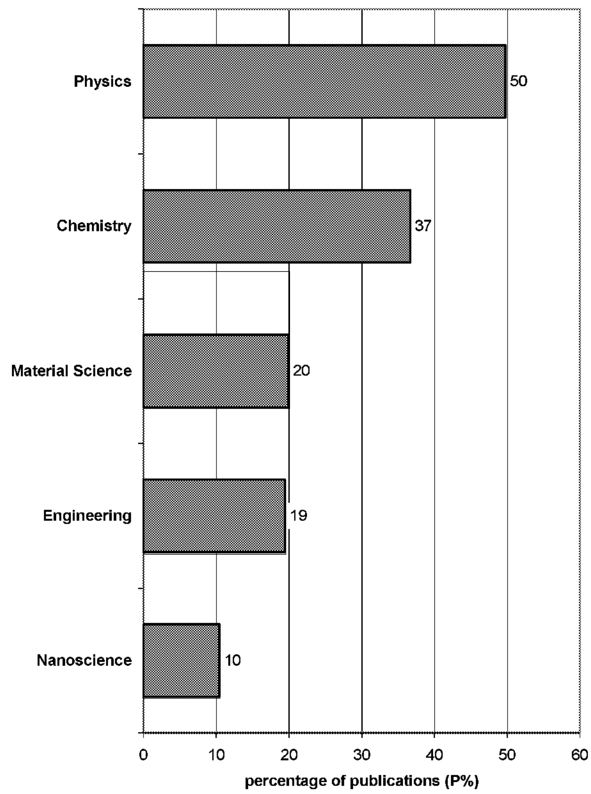

Fig. 11: Disciplinary profile based on cooperating institutions for C2-80 "current-carrying nanostructures" (P% >= 10).

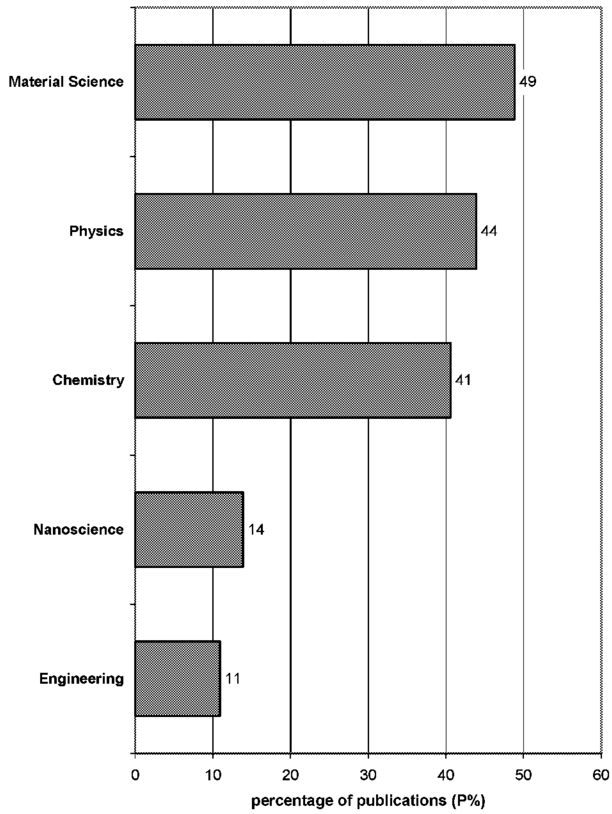

Fig. 12: Disciplinary profile based on cooperating institutions for C2-94 "synthesis of nanowires" (P% > 10).

The relative broad scope of research fields, which are covered in the lists of journals and institutional actors show the multidisciplinary character of the compared research fields, but it remains the question of interdisciplinarity: Is the work on the research themes, which are represented by the two compared clusters, done in a really interdisciplinary way or only at the same time by the institutions from the different disciplines? One possible indicator for interdisciplinary research is the co-publishing of articles by institutions with a different disciplinary orientation. Although there are various kinds of interaction indicated by the co-publishing of an article, the proportion of publications with collaborating institutions from different disciplines should be a good approach to measure interdisciplinarity in a given set of publications. This simple index of interdisciplinarity is above the field average of 31 for both of the analysed clusters.

The research front of the cluster "Synthesis of nanowires" exhibits a significant higher degree of interdisciplinarity, with more than 40% of the publications produced by at least two disciplinary actors. For cluster C2-94 the matrix of bilateral relations (table 3) between the most active disciplines in terms of shared publications reveals a central position of materials science, which is the most frequently connected category of the other large disciplines physics and chemistry. The "Nano"-institutions are collaborating most frequently with institutions classified as material science, but on a slightly lower level also with research institutions from physics and chemistry. A similar relational profile can be found for the engineering disciplines, but the institutions affiliated to this disciplines are only infrequently publishing together with the "Nano"-institutions.

Fields	Material Science	Physics	Chemistry	Nanoscience
Physics	60			
Chemistry	43	26		
Nanoscience	14	6	6	
Engineering	11	9	12	1

Tab. 3: Number of publications in cooperation of most active disciplines
for research front of C2-94.

For the cluster C2-80 the relations between the three most active disciplines are more equable (table 4), and "Nano"-science and Engineering both are more closely connected with Chemistry.

Fields	Physics	Chemistry	Material Science	Engineering
Chemistry	26			
Material Science	19	15		
Engineering	9	15	5	
Nanoscience	7	11	3	0

Tab. 4: Number of publications in cooperation of most active disciplines
for research front of C2-80.

These examples for the analysis of the cluster's co-citing literature have shown the capability of the cocitation cluster analysis to explore and analyse the scientific landscape of a field at a medium level of aggregation and with regard to selected dimensions. As a last example we will zoom much deeper into a selected region, to demonstrate the applicability of the method to examine small specialities, research themes or special cognitive aspects represented by highly cited and co-cited articles, which can be found in selected clusters.

Figure 13 shows the map of the cluster "CU nanowires/current carrying nanostructures" (C2-80). Only 17 clusters with larger research fronts or cluster cores are mapped, because these are the more dense regions of the cocitation structure, representing the important distinct cognitive themes. These are the electrical characteristics of different metal nanowires represented by the central cluster C1-1039, "Quantum transport in metal nanowires" and the clusters in the left upper area like "Ultrathin metal nanowires/atomic scale simulations" or "CU nanowires" and on the other hand the mechanisms of electronic transport on the molecular level in general or regarding other nanostructures like nanoparticle arrays or monolayers, which are shared topics of the clusters co-citing literature on the left side and, especially of the research front of C1-975 "Electronic transport of molecular junction". Both regions are bridged by papers co-citing articles from the cluster cores of the neighbourly clusters C1-975 and C1-1039. The comparison of the actor profiles on national and institutional levels reveals, that the research fronts can be clearly distinguished on this dimension. At the research front of cluster C1-975 the United States are by far the most active country, but the European Union is also strongly represented, especially by German researchers, whereas in case of C1-1039 the Asian countries Japan and South Korea, but also Brazil are at the top of the list together with the USA. This difference can be found again on the side of the clustered articles: In case of cluster C1-1039 US institutions have contributed to a much higher proportion of the cluster core than the following active countries (Israel, Belgium, France), whereas for the core of cluster C1-975 the contribution is more balanced between the top national actors USA, Denmark, Spain and Japan. The last step of the example for zooming into the socio-cognitive landscape of the nanosciences is the visualising of the underlying cocitation relations on the basic level of cited documents.

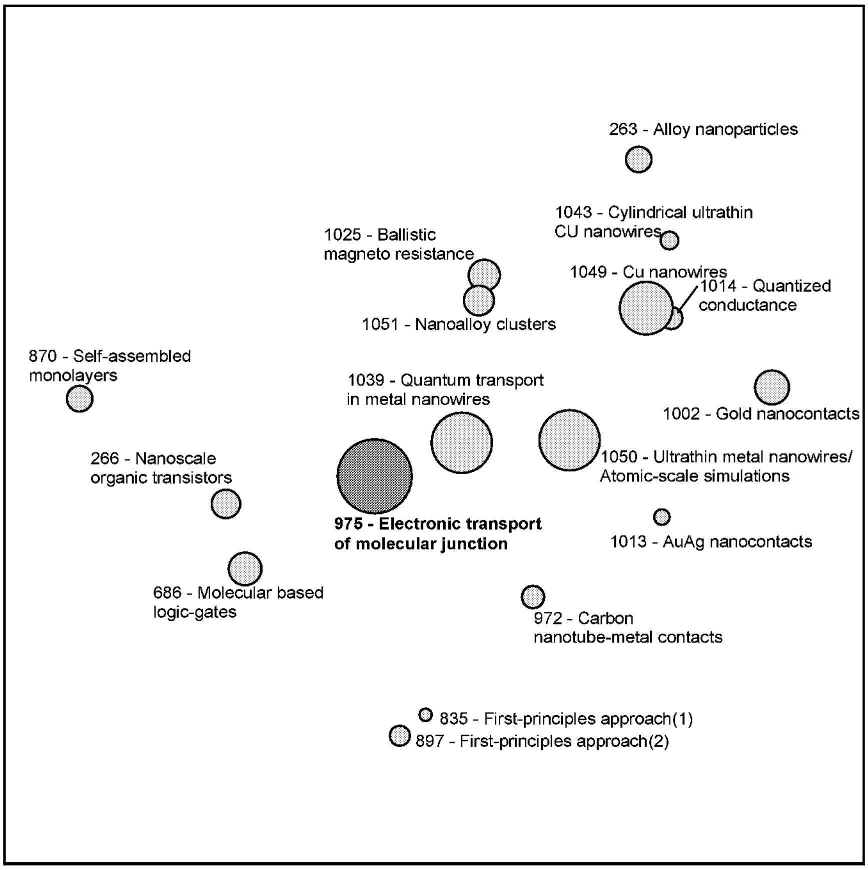

Fig. 13: Cocitation map of cluster C2-80 "CU nanowires/current carrying nano-structures".

On the map of cluster C1-975 (figure 14) the 30 cited publications are placed according to their mutual similarity in terms of relative cocitation frequency. The circle size is proportional to the number of citations received from the set of selected recent "Nano"-publications. A striking characteristic of the configuration in the map is the formation of two more dense regions. The larger group of papers on the right contains the most highly cited articles of the cluster and is composed of three subgroups. One of these groups of closely connected papers can be found in the centre of the map forming a bridge to the region on the left margin, which is dominated by papers from chemistry journals, whereas on the right side of the map most of the articles are published in journals from physics, and in the central region especially in the *Journal of Chemical Physics*. Regarding the thematic focus of the clustered publications a clearly distinction between the left group and the other regions can be found. Whereas the publications on the left are dealing with electronic properties of nanocrystall superlattices and quantum dot networks, the focus of the remaining publications is the conductance of molecular wires. With additional information about co-authors, national and institutional actors, disciplinary categories the map can be enriched to build the basis of an expert interpretation and validation. In other projects this has been done yielding interesting results. In three cases interviews with well known experts in the field showed a good accordance of the presented picture with the experts perception of the field. The experts could identify and interpret main regions of the maps as well as the position of single clustered publications, referring to the cognitive development of the speciality. [7]

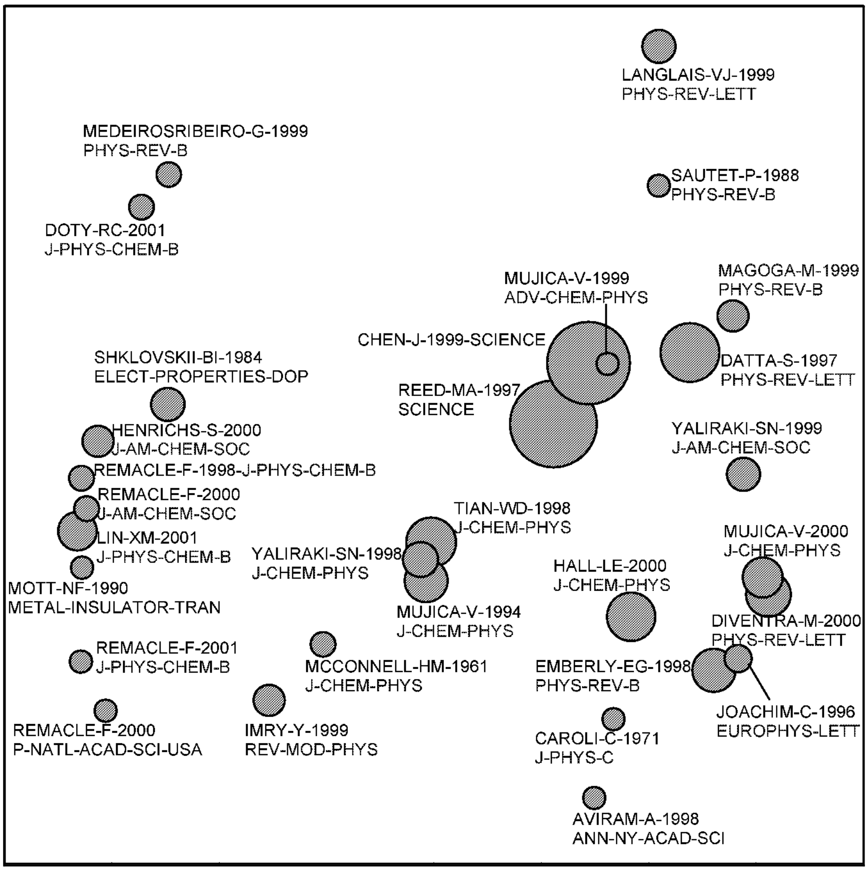

Fig. 14.

[7] The results of an expert interview have been discussed in Schwechheimer & Winterhager 2001.

Conclusions

The few examples for spots in the huge landscape of science, which can be explored with cocitation analysis have shown, that the instrument is able to reveal implicit structures on different levels of aggregation with a good selectivity regarding cognitive and institutional dimensions. For selected regions and research fronts especially information about the contribution of the most important disciplines in the field could be seen as an evidence for the interdisciplinarity of these parts of the field.

The meaningfulness of these findings depends on the variability of the used indicator among typical disciplinary research fields in the centres of the contributing disciplines. This check of significance and the comparison of the found structure with the individual views of experts of the field will be one of the next steps in the project, from which the examples have been token.

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International Case Studies

Journal selection policy and the contribution of Iranian researchers in international journals as specified in ISI

Jafar Mehrad and Mir Fazlollah Mousavi

Introduction

The main objective of ISI is to cover and reflect the most important research endeavours carried out throughout the globe. It, in fact, represents more than 16000 international journal titles, books and conference proceedings related to subject areas like Science, Social Sciences and Arts & Humanities.
The fact that ISI holding embodies 8600 international journals reveals the importance and priority given by ISI to this form of information over others. For each record, ISI provides complete bibliographical information including an English abstract, the name of the author, the publisher and so on and so forth (Garfield 1990).

Why selection?

Scientific journal indexes endeavour to cover all published scientific journals for the sake of completeness. Not only is this objective impossible to attain, but as the analysis of scientific writings indicates, it is also unnecessary. A random overview of the literature indicates that the majority of articles and research results are put to print in a limited number of journals. This is usually termed as the Bradford Law (Garfield 1979). In his studies, Bradford found out that in any subject area, the majority of articles, in general, and almost all highly valued articles, in particular, are published in a small group of journals, best called "core " journals.
The main objectives of the ISI database are two-fold: (1) to include, after evaluation, new journals thought to be useful to the end users, and (2) to rule out journals of little scientific value.

Evaluation process

The process of evaluation and selection of journals is an unseparable part of ISI, since at any given point in time, some new journals come in and some old ones go out of the database. This evaluation process is carried out every other week. Each year, more than 2000 journal titles are evaluated with the objective of including them in the database, but only 10 to 20 percent of them are eventually included.
In order for a journal to be included in ISI, it must observe a number of criteria as follows:

1. Be up-to-date
2. Have an international Editorial Board
3. Provide the keywords, abstracts and titles of the articles in English
4. Consider the feed backs received from the experts.

E-journals

As was stated before, one of the main objectives of ISI is to provide easy access to important journals published throughout the world. Many e-journals are evaluated as important, which is a good justification for their inclusion in ISI.
The selection criteria valid for e-journals are somewhat different from those mentioned above. It was no sooner that 1994 that the first e-journal found its way into ISI but since then a large number of them have attained the criteria needed for inclusion into ISI.

Discussion and findings

Publication of articles, resulting from research endeavours, in valid journals and periodicals, constitutes an important aspect of information production.
Based on Ulrich, the International Journals' Guide (1998), about 156000 journals are being published, at the moment, throughout the world. This journal holding covers 869 subject areas. From amongst these 156000 journals, 8800 journal titles are indexed under ISI: they cover three areas of Sciences (5800 journals, 66%), Social Sciences (1800 journals, 20%) and Arts and Humanities (1200 journals, 14%).
Of course, as was mentioned before, ISI, other than journals, includes 16000 books and conference proceedings as well. Almost 85% of the most important articles are published in just 2000 journals, to which 95% of the references are made[1].
Until the first half of 2001, 168 scientific journals have been approved in Iran by the Ministry of Science, Research and Technology and the Ministry of Health, Treatment and Medical Education From amongst these, 116 titles, 70 %, have been ranked as 'research-scientific', having the best quality, and 52 titles, 30%, as scientific, ranked after research-scientific journals. From amongst 116 research-scientific journals, 36 titles, 30%, are related to specific areas. Also, three of these journal titles are included in ISI index.
To carry out this study, first numerical data were collected concerning all the articles published world-wide in three major areas as classified by ISI between 1993 and 2000 (Table 1).
As shown in Table 1, in 1993, 955447 articles were written throughout the world. This number raised to 1164627 in the year 2000, which shows an increase of 1.2% (Figure 1).

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[1] <http/www.isinet.com/isi/hot/essays/199701.html>. The ISI Database: The journal selection process.

Figure 2 shows that in 1993, 323 articles were written by Iranian researchers and that this number increased to 1393 articles, 4.3 times more, in the year 2000.
In the area of Sciences, 755800 articles were written by researchers would- wide in 1993. This number raised to 956395 in the year 2000. In Iran, of course, this number raised from 299 articles in 1993 to 1369 articles in the year 2000, which shows an increase of 4.6 times[2].

Total Percent	The total articles	Percent of Sci	The world Sci	The world SS	The world A&H	Iran's total articles	Iran Sci	Iran SS	Iran A&H	Year
381%	955447	396%	755800	129369	177510	323	299	14	10	1993
387%	1008393	461%	798220	127910	191624	390	368	10	12	1994
455%	1069840	542%	853469	144394	199252	487	463	13	11	1995
559%	1127374	645%	901981	147194	211673	631	582	23	26	1996
623%	1144074	722%	923333	141518	19319	713	667	17	29	1997
892%	1166692	1068%	957717	141609	114767	1041	1023	17	1	1998
868%	1144432	1018%	945961	140073	110990	993	963	28	2	1999
1196%	1164627	1431%	956395	145125	115951	1408	1369	39	0	2000
	8780879		7092876	1117192	1141086	5986	5734	161	91	Total

A = Arts, H= Humanities, SS = Social Sciences, Sci = Sciences

Tab. 1: The total number of articles written by researchers within Iran and throughout the world between 1993 and 2000 as indicated by ISI.

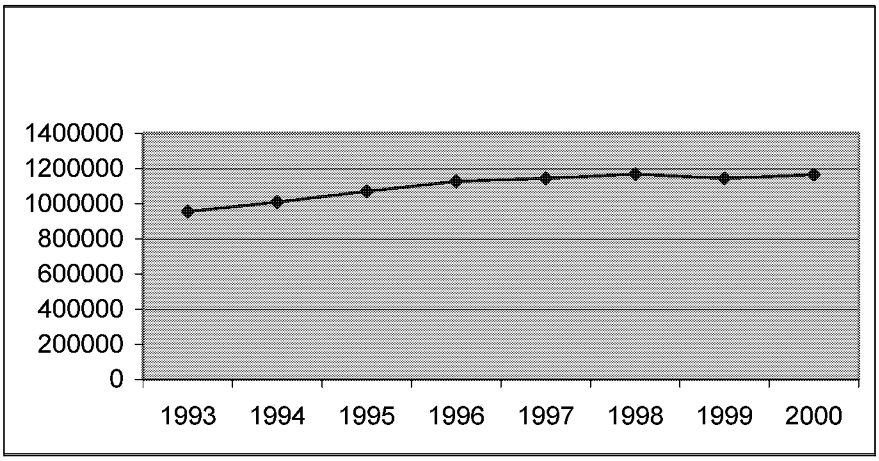

Fig. 1: Articles published by the researchers of the world between 1993 and 2000 as shown by ISI.

[2] ISI / Web of Science.

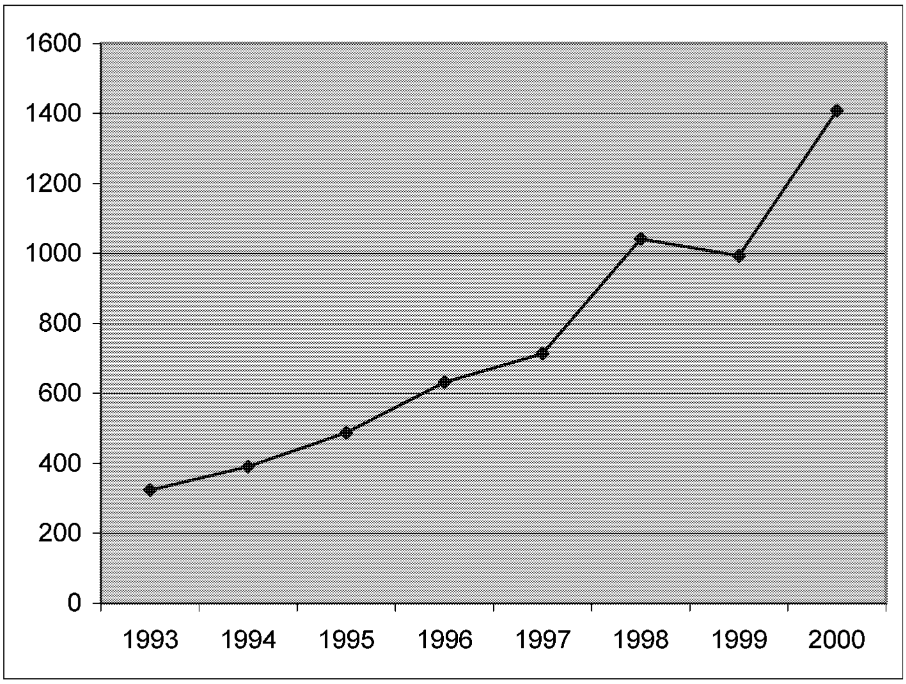

Fig. 2: Articles published by Iranian researchers between 1993 and 2000 as indicated by ISI.

In the Science Citation Index, which evaluated about 3300 journals, the contribution of the Iranian and Iraqi researchers was estimated to be 0.03% (Gibbs & Witer 1995). But in the year 2000 a great improvement occurred. In fact, in this year, Iran's total contribution raised to 0.12%. This contribution increased to 0.14% in the area of Sciences, which shows an increase equal to 460%.

According to the above source, the Science Citation Index, America had the highest contribution, 30%, in the production of articles. Other countries like Australia, 21.152%, Taiwan, 0.80% and Iran & Iraq, 0.03%, ranked 10th, 20th and 55th respectively. In deserves mentioning that the above statistics is rated to the year 1994, and since then the contribution of the Islamic Republic of Iran has shown a remarkable increase.

In fact, in the year 2000 Iran ranked as the 41st country, compared to the previous 55th status, in the production of articles throughout the world. One important point to be taken into account, here, is the proportion of articles written to the total population of each country. If this proportion is considered, American's rank as the first contributing country can no longer be preserved.

It deserves mentioning that between 1993 and 2000, in all 5971 articles, written by Iranian authors, are retrievable using the keyword 'Iran'. During the same period, there

were 114 researchers in Iran, each with 10 or more articles, whose articles could be retrieved using just the keyword. 'Iran'. Table 2 provides information concerning these researchers and their contribution. In all, they published 2512 articles. (The fact that some articles have co-authors have not been reflected in the statistics given in Table 2). The point that is important here is that each researcher contributed with more than 10 articles. The total number of articles written by these researchers is actually higher, since the list doesn't include the articles published by keywords other than the one given in Table 2.
137 was the highest number of articles written by an Iranian researcher during 1993-2000. (This means an article each three weeks). The lowest contribution was ten articles, 1.25 articles each year.

	rank	Author	Field of endeavour	Address	Key Word	No. of articles
1	1	Shamsipur	Chemistry	Razi University	Shamsipur M	137
2	2	Heravi	Chemistry	Al-Zahra University	Heravi MM	83
3	3	Dehpour	Pharmacology	Tehran Medical University	Dehpour AR	70
4	3	Yavari	Chemistry	Tarbiyat Modarres University	Yavari I	70
5	4	Zarrindast	Pharmacology	Tehran Medical University	Zarrindast MR	67
6	5	Iranpoor	Chemistry	Shiraz University	Iranpoor N	54
7	6	Ensafi	Chemistry	Isfahan Industrial University	Ensafi AA	53
8	7	Safavi	Chemistry	Shiraz University	Safavi A	52
9	8	Sohrabi	Chemical Engineering	Amir Kabir University	Sohrabi M	51
10	9	Firouzabadi	Chemistry	Shiraz University	Firouzabadi H	47
11	10	Hajipor	Chemistry	Isfahan Industrial University	Hajipor AR	44
12	11	Mallakpur	Chemistry	Isfahan Industrial University	Mallakpur SE	43
13	12	Shafiee	Chemistry	Tehran Medical University	Shafiee A	38
14	13	Saboury	Biochemistry	Tehran University	Saboury AA	37
15	13	Sharghi	Chemistry	Shiraz University	Sharghi H	37
16	14	Kumar	Physician	Shiraz Medical University	Kumar PV	35
17	15	Khorrami	Physic	Centre for Studies of Mathematics and Theoretical Physics	Khorrami M	34

18	16	Moosavi-Movahedi	Biochemistry	Tehran University	Moosavi-Movahedi AA	31
19	17	Boushehri	Chemistry	Shiraz University	Boushehri A	30
20	18	Moshfeghiyan	Chemical Engineering	Shiraz University	Moshfeghiyan M	28
21	18	Sarrafzadegan	Physician	Isfahan's Centre for Heart Surgery	Sarrafzadegan N	28
22	19	Abdolahi	Physician	Iran Medical University	Abdolahi M	26
23	19	Saidi	Chemistry	Sharif Industrial University	Saidi MR	26
24	20	Mohammad-poor Baltork	Chemistry	Isfahan University	Mohammadpoor Baltork I	25
25	20	Zolfigol	Chemistry	Abu-Ali Sina University	Zolfigol MA	24
26	21	Agamoham-madi	Physics	Centre for Studies of Mathematics and Theoretical Physics	Agamohammadi A	24
27	21	Faiz	Electronics	Tehran University	Faiz J	24
28	21	Jafarizadh	Physic	Tabriz University	Jafarizadeh MA	24
29	21	Karimipor	Physic	Sharif Industrial University	Karimipor V	24
30	21	Rustaiyan	Chemistry	Shahid Beheshti University	Rustaiyan A	24
31	22	Taher	Chemistry	Shahid Bahonar University	Taher MA	23
32	20	Tammami	Chemistry	Shiraz University	Tammami B	2
33	23	Alimohammadi	Physic	Tehran University	Alimohammadi M	22
34	23	GanjAli	Chemistry	Tehran University	GanjAli MR.	22
35	23	Golabi	Chemistry	Tabriz University	Golabi SM	22
36	23	Tangestani-nejad	Chemistry	Isfahan University	Tangestaninejad S	22
37	24	Ghassemzadeh	Chemistry	Isfahan University	Ghassemzadeh M	21
38	24	Mojtahedi	Chemistry	Iran's Centre for Research on Chemistry and Chemical Engineering	Mojtahedi MM	21
39	24	Ghavamzadeh	Cancer therapy	Tehran Medical University	Ghavamzadeh A	20
40	25	Kaveh	Civil Engineering	Iran's University of Science and Industry	Kaveh	20
41	25	Shaabani	Chemistry	Shahid Beheshti University	Shaabani A	20

42	26	Afkhami	Chemistry	Abu-Ali Sina University	Afkhami A	19
43	26	Ajami	Chemistry	Iran's Centre for Research on Chemistry and Chemical Engineering	Ajami D	19
44	26	Karimi	Physic	Zanjan Centre for Research on Sciences	Karimi B	19
45	26	Massarrat	Physician	Tehran Medical University	Massarrat S	19
46	26	Motamedi	Physician	Bagiyat-Alla Medical University	Motamedi M	19
47	27	Bolourchian	Chemistry	Iran's Centre for Research on Chemistry and Chemical Engineering	Bolourchian M	18
48	27	Boshtam	Physician	Isfahan Medical University	Boshtam M	18
49	27	Jahani	Hematology	Tehran Medical University	Jahani M	18
50	28	Alizadeh	Chemistry	Tarbiyat Modarres University	Alizadeh N	17
51	28	Fathollahi	Physiology	Tarbiyat Modarres University	Fathollahi Y	17
52	28	Ghahramani	Physician	Shiraz Medical University	Ghahramani N	17
53	28	Mousavi	Chemistry	Tarbiyat Modarres University	Mousavi MF	17
54	28	Nazifi	Physician	Shiraz Medical University	Nazifi S	17
55	28	Oryan	Pathobiology	Shiraz University	Oryan A	17
56	28	Taheri	Chemical Engineering	Shiraz University	Taheri	17
57	28	Yamini	Chemistry	Tarbiyat Modarres University	Yamini Y	17
58	28	Marghussian	Mathematics	Iran's University of Science and Industry	Marghussian VK	17

59	28	Malekzadeh	Physician	Tehran Medical University	Malekzadeh R	17
60	29	Mahmoudian	Physician	Iran's Medical University	Mahmoudian M	16
61	29	Maraghechi	Physic	Centre for Studies of Mathematics and Theoretical Physics	Maraghechi B	16
62	29	Modarress	Chemical Engineering	Amir Kabir Industrial University	Modarress H	16
63	29	Semnanian	Physiology	Tarbiyat Modarres University	Semnanian S	16
64	30	Aghapoor	Chemistry	Iran's Centre for Research on Chemistry and Chemical Engineering	Aghapoor K	15
65	30	Asgary	Physician	Isfahan's Centre for Heart Surgery	Asgary S	15
66	30	Gharib	Physician	Shahid Beheshti University	Gharib F	15
67	30	Ghazi	Veterinary medicine	Shiraz University	Ghazi SR	15
68	30	Salehi	Physic	Shahid Beheshti University	Salehi H	15
69	30	Samini	Pharmacology	Tehran Medical University	Samini M	15
70	30	Salahi	Physician	Shiraz Medical University	Salahi H	15
71	31	Golnabi	Water and Energy	Sharif Industrial University	Golnabi H	14
72	31	Motamedi	Physiology	Shahid Beheshti University	Motamedi F	14
73	31	Nezakatgoo	Physician	Shiraz Medical University	Nezakatgoo N	14
74	31	Taajbakhsh	Chemistry	Abu-Ali Sina University	Taajbakhsh M	14
75	32	Dabir	Chemical Engineering	Amir Kabir Industrial University	Dabir B	13
76	32	Maleki	Chemistry	Shiraz University	Maleki N	13
77	32	Mansoori	Chemical Engineering	Amir Kabir Industrial University	Mansoori GA	13

78	32	Rafie	Physician	Isfahan's Centre for Heart Surgery	Rafie M	13
79	32	Rezayat	Pharmocology	Tehran Medical University	Rezayat M	13
80	32	Tabar	Physics	Centre for Studies of Mathematics and Theoretical	Tabar MRR	13
81	32	Tajalli	Physician	Shiraz Medical University	Tajalli M	13
82	33	Azizi	Physician	Shahid Beheshti University	Azizi F	12
83	33	Farsam	Pharmocology	Tehran Medical University	Farsam H	12
85	33	Khosroshahi	Mathematics	Centre for Studies of Mathematics and Theoretical	Khosroshahi GB	12
86	33	Mahmoudiyan	Mathematics	Sharif Industrial University	Mahmoudiyan ES	12
87	33	Manzoori	Chemistry	Tabriz University	Manzoori	12
88	33	Mirzadeh	Polymer	Iran's Institute of Polymer	Mirzadeh H	12
89	33	Moghaddam	Chemistry	Sharif Industrial University	Moghaddam FM	12
90	33	Peyvandi	Hematology	Tehran Medical University	Peyvandi F	12
91	33	Seddighi	Mathematics	Shiraz University	Seddighi K	12
92	34	Arfaei	Physics	Centre for Studies of Mathematics and Theoretical	Arfaei H	11
93	34	Gharibi	Chemistry	Tarbiyat Modarres University	Gharibi H	11
94	34	Ghasemi	Parasitology	Tehran Medical University	Ghasemi J	11
95	34	Gholami	Physician	Shiraz Medical University	Gholami	11
96	34	Khajavi	Chemistry	Shahid Beheshti University	Khajavi MS	11
97	34	Mohajer	Chemistry	Shiraz University	Mohajer D	11
98	34	Pourgholami	Pharmacology	Shahid Beheshti University	Pourgholami MH	11
99	34	Pournaghi-Azar	Chemistry	Tabriz University	Pournaghi-Azar MH	11
100	34	Salajegheh	Civil Engineering	Kerman University	Salajegheh E	11

101	34	Sarbolouki	Biophysics	Tehran University	Sarbolouki MN	11
102	34	Shafaghi	Pharmacology	Tehran Medical University	Shafaghi B	11
103	35	Parsafar	Chemistry	Isfahan's Industrial University	Parsafar GH	10
104	35	Brumand	Physician	Iran's Medical University	Brumand B	10
105	35	Eshghi	Chemistry	Sistan and Baluchestan University	Eshghi H	10
106	35	Ghods	Pharmacology	Iran's Medical University	Ghods AJ	10
107	35	Hashemi	Chemistry	Isfahan's Industrial University	Hashemi MM	10
108	35	Medaeni	Chemical Engineering	Razi University	Medaeni SS	10
109	35	Mehrabzadeh	Polymer	Iran's Institute of Polymer	Mehrabzadeh M	10
110	35	Montazeri	Physician	Jahade Daneshgahi	Montazeri A	10
111	35	Rezaian	Internal Physician	Shiraz Medical University	Rezaian GR	10
112	35	Rezakhani	Internal Physician	Shiraz Medical University	Rezakhani A	10
113	35	Salehi	Chemistry	Razi University	Salehi P	10
114	35	Zeynizadeh	Chemistry	Shiraz University	Zeynizadeh B	10

Tab. 2: Fields of endeavour and addresses of the Iranian researchers who contributed, between 1993 and 2000, with at least ten articles with the keyword 'Iran'.

From among these 114 researchers, 44 researchers, 38%, are chemists. This shows the priority and importance given to this field in Iran. Studies show that towards the end of the period 1986-1997, Clinical Medicine, 28.7%, Physics, 15.1%, Biochemical Research, 14.9%, and Chemistry, 12.5% have ranked first to fourth, among different fields throughout the world respectively. After these two groups, researchers in the area of Pharmacology ranked third with 199 articles, 8%, written by seven researchers.
Now there is the question of how many articles should be published in order for our country to be one of the top-ten contributors of information? The answer is 21000 articles. If we publish 9000 articles each year, we'll be one of the top-twenty contributors.

Now, let's look at the information production potentials of Iran based on the statistics printed by the Ministry of Science, Research and Technology (Iran Higher Education Statistics 1998-1999).

1) Faculty Members of the Ministry of Science, Research and Technology, and Ministry of Health, Treatment and Education:

The number of faculty members in the academic year 1999-2000:
25000

2) Graduate Students of governmental institutes in the academic year 1999-2000:

1. PhD 10547 students
2. MA/MS, 30093 students
3. MD and DVM, 36906 students

3) Graduates of governmental institutes in the academic year 1998-99:

1. PhD 1318 students
2. MA/MS 6700 students
3. MD and DVM 5394 students

If each faculty member writes just a single article each year, in all, 25000 articles will be published. But, at the moment, just 5000 articles are published in home and foreign journals. It seems that only 2000 (8%), faculty members are active in information production and more than 90% of them are not involved in this endeavour at all. In fact, although some faculty members publish even more than 30 articles each year, the majority of them don't publish even a single article during the same period.

Following the change occurred in the title of the Ministry, from 'Higher Education' to 'Science, Research and Technology', it is expected that a priority be given to information production rather than information use.

Nowadays in Iran, MA and MS students work some 6-12 months on their theses. Now, if writing an article or solving an important problem is made a prerequisite for holding the thesis defense session, this will result in 6700 solved problems, or better hundreds of articles. Forcing PhD students to write two articles, or write one article and solve an important problem, will result in 2600 articles and solved problems in Iran. Similarly, 5394 articles will be produced if students of MD and DVM are forced to write an article or solve a problem before they graduate from the university. It is necessary to note that there might be an overlap between the statistics given for faculty members and those given for the students, since in many cases authors from both groups are involved in writing an article. What is important here is that we have based our discussion on the minimum contribution of each group. As was mentioned earlier in this article, some Iranian researchers are very active in information production. Some active students may publish up to ten articles in international journals. It can be concluded that Iranian governmental universities can potentially produce 40000 articles each year. This number doesn't include the numerous works carried out in non- governmental universities and research institutes.

The availability of experts is an important prerequisite to get to this objective. Fortunately, in Iran there are lots of experts. Supporting them in their research endeavours will raise the country's information production rate considerably.

In this study, we concentrated on the quantity of the articles produced, but including discussions concerning the quality of the articles will make our discussions even more comprehensive. A brief study carried out on Chemistry revealed that just lately some works have been very influential. Articles published in journals like J. Phys. Chem., Anal. Chem., and Org. Chem. could be mentioned as some examples. This is indicative of the fact that the quality of the articles has also increased considerably. This is in part due to the expansion and establishment of MA/MS levels and also PhD levels in more and more universities within the country.

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Bibliometric research in China — its history, achievements, and the new challenges with which it will be confronted in the future

Ning Lu

Introduction

China is an ancient civilised country with a long history. The embryo of librarianship appeared early in the 13th century BC Due to profound social and historical reasons, the closed and conservative "Storage Building" culture reigned over the whole country for quite a long time, and, to a certain extent, trammelled the thinking and creativity of Chinese scholars. Thus, by the end of 1949, quantitative research on literature was nearly nonexistent in China. During the period from the founding of the People's Republic of China to the early 1960s, theoretical research on information science in China was mainly under the influence of the former Soviet Union, an independent and integrated system of the subject still had not been established. In 1964, Prof. Zhang Qiyu and Mr. Wang Enguang published a paper introducing SCI in a professional journal, which is known as the first paper in China associated with bibliometrics. During the time of 'Cultural Revolution' (1966-1976), heavy losses were inflicted on information science, which brought it nearly to a standstill. The vitality of research did not come back to life until 1979, when the reform and opening-up policy was put into practice. After more than two decades of arduous efforts, the development of bibliometrics has already laid its initial foundation and a favourable condition was basically created for the comprehensive development of research, training and practical application. Great progress has now been made and the discipline has already turned out to be a valuable branch of library and information science. This paper has been divided into four parts, which will present a full account of its applications in China.

A brief history of the development of bibliometrics in China and its main achievements (Qiu 1994)

Three phases in the development of bibliometrics in China:

1979-1982: the start-up phase

The introductory paper entitled "Objectives of bibliometric research and its applications" published in 1979 marked the formal dissemination of bibliometrics in mainland China. During this period, there were very few papers published and the subjects which they covered were quite scattered. The majority of these papers were associated with translation, introduction, or absorption of foreign research achievements, lack of independent and systematic research. In comparison with our foreign colleagues, the start-up phase for bibliometrics in China was relatively short. After a short period of 4 years, the bibliometric research entered its relatively concentrated development phase.

1983-1987: the initial development phase

In 1983, the Library and Information Science School of Wuhan University first offered "bibliometrics" course for undergraduate students in China. From then on, this discipline has been formally included in the curriculum in universities. In 1984, the first "Bibliometrics" textbook was published by Wuhan University. And in 1986, Wuhan University again offered a "bibliometrics" course for postgraduates. To date, there are 23 tertiary institutes which offer this course. Besides, research on bibliometrics was quite active and the papers increased sharply during this period. They were either associated with introductions or reviews of foreign research achievements, or applied research based on the practical situations in China.

1988-present: the full-scale development phase

Bibliometric research in this period was characterised by the equal attention paid to both theories and applications. Applications to scientific assessment and scientific and technical administration had been particularly widely carried out and many a remarkable achievement had been obtained. For example, in 1987, Zhao Hongzhou et al. established the ranking list of major universities in China, based on the number of their published papers, and this list aroused an intense response by the society. The Institute of Scientific and Technical Information of China created the Chinese Science & Technology Paper & Citation Database, which objectively assessed the social status of the scientific and technical standard of China, and the productivity and academic standard of major universities and research institutes; In addition, published monographs and teaching materials on bibliometrics have sprung up like mushrooms. All these transformed research on bibliometrics from the partial or fragmentary knowledge stage to a systematic knowledge stage.

Main achievements and progress made on bibliometric research in China

Stable annual publications and core information sources have been formed The growth of papers on bibliometrics in China is rapid and very phasic. Meanwhile, the distribution of papers in journals obviously demonstrates the rule of centralisation and dispersion. Further analysis shows that the growth of literature on bibliometrics, and the distribution of core authors and journals was basically in conformity with the bibliometric laws, e.g. the exponential growth law for literatures and the Bradford's law of scattering, that is to say, 80% of the papers are concentrated in the core journals which accounting for 20% of the total titles.

The social status of bibliometrics has been established and improved, related academic organisations formed, and cared for the administration organs concerned. In 1992, bibliometrics was formally specified as a class-3 discipline in the China National Standards (GB/T 13745-92). In the Encyclopaedia of China, 11 detailed entries have been arranged for bibliometrics. In 1991, the Committee on Scientometrics and Informetrics was established with the strong support of the Chinese Academy of Sciences, which marked the beginning of academic acceptance. During the past years, the National Natural Science Foundation in China financed over 10 projects on bibliometrics and scientometrics, which has added fuel to the spread and development of this subject in China.

The scope of research has been expanded and much progress made in several main topics

The scope of bibliometric research in China has far exceeded that of library and information science. It has been related to more than 50 disciplines and specialities. The most dominant and active area of which is medicine, following by agriculture and chemical engineering. Generally speaking, the main topics of bibliometric research in China are as follows : citation analysis and core journals, concentrating and scattering laws, literature statistics and its applications, pandect of bibliometrics, methods for citation analysis, applications to sci-tech forecasting and administration, talents assessment, literature growth and obsolescence.

The tools and approaches for bibliometric research have been modernised day by day

Besides introducing SCI, the Library of Lanzhou University first compiled the 'Chinese Natural Science Citation Index'. Since 1987, the Institute of Scientific & Technical Information of China has made multi-measures analysis of Chinese literatures, such as the ranking position of these literatures in the world and their citation frequency and distribution etc. During this period, the activities of creating bibliometric evaluation databases reached their peak point.

Backbone force for bibliometric research has been formed

Thanks to the popularisation of bibliometric education in China, many people with higher educational background have joined in the research group and a fresh batch of core authors is on stage. Their presence has enhanced the vigour of this subject. The majority of the core authors are young and middle-aged. They given their best in the front line with sharp vision and information consciousness, thus making themselves the core force in this field.

Academic co-operations and exchanges with foreign colleagues are thriving

Many Chinese scholars have established relationship with famous scientists such as Garfield, Braun, Griffith, Targe, etc. throughout the world. The International Conference on Bibliometrics has had Chinese representatives since its first session, while foreign delegates attended such international seminars which held in China. In 1993, Prof. Zhao Hongzhou was appointed to the editorial committee of 'Scientometrics'. In 2003, Dr. R. Rousseau, the well-known bibliometric expert from Belgium, was invited to be a guest professor at the Library of the Chinese Academy of

Sciences, and as academic consultant for the Chinese Scientometric Indicators Database.[1]

Bibliometric research in Taiwan Province, China[2]

It's worth saying that uncommon achievements have also been made in this field in Taiwan, China during the past years. Bibliometrics is not only on the curriculum for library and information science students, but also a mandatory or optional course offered in other faculties. Certainly, our colleagues in Taiwan Province also lay stress on the academic exchanges with scholars from the mainland and all over the world. From the reference list for students you can easily find some famous names. since 1990s, seminars were frequently held across the Taiwan Strait which have undoubtedly improved the overall standard on bibliometric research in China.

New trends of bibliometric research in China: developments from bibliometrics to informetrics

Currently, bibliometric research on knowledge units and related information has been carried out by Chinese scholars and segmental progress made. For example, the research on information quantification and clustering functions of knowledge elements for e-publications; the research on discrete distribution of scientific information by choosing keywords or descriptors from the literature as quantitative units (using Bradford's law as a reference) etc.

The convergent tendency of bibliometrics, scientometrics and informetrics

Since the 1980s, the convergent tendency of bibliometrics, scientometrics and informetrics has emerged in the world academic community. In order to go with this stream, two consecutive annual meetings on scientometrics and informetrics held in China chose this trend as their main topic. In 1994, the first seminar on bibliometrics, scientometrics and informetrics was held in China and the participants made an outline of co-operation and research projects in China in the course of the century, thus putting the assessment of scientific decision-making and scientific administration in a prior strategic position.

Start-up for research on webmetrics

Although research on webmetrics in China is still in its embryonic stage, and lag behind western countries, a group of young scholars in China has made valuable explorations in the field. For example, the quantitative analysis on web resources by using domain name analysis and citation analysis, in order to find their distribution pattern and inherent characteristics (in doing such analysis, web robot technologies and the Dublin Core set were used); putting forward and explaining the 'core websites' conception through the efforts of counting the clicks ratio of websites.

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[1] The Emissary of Scientific Exchanges between China and the Western Countries--Interview with Dr. Rousseau. <http://www.las.ac.cn/yjst/No_9/9_2_1.htm>.

[2]<http://www.lib.tku.edu.tw>.

Industrial colour added to bibliometric research

In order to face the transition of economic systems and improve their own innovative capability, many domestic research institutions have carried out society-oriented services such as statistical assessment and analytical consultancy based on their specialised databases. Some of them have even established quantitative assessment and statistical information consultancies with the status of legal person. These firms will eventually turn out to be a new mode of information service and consultancy industry.

Internationalised tendency continuously enhanced

As a member country of WTO, China will certainly internationalise its bibliometric research. That means, either its topics, the determination of its aims, the choice of its methods, or the release, exchange and application of its achievements will have a higher start-up point. Consciousness of protecting intellectual properties will also be further strengthened.

Main mathematical tools used for bibliometric research in China and the introduction to the associated databases

Main mathematical concepts and models associated with bibliometric research in China (Qiu 1994)

It's very clear that without using mathematical tools and models, the complicated quantitative analysis of bibliometrics will not function any more. Thanks to their solid mathematical knowledge and rich theoretical attainments, Chinese scholars have made fruitful achievements in certain major fields.

Research on growth and obsolescence of literature

Chinese researchers established the GM model for literature growth and obsolescence by using functions of grey systems; compared the synchronism method and the inverse-time method; put forward the new concepts of citation half-life and literature half-life; carried out diachronic and synchronic observation and comparison for literature obsolescence by using grey relationship analysis and grey modelling approaches. Moreover, the real obsolete speed of literatures has also been studied.

Research on Bradford-Lotka-Zipf's Laws

Research on these three classic laws is also a' hot spot' in China. Scholars set up the low frequency formula for the distribution of papers published in journals; determined Bradford's nuclear zone by using an approximate method of three analytical lines; discovered the inherent relations among the classical laws (log rectilinear formula, Zipf formula, Brookes formula, Simon formula, etc.) (Sun 1994); established co-author networking systems and the model for hierarchical structures by using methods of systems engineering; modified the Price formula by using the principle of biased distributions; studied the words frequency distribution in literatures by using clustering methods; explained self-similarities of Zipf distribution by using the fractal method;

divided the classic laws and their inferences into two groups, the first group with the written description of Bradford's Law (also including Leimkuhler's Law, Mandelbrot's Law, Lotka's Law) as its core and the second with Zipf's Law (also including Brookes' Law, graphic description of the Bradford's Law) as its core. They then deducted the equivalent relationship among the first groups and the asymptotic relationship among the second groups, while the two groups were neither asymptotic nor equivalent.

Research on citation analysis

The number of papers on this topic was absolutely huge, accounting for 52.8% of the entire documents, which included the research on impact factor, immediacy index, fuzzy clustering analysis, citation analysis matrix etc.

Key databases used for bibliometric research in China

After the successful settlement of the bottleneck concerning Chinese character coding, Chinese scholars have made rapid progress in computer-aided bibliometric analysis and succeeded in developing a series of bibliometric tools for electronic documentary information in Chinese one after another. Here are just some important examples:

Chinese Science & Technology Paper & Citation Database[3]

This database was jointly developed by the Institute of Scientific & Technical Information of China and the Wanfang Data Company. It was put into formal operation in 1989, with annual updating. All the data were collected from 1447 core sci-tech journals and the annual statistical results for sci-tech papers and their citations by the Ministry of Science & Technology in China. By the end of 2000, it had collected 586,299 papers and 945,033 citations altogether.(more records will be added in the near future). This database is of great use in citation analysis.

Chinese Social Sciences Citation Index[4]

This database was jointly developed by Nanjing University and Hong Kong University of Science & Technology, first launched in 2000. It's a major achievement of the 'Ninth Five Year Programme of Humanities and Social Sciences' by the Ministry of Education in China. The database releases a series of important statistical indexes every year, such as the ranking sequence of the papers issued by universities and colleges in China, the ranking sequence of these papers in specific disciplines, the cited frequency of their authors etc. It provides reliable support for quantitative assessment of the research standard in the social sciences.

Chinese Science Citation Database[5]

This database was created in 1989, jointly launched by the Library of the Chinese Academy of Sciences and Qinghua University. It's the largest authoritative science citation index database in China, and may be rated as China's SCI. As of now, the

[3]<http:// 168.160.184.9/cecdb/product/cstpc.htm>.

[4]<http:// cssci.nju.edu.cn/xxfb.htm>.

[5]<http:// 159.226.100.178/html/sjkgk.htm>.

database has a coverage of around 1000 core sci-tech journals in Chinese or English (its core database has a stable source of 650 journals) and has cumulated records of 0.9 million papers and 3 million citations. It is of great value for research on cross-disciplines and newly emerging subjects, and is also designated for screening candidates for academicians of the Chinese Academy of Sciences, candidates who apply for "National Grants for Outstanding Youth", etc.

Chinese Humanities & Social Sciences Citation Database[6]

It was jointly developed by the Centre for Documentation and Information of the Chinese Academy of Social Sciences and Qinghua University in 2002, and has a coverage of 860 formally published humanities and social sciences journals (among them around 500 core journals). This database has cumulated 0.34 million papers and 1.2 million citations and is the largest humanities and social sciences database in China at the moment. It is used as an important tool for bibliometric research on humanities and social sciences.

Chinese Scientometric Indicators Database[7]

It is the first education-oriented and research achievements assessment-oriented fact database, jointly launched by the Library of the Chinese Academy of Sciences and Qinghua University in 1998. It uses CSCD and SCI as its statistical source. This database has set up over 100 important indexes such as research funds, key or open laboratories, talent development, issuance of patents, etc., and thus assesses the productivity of sci-tech papers in China and sequences them in specific fields fairly and objectively.

Chinese Core Journals Database[8]

This database was jointly developed by the Journal Affairs Consortium of University and College Libraries in Beijing and the Library of Beijing University. as a sub-project of "Bibliometric Research on Core Journals", the 'Ninth Five Year Programme of Humanities and Social Sciences' by the Ministry of Education. It is the most practical database for the assessment of core journals in China. At present, the database has a coverage of 1571 core journals. (excluding journals published in Hong Kong, Macao and Taiwan) It provides important reference for acquisitioning journals, guiding library users, assessing academic achievements etc.

Chinese Academic Journals Citation Reports Database[9]

This database was created in 2002, includes about 5000 high quality Chinese professional journals and has cumulated 0.78 million papers, 3.14 million citations. It provides fact support for quality assessment of the Chinese journals by using the citation analysis method.

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[6] <http://www.cnki.net/yantaohui/jieshao.htm#2>.

[7] <http://www.cnki.net/yantaohui/jieshao.htm#2>.

[8] <http://211.151.91.75/HXQK/mainframe.asp?encode=gb>.

[9] <http://www.cnki.net/wxpj/index.htm>.

Chinese Academic Journals Comprehensive Evaluation Database[10]
In 1999, Qinghua University started to develop this databases. Then, the Library of the Chinese Academy of Sciences, the Centre for Documentation and Information of the Chinese Academy of Social Sciences, the Library of Beijing University decided to use its data and agreed to establish the Research Centre for Bibliometric Evaluation of Chinese Scientific Literature with Qinghua University. Naturally, the 'Bibliometric Evaluation Projects of Chinese Scientific Literature' were carried out at the same time. Now, this database is still under further construction.

Typical cases of bibliometric research carried out by universities and academic institutions in China

Case 1. Analysis of the Chinese papers cited in MEDLINE(CD-ROM) during the past 5 years (1998-2002.05) (Leng 2003)
General situation of this case : From 1995 to 1997, the total number of Chinese papers cited in MEDLINE (CD-ROM) was11,947, and the number of journal titles was 29 ; From 1998 to May 2002, the total number of Chinese papers cited in MEDLINE (CD-ROM) was 11,485, and the number of the journal titles was 46.
After analysing the Chinese papers cited in the MEDLINE CD-ROM of the period from 1998 to May 2002, we can draw some conclusions as follows:
First, the number of the Chinese literature cited in MEDLINE has decreased while the journal titles increased
The increment of journal titles reflects the growth of biological and medical journals published in China. It also indicates that the quality and standard of the Chinese journals have been gradually approved by international authorities. But, the evaluative specialists of MEDLINE still maintain a strict criterion for each paper. Therefore, the decrease in the number of Chinese papers shows that their quality still needs improving in the future.

[10]<http://www.cnki.net/wxpj/index.htm>.

time leg year	number	the proportion of the magazines (%)
6	5	0.94
5	22	4.14
4	52	9.77
3	45	8.46
2	106	19.92
1	291	54.70
current year	11	2.07
total	252	100.00

Tab. 1: The time-lag of 46 journals cited in MEDLINE.

Second, the annual distribution of the Chinese literature cited in MEDLINE was uneven, with a relatively long time lag

The 8212 sampled papers were mainly published in 1998 (accounting for 31.42%) and in the period from January to May 2002 (accounting for 47.44%). As Table 1 shows, the time lags of the 46 journal titles are quite different because some journals were only cited in MEDLINE for individual years. Such a result basically accorded with the average time lag of 21.6 months for the Chinese literature cited in MEDLINE.

publication place	number of magazines cited in MEDLINE	proportion of journals (%)
Beijing	27	58.70
Chengdu	4	8.70
Shanghai	4	8.70
Taiwan	4	8.70
Chongqing	2	4.35
Changsha	1	2.17
Dalian	1	2.17
Shenyang	1	2.17
Tianjin	1	2.17
Wuhan	1	2.17
altogether	46	100.00

Tab. 2: The publication place distribution of 46 journals.

Third, the publication place distribution of Chinese literature cited in MEDLINE was relatively concentrated

Among the counted papers, many of them were published in Beijing, which followed by Shanghai and Guangdong. (27 titles out of the 46 journals were published in Beijing, accounting for 58.79%) This indicates the disequilibrium of the sci-tech development in different areas of China. The provinces and municipalities where over 100 papers had been published are relatively highly developed areas with high sci-tech research standard, and economically developed as well.

Case 2. Study on authors who published papers in 'China Tibetology' (Deng 2001).

'China Tibetology' [11] is a very famous journal for research on Tibetology in China. The data used in this case were collected from 'Tibetology Literature Database' and its time span is 12 years (1988-1999). By using Lotka's method, this case only selected the first author of each paper, altogether 109 authors and 611 papers. Table 3 shows the relationship between the number of papers (x) and the number of authors (y).

x	1	2	3	4	5	6	7	13
y	296	55	30	12	7	7	1	1

Tab. 3: The correspondence of number of papers (x) to the number of authors (y).

According to Lotka's Law $f(x)=c/x^2$, the formula could be further interpreted as: the number of authors (y_x) who published x papers was inversely proportional to the number of papers x issued by each author, namely, c (1)

$x^n + y_x =$

In this formula, y_x stands for the number of authors who published x papers in a certain field, n and c were two constants corresponding to the specific data set. In order to estimate the constant n in formula (1), measures were made to take logarithmic transformations of formula (1) and the linear relationship between log x and log y could be obtained, that was: (2).

$n\log x + \log y_x = \log c$

By using the least square method, the following formula could be obtained for calculating the value of n: (3)

$$n = N - \sum \times Y - \sum \times \sum \frac{Y}{N} \sum X^2 - (\sum X)^2$$

Soon afterwards, we established Table 4 which made use of the data from Table 3, then applied the associated data from Table 4 to formula (3), thus got n equal to 2.3675.

[11]<http://www.tibetology.ac.cn>.

x	y	x=logx	y =logy	XY	X^2
1	296	0	2.1713	0	0
2	55	0.3010	1.7401	0.5239	0.0906
3	30	0.4771	1.4771	0.7047	0.2276
1	12	0.6021	1.0792	0.6498	0.3625
5	7	0.6990	0.8451	0.5907	0.4886
6	7	0.7782	0.8451	0.6577	0.6056
7	1	0.8451	0	0	0.7142
13	1	0.1139	0	0	1.2408
$\sum$	409	4.8164	8.4582	3.1268	3.7299

Tab. 4: Data list used for calculating n.

Calculation of the value of C: The following formula could be used to obtain the asymptotic value of C if it was not equal to 2: (4)

$$C = 1/\sum_{X=1}^{n} 1/X^{n} + \frac{1}{20}\times 20^{n} + \frac{1}{n-1}\times 20^{n-1} + \frac{n}{24}\times 19^{n+1}$$

If n equalled 2, C equalled 0.6079. If n was not equal to 2, the resulting error could be ignored. By applying n=2.3675 to formula (4), C equal to 0.7151 could be obtained. Therefore, the Lotka distribution of the relationship between the number of papers and the number of authors in 'China Tibetology' could be expressed as: $f(y_x)=0.7151/x^{2.3625}$.

x	y	$\sum f_0(y_z)$	$\sum f_e(y_x)$	$\sum f_0(y_z)-\sum f_e(y_z)$
1	296	0.7237	0.7151	0.0086
2	55	0.8582	0.8537	0.0045
3	30	0.9315	0.9068	0.0247
4	12	0.9608	0.9337	0.0271
5	7	0.9779	0.9495	0.0284
6	7	0.9950	0.9598	0.0352
7	1	0.9974	0.9669	0.0305
13	1	0.9998	0.9685	0.0313

Tab. 5: List of the authors' cumulated frequency and the practical value of the cumulated frequency.

If D_{max} equalled to 0.0352, and the significant level was 0.01, the critical value D_{crit} could be expressed as:

$D_{crit} = 1.63 / \sqrt{\sum Y_x} = 1.63 / \sqrt{409} = 0.0806$

Because D_{max}=0.0352 was smaller than D_{crit}=0.0806, the distribution of the authors accorded with the Lotka distribution, namely, f(yx)=0.7151/$x^{2.3625}$.

The above statistical analysis indicates:

The number of authors and the number of papers in 'China Tibetology' were basically in conformity with the Lotka distribution.

The percentage of co-authored papers in the journal accounted for 11%, which was close to the rate at the time when Lotka lived. The majority of papers were published by single authors.

n=2.3675, indicates that most of the papers had been written by authors who with very few publications (accounting for 71.51%). Prolific authors were scarce. This phenomenon also shows a diversified content of the papers, that means, the journal not only possesses a group of fixed authors, but also pays more attention to discovering and cultivating new talents. It really epitomises the prosperity of Tibetology in China.

Tibetology is still in its developmental stages, so it's no wonder that the replacement of authors was frequent. Although there are only a few outstanding authors, prolific authors are emerging, and will come to light as time goes by. Meanwhile, some of the authors are attracted by other new professional journals, thus this journal has very few duplicated papers.

Case 3. Web evaluation and analysis of Chinese library science experts (Wu & Zhong 2002)

This case is an example of applied research on webmetrics. Tools and retrieval methods used in the case are as follows : The list of members of the 5th Academic Committee of the Chinese Society for Library Science (altogether 156 members) was used as a sample. Meanwhile, the China Journal Net and Netease (a Chinese search engine) were chosen as evaluation tools. The number of cited papers published on the China Journal Net during the period of 1994-2001 were added up to represent the data of CJN, on the other hand, keywords such as 'name + library' and 'name + Information administration' were selected for retrieval on Netease by using the Boolean search method, and the results were added up to represent the Internet data.

position comparison between CJN and Netease	the first 50 experts in the list	the first 40 experts in the list	the first 30 experts in the list	the first 20 experts in the list
coincident number between CJN and Netease	36	27	17	10
coincident percentage between CJN and Netease	72%	67.5%	56.7%	50%

Tab. 6: Comparison of the top 50 library experts between China Journal Net and Netease's evaluation.

Among the first 50 top library experts evaluated by CJN, doctoral tutors were all in the front row. Dr. Wu Jianzhong, Director of Shanghai Library, also ranked among them because his monograph 'New Perspectives on the Library of the 21st Century' had pointed out the orientation for the development of Chinese librarianship in the new century. As for the assessment with the Internet data, doctoral tutors were also in the front row. Table 7 shows the comparison of the data of CJN to those of the Internet. The coincidental percentage was as high as 72%. It demonstrates that the use of Internet to scientifically evaluate professional talents of library science is quite objective.

District net	Beijing	Guangdong	Wuhan	Shanghai	Nanjing	others
CJN	16	8	7	5	3	11
Netease	19	7	6	5	5	8

Tab. 7: Evaluation of the district distribution of the top 50 experts by using China Journal Net and Netease.

As Table 7 shows, the majority of library scientists are concentrated in Beijing, Guangdong, Wuhan and Shanghai, because these regions are key bases for library science education in China. The phenomenon that the talents are concentrated in the developed regions along the coast of China is determined by the economic differences among the regions.

System net	Universities	Libraries
CJN	27	23
Netease	24	26

Tab. 8: Evaluation of the systems to which the library experts belong by using CJN and Netease.

Table 8 shows that the majority of the experts work in libraries or do educational work in universities or colleges, each accounting for nearly 50%.

System net	Public libraries	University libraries	Library of Chinese Academy of Sciences	others
CJN	21	14	4	1
Netease	19	17	3	1

Tab. 9: Distribution of the experts in Chinese library systems.

Table 9 shows the distribution of the top 40 experts in library systems. The results of this evaluation which obtained by using CJN and Netease are almost the same: the public library system is the backbone of the librarianship in China, therefore, it has assembled numerous professional talents; the attraction of university and college libraries is just next to the former, the Library of the Chinese Academy of Sciences represents sci-tech libraries in China, which plays an important role that can't be ignored either.

This case indicates that the district distribution of the library experts in China is restricted by the economic environment. The educational system of library science plays a guiding role on the research of library science, while public libraries hold an important position in the Chinese library system.

Important roles played by bibliometrics in the course of further development of China and the challenges and opportunities with which it will be confronted

Important roles played by bibliometrics in the course of further development of China

Bibliometric research is an important prerequisite for establishing a national innovative system, promoting national and sci-tech competitive strength, as well as developing the knowledge economy in China.

Although China's economy has been developing rapidly during these years, the economic system and its growth are still under transformation. If China really wants to catch up with developed countries, it should pay great attention to sci-tech innovations. In 1997, the Chinese Academy of Sciences put forward a suggestion of creating a national innovative system (Hou 2002) in the hopes of enhancing the production, dissemination and use of knowledge, promoting China's economy into a knowledge economy, and raising its international competitive strength. Universities, colleges and research institutions will play an active role in such a system. Their academic standard, potentially economic value and social impact should be constantly assessed, examined and advanced. All these efforts can't be easily done without the involvement of bibliometrics.

Bibliometric research is a passport for China to enter the world's information family against the globalisational background

The advent of the Internet and the wave of globalisation have started to build our world into a real big family. With the aid of digital libraries, people from different countries and nationalities, with different ages or occupations, could come together. But the flood of information on the internet, with the good and the bad being intermingled, always make people confused and helpless. In order to arrange and exploit this information, information specialists have dedicated themselves to the research on retrieval engines, hyperlink, data mining, and metadata theories etc. Such front-line projects will unavoidably use bibliometrics as their tool. If just satisfied with creating a few more websites and paying no attention to the analysing and mining of in-depth information, we, the Chinese people, can not obtain the passport to the world information family.

Bibliometric research has bright prospect in e-business, e-government, exhibition industry, and other important social and cultural activities

Following the validity of WTO's historic decisions in Doha, the success in bidding for the 2008 Olympic Games in Beijing and the 2010 Expo Fair in Shanghai, China is now confronted with unprecedented developmental opportunities. Although economic transformation is full of difficulties, even hardships, it has offered a sufficient space for the development of e-business. Meantime, the advancement of democracy at grass roots endows e-government with a sacred task, which is, fully reflects the public opinions. At present, these e-affairs are still immature, lacking the scientific and quantitative guidance. Therefore, the bibliometric research in China has its new incisive points, such as analyses of enterprise's competitive intelligence, surveys of the information urgently demanded by the public, input-output analyses on the commercial operation of the Olympic Games, collection of Expo Fairs' information, etc. All these efforts will certainly widen bibliometrics' scope and background, get rid of its mystery, and integrate it into common people's life.

Problems and challenges with which the bibliometric research in China is now confronted

There are intellectual deviations of bibliometric research and the ideological concepts need to be further rejuvenated

China has a profound tradition of Confucianism which reigned for a long time. Thus, ruling classes in the feudal era did not give full support to intellectuals for their mathematical research, scientific innovations and inventions. Even now, such ideas still have left a negative influence on our society. Several years ago, those who used a few more mathematical formulas or models in their papers were criticised as being engaged in "metaphysics" or playing "digital games" (Qiu 1994). Although this situation has taken a favourable turn, some professionals still fear to use mathematical models for their research. Such phenomena even exists among the students from library and information science faculties (Luo 1996). Therefore, it needs time to completely reverse such intellectual deviations.

Disequilibrium exists in subject distribution and regional development of bibliometric research (Hu 2002)

At present, the main achievements of bibliometric research have been concentrated on fields such as library and information science, biomedicine, chemical engineering, etc., while with very few applications to the important humanities. Due to the strong social value and uncertainties of the humanities and literature, the scattering of their distribution is much greater than that of natural sciences. And the indistinct boundary of the humanities adds more difficulties to bibliometric research. Furthermore, because of the educational system in China has a clear demarcation between the courses of natural sciences and humanities, and the scarce involvement in mathematical fields by experts in the humanities, the bibliometric research has a strong bias towards the choice of subjects. Besides, the notable economic and social differences between the south-eastern and western part of China have caused the Matthew Effect in information use and dissemination. The convergence of the experts of library and information science in economically developed regions is a typical example. It's really a pity that such a gap will be further expanded following the popularisation of the Internet in large and medium-sized cities in China.

The overall standard of the research groups in China needs upgrading

In comparison with the United States, Russia, Britain, India, Hungary, etc., the biggest disparity between China and those countries is human resource. Under the wave unlashed by the market-oriented economy, quite a few graduates of library and information science have left their posts for other jobs, which has, to a certain extent, resulted in the waste of talent resources. In addition, due to insufficient knowledge of foreign languages, the obstruction of information communication channels, and the indifferent sense of self-introduction, Chinese scholars have presented very few papers at IFLA or other important international conferences except for some leading exponents and core authors. Such a phenomenon does not correspond to China's international status. Thus the sustainable development of the bibliometric research in China is still not optimistic.

Certain ideas and suggestions concerning improvement of the bibliometric research in China

The Chinese Government should make more efforts at regulating and controlling the bibliometric research by utilising multiple means such as administrative, legal and economic approaches to rationally allocate information resources, so as to bring the bibliometric research into a virtuous circle

More efforts should be made by the Chinese Government to further supplement and perfect rules and regulations for sci-tech administration and information management. It should use legal means to ensure the budget for bibliometric research activities, strictly supervise the person or organisation in charge of projects, and resolutely stop academic corruption. It should make overall plans and take all factors into consideration, realising the rational allocation and optimisation of various resources (including fund, manpower, information, etc.), especially strengthening the financial support for basic and theoretical research. In addition, the government should also offers sufficient supervision and necessary material rewards for the scientists, so that they could obtain first-class research achievements in a just and fair academic environment.

The academic community in China should actively establish academic exchanges with foreign colleagues and speed up the training various unexploited talents with significant personalities

Scientific research institutions and universities should actively establish comprehensive exchanges with colleagues all over the world, not only with the traditional developed countries, but also with some developing countries which have beneficial experiences; when undertaking key projects, the system of public bidding for projects can be used to attract more foreign experts to come to China. This will bring the competitive mechanism into full play and encourage domestic scholars to try their best to catch up with their colleagues ; Professors from famous foreign universities should be invited or introduced to give lectures for library and information students, so that the students could get some new ideas of the front-line subjects in the world. In addition to dispatching visiting scholars to foreign countries, the Ministry of Science & Technology and the Ministry of Education in China should also select some outstanding students from library and information faculties to advance their study abroad. If the courses (for example foreign languages, aesthetics, culturology, philosophy etc.) can improve the students' comprehensive qualities, they should not be restricted just to professional knowledge. It is surely the case that more talents will spring up by ways of competition and openness.

By upgrading their concepts, the Chinese scholars should make efforts to set up 'Virtual Knowledge Alliance' with information specialists throughout the world, so as to share professional information resources in a true sense

The terms 'Virtual Organization' and 'Knowledge Alliance' originated from new concepts in enterprise administration (Hou 2002). 'Virtual Organisation' is a dynamic organisational mechanism. It stands for a dynamic alliance which made up of over two independent entities in a certain period of time, rapidly providing products and services for markets. Such an organisation is an open, loosely organised entity without the status of a legal person, it has neither a fixed structural hierarchy nor internal command system. On the premise of possessing sufficient information, it can select the right partners from a variety of organisations and achieve an integrated use of resources. The objective of the 'Knowledge Alliance' is to obtain the necessary knowledge and skills for the organisation from other organisations and the innovative strength through collaboration. These two concepts can also be transplanted to the bibliometric research. Chinese scholars should be as an active initiator involved in the establishment of a 'Virtual Knowledge Alliance'. We are confident that this alliance will surely turn out to be a vivid, mighty intelligent group under the common efforts of the specialists throughout the world. It will probably solve some academic problems in the near future.

Conclusion

For the experts and scholars who work on bibliometric research in China and all over the world, the 21st century is undoubtedly a period with the coexistence of challenges and opportunities. In the course of getting rid of digital gaps, accessing and exchanging information democratically, freely and equally, both the East and the West must go forward hand in hand, overcoming various contradictions and differences of race, religion, culture, language, and ideology, thus building up a magnificent information stage for human beings in virtual space and real society. We are fully confident that specialists doing research into bibliometrics will surely make many achievements on this bright and colourful stage, and play an active guiding role in the new era.

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Trends in information science in Poland: bibliometric analysis

Wanda Pindlowa

Bibliometry and informetry have to perform a lot of tasks and have hidden capabilities and that are also indicated by the programme of today's conference. It is possible that incompetent interpretation of the results of the analysis could do both science and practice bad turn.

It should be also stressed the important role of bibliometry and informetry in scientific communication. The processes of the scientific communication that have formal and informal capacity, are based on extracting the knowledge from the predecessors and conveying the particular knowledge to other interested people and rendering the predecessors something that was taken, in the shape of citation. It is a permanent process of "taking" and "giving back" ("returning") that carries on in scientific communication and serves a science development.

Bibliometry and informetry in Poland

The quantitative analysis have indeed their own tradition in Poland, but during the estimation it should be admitted that they did not achieve the impressive position. It is worth mentioning about some initiatives evidencing the ascended interest in bibliometry and informetry. Perhaps, even if it sounds a little strange, the considerable popularity of the qualitative analysis in Poland, was observed for instance in social science. More and more the adherents of that kind of research consolidate the conviction that the qualitative analysis are usually based on earlier executed quantitative analysis that can not be omitted.

Bibliometric analysis in Poland were researched mostly for institutions and people estimations and were generally restricted to the citations of Polish authors' publications in the citations indexes searching (Stefaniak 2002b).

Publications that use bibliometric analysis methods arise far often in medicine, physics, natural science and chemistry than in social or humanistic sciences. The race in scientists and institutions rankings in humanistic and social sciences in Poland that is estimated according to the citations in citation indexes and it is not satisfactory. It is because few titles of periodicals in humanistic and social sciences are registered in the Philadelphian specifications. That is the reason, the University of Nicolas Copernicus in Torun initiates the works on Citation Index in Polish Sociology. The database of citations in Polish humanistic literature in the Library of University of Silesia is arising. Also in the Institute of Librarianship and Information Science at this University the attempts to creation national database of citations for library and information science were undertaken (Stefaniak 2002a).

The thesis and dissertations (Wincławska–Webster 2001) using the bibliometric and informetric methods were presented at the Polish universities (Stefaniak 1998) and also some thesis for associate professors were prepared (Pindlowa 1994).
In the last two years in both periodicals choosing for presented analysis, there were 5 articles dedicated to bibliometry and informetry, while in the previous a five-year period (1996-2000) that was analysed, had annotated only 3 articles.
It should be pointed that in the Committee of the Science of Science in the Polish Academy of Science, the Section of Scientometry was created in 2002 and the 38th volume of *Problems of the Science of Science* quarterly was dedicated to bibliometric, informetric and scientometric problems, because of the conference organised in Cieszyn, in 2001 by the University of Silesia and mentioned Committee.
Comparatively, a little attention is paid to bibliometric and informetric problems at the universities' curricula in Poland. The lecture about bibliometry is given for only one semester at the University of Silesia and at the Jagiellonian University in Krakow, there is only two-hour lecture. But the new course about the statistic was introduced last academic year 2002/2003 at the Jagiellonian University, as the preparation to use the qualitative methods in research.
The outline is rather the abbreviation of the bibliometric and informetric situation and it should be pointed the important role of the issues for developing the quantitative analysis.

Researches carried out by the practitioners and theoreticians of the information science in Poland based on quantitative and qualitative analysis.

The two basic periodicals in information science were analysed. The first one was Problems of Information Science *and the second was* Practice and Theory of Information and Technical Science. *Both are the quarterlies. The first quarterly have been publishing from the fifties, but firstly it was entitled differently and published by the Centre of Information Science of the Polish Academy of Sciences. Actually it is editing by the Institute of Scientific Information and Book Studies at the Warsaw University and the publishing process is engaged by the Society of Polish Librarians.*
Practice and Theory of Scientific and Technical Information *celebrated in 2002 the 10th anniversary of the existence and it is published by the Polish Society of Scientific Information.*
It should be pointed that in the analysis the Business Information *journal was disregarded because of its too technical capacity.*
Such conclusions have of course the arbitrary capacities. The articles about the information science are also published in periodicals connected with library science that were not taken to analysis.
In Poland, the librarianship has more periodical and is richer in number of published titles. It should be noticed that it is hard to decide repeatedly if the article should be

ranked to one or the other discipline, unless the title has the theoretical capacity and appears clearly to the domain's adherence.
This qualitative and quantitative analysis was researched for only two last years from 2001 to 2002, so it is after entering the 21st century. Actual analysis is a kind of continuation of the similar analysis for 1995 - 2001 period (Krakowska & Pindlowa 2001). The qualification is concerned with asking different research questions and introducing some changes in approach to research. It gives a new interpretation of the analysis. The two-year period is too short for qualify the changes in the directions of research in the disciplines, but continuous observation of the information science development allows to notice some trends indications and some disappearance of the trends in the time taken to analysis.
The purpose of the analysis was to establish the condition of the information science from the point of view of thematic and formal structure and eventually to mention the new directions of interests and the appearance or disappearance of the trends.
Also the analysis tries to conduct the attempt if foreign ideas were transferred to the native literature (citations of foreign publications) and if there were any interest in using the electronic documents. Those aspects of research were not used in previous analysis.

The following questions were posed during research:

1. Have any changes come into being in the range of themes preferred by authors publishing in both periodicals in connection with previous analysis?
2. Do Polish authors cite many foreign authors and what language of the literature do they prefer?
3. What position have the electronic documents within the cited literature?

Only the articles were taken to analysis as it was in the previous one. The other texts that are placed in periodicals were omitted. It means such information as opinions, reviews, reports, etc. Generally, there were published 83 articles in the analysed period. It was found that there was necessity to achieve some changes both in thematic groups accepted in previous analysis and in introducing the new groups. In comparison to the previous analysis, the thematic groups from XV to XIX were added.

Also some groups were specified by adding:

- to group III – *Networks*, the themes *Internet* and *Intranet*;
- to group IV – *Information Retrieval*, the themes *Information Retrieval Languages* and *Linguistics*;
- to group X – *Social Communication* and *Information* the problem of accessibility;
- the group XII was changed from *Information Science – generally* to *Information Science. Knowledge*;
- the group XI - *User of Information* was specify by adding *Needs and Use of information.*

In the analysis the thematic groups were titled as:

I. Information Source and Tools.
II. Information Retrieval Systems.
III. Networks. Internet. Intranet.
IV. Information Retrieval. Information Retrieval Languages. Linguistics.
V. Information Activity. Processes. Services.
VI. Information Science – theory and methodology.
VII. Information Centres. Libraries.
VIII. Automation.
IX. Librarianship and Information Science – education.
X. Social Communication. Information Society. Accessibility.
XI. User of information. Needs and Use of information.
XII. Bibliometry. Informetry. Statistics.
XIII. Information Science. Knowledge.
XIV. Information Professionals.
XV. Standardisation.
XVI. Legal aspect.
XVII. Information activity history. Biographies.
XVIII. International Co - operation.
XIX. Associations.

In relation to previous analysis the approach in describing the main theme of the analysed articles was changed because the placing the one article to only one thematic group is limit the possibility to estimate the issues and deform the problems that the authors were interested in (Tab. 1).
The table shows only the numbers of the articles that was classified to the thematic groups.

Group No.	Thematic groups	Number of articles
I.	*Information Source and Tools.*	22
II.	Information Retrieval Systems	6
III.	*Networks. Internet. Intranet.*	4
IV.	*Information Retrieval. Information Retrieval Languages. Linguistics.*	10
V.	*Information Activity. Processes. Services*	8
VI.	*Information Science – theory and methodology*	8
VII.	*Information Centres. Libraries.*	19
VIII.	*Automation.*	3
IX.	*Librarianship and Information Science – education.*	0
X.	*Social Communication. Information Society. Accessibility*	5
XI.	*User of information. Needs and Use of information*	10
XII.	*Bibliometry. Informetry. Statistics.*	5
XIII.	*Information Science. Knowledge*	8
XIV.	*Information Professionals.*	2
XV.	*Standardisation.*	1
XVI.	*Legal aspect*	1
XVII.	*Information activity history. Biographies*	2
XVIII.	*International Co-operation*	1
XIX.	Associations	3

Tab. 1: The number of articles in the thematic groups.

The answer is positive to the first research question that relates to changes in the interests of Polish authors. It means that after the short period the verification of previous attitude both to quantity and to the range of thematic groups. As it was mentioned the new groups from XV to XIX were added and some groups were specified that concerned changes of range of the groups. The colour figure better shows the interests of authors (Fig.1).

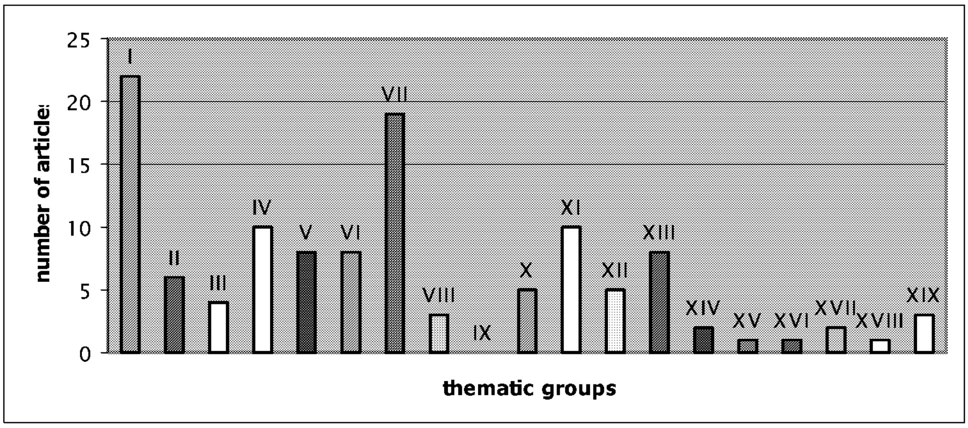

Fig. 1: The number of articles in the thematic group.

The structure of the interests was changed and it is possible to observe in case of enduring the interests from information retrieval systems [only 6 articles] to the problems of presentation of the libraries and information centres [19 articles]. Also the interest in problems of networks was diminished [4 articles] that seems to be strange indeed, but it may follow the common use of the Internet and on the other hand there have been a few research in the networks in Poland lately.

On the top there is the group Sources and Tools of Information [22 articles] as it was previously. The author rank there articles about problems of databases, OPAC catalogues, bibliographies, electronic publishing and also articles regarded to the networks as the sources of information.

Information Retrieval. Languages of Information and Linguistic group ranked on the fourth place in the previous analysis, has also higher position as the group titled *Users of Information – Needs and Use of Information*. There were equally 10 articles in those groups. In the last two years the authors supposed to be less interested in problems of the users.

There were 8 articles in the following groups:

- Information activity. Processes. Services.
- Information science – theory and methodology.
- Information science. Knowledge.

It is observed that in analysed period a number of theoretical articles were published about users, information linguistics as well as the future of information.

In the group titled *Social Communication. Information Society. Accessibility* were 5 articles as well as in the group *Bibliometry. Informetry. Statistics*. It indicates the more interest in that thematic.

In the third group titled Automation, there were only 3 articles. Probably the problems of automation of the libraries are general and do not evoke emotions. To the rest groups it was possible to rank only one or two articles. The still added 19th group, titled Associations have 3 articles because during the analysed period there was the 10th anniversary of establishing Polish Society of Information Science. That was the reason why there were the articles about the history of the Society. That was also why the group History of Activity was introduced because there were publishes some articles about memories concerning the rough road of establishing the Society of Information Science, what was impossible in the communistic times.
The number of articles in the group IX concerning the problems of the education in librarianship and information science is the same after two years. It is a little strange because there were accreditation process of information and library science departments at the Polish universities. There were no reflections after that process in the published articles. Only, there was a reflection after the accreditation in the report part in the periodicals, what was not taken to the analysis with regard to formal principles in the research.
The ranking of the thematic groups is presented on figure (Fig. 2).

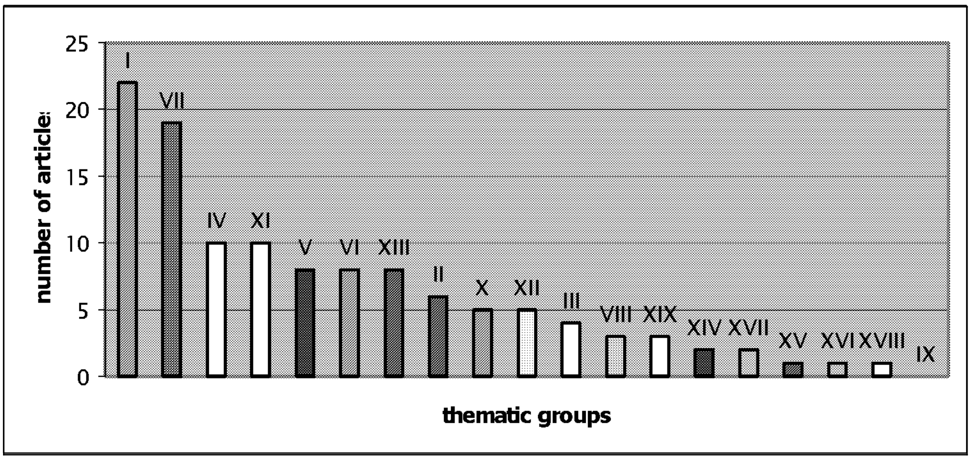

Fig. 2: Ranking of the thematic groups.

The second question concerning the number and language of citations gave the information that there were 742 cited publications (Tab. 2).

Language of citations	Number of citations
English	178
French	2
German	2
Russian	34
Polish	526

Tab. 2: Language of citations.

The 23,99 % of all cited publications came from English literature and 4,58 % from the literature in Russian language. Among all citations there were only 2 cited publications in French and 2 in German. About 71 % of publications are in Polish (Fig. 3)

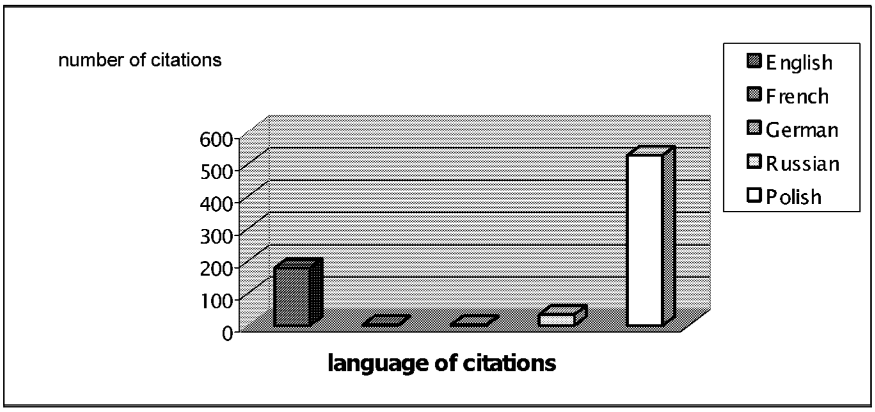

Fig. 3. The number and the language of citations.

What about the third question concerning the number of cited electronic publication, there were 66 electronic documents cited in all 742 cited publications. And it gives about 9 %.

The great differences between description of electronic documents were observed. Sometimes authors give only the website address without information what is about. There were no dates that inform about the actuality of the document or at least the period of the access to the document by the author.
The oldest publications that were referred to go back to 1936 and 1943. It is not surprised because as it was mentioned there were memories published because of the 10th anniversary of Polish Society of Information Science and others biographic articles cited old publications. General observation of the age of cited publications leads to conclusions that the most often cited documents are dated in the nineties and from 'the last moment', the 2001 and 2002.

Conclusions

It is not possible to compare fully actual analysis with the previous one, because the foundations was a little different. Drawing the conclusions has to be very careful. Nevertheless, it is possible to observe the changes in the trends in forming the interest of authors writing about information science. Some themes were evoked by occurred anniversaries in the analysed period.
Similar research should be continued because they allow value, estimate the condition of the development and the place where the research are. Naturally it is worth confronting and comparing with the research in other countries.
Also it is worth intensifying the knowledge about the ideas transfer coming from the developed countries and intending for the information science research more finances than in our country. Economical and social situation does not promote research, especially such expensive as in bibliometry and informetry.
Analysis even those two-year period reflected some recognition in citation of foreign publications and electronic documents.
The results should be in that case recognised as very interesting. If accept that there were only 83 articles analysed and couple of them did not cite any publications, the general number of cited publication that is 742 documents, the number of 216 cited foreign publication with 178 in English could inform that authors transfer to native literature the scientific ideas from developed countries.

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Research Indicators
and
Science Policy

The role of publications in the new programme oriented funding of the Hermann von Helmholtz Association of National Research Centres (HGF)

Jürgen Goebelbecker

The Helmholtz Association

The Helmholtz Association is a community of 15 national centres for scientific-technical and biological-medical research, with 24 000 employees and an annual budget in excess of over two billion Euros. Her mission is research striving for answers and insights to grand and eminent matters of science, society and economy. In order to accomplish this, the Association performs research in six core fields: Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, Transport and Space.

Helmholtz scientists are researching complex systems defined by man and/or environment. To further knowledge scientists are co-operating with each other and with external partners - beyond the limits of disciplines, organisations and nations. Research in the Helmholtz Association takes aim to insure the basics of human life on a long term basis, and to create a technological base for a competitive economy. To cope with this task the Association offers a potential of outstanding minds, efficient infra structure and capable research management.

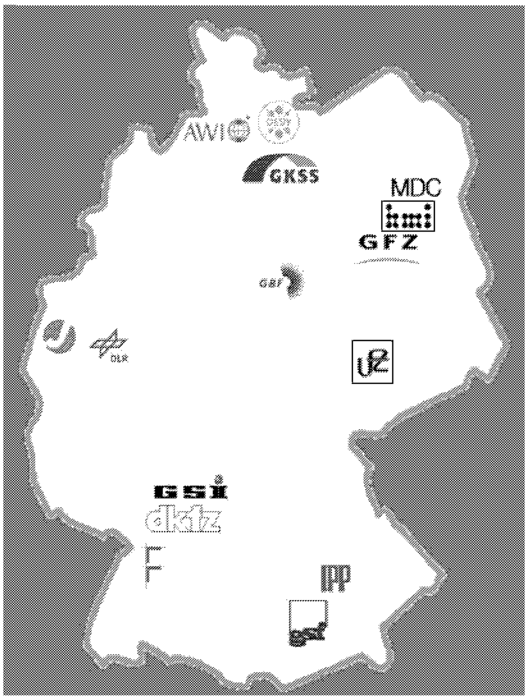

Fig. 1: The 15 Research Centres of the HGF

Programme Oriented Funding (POF)

To carry out their visions, aims, and strategies the Helmholtz scientists develop programmes in each research field that eventually combine the contributions of individual research groups. By means of these programmes the Association clusters her competencies and resources, thus increasing the efficiency, flexibility and purpose of her research. With the long-term programmes the scientists are at the same time competing for financial support. Each programme will be evaluated by an international group of experts whose decision will form the foundation for the promotion of federal and state funding (HGF, Programmes - Numbers - Facts 2003).

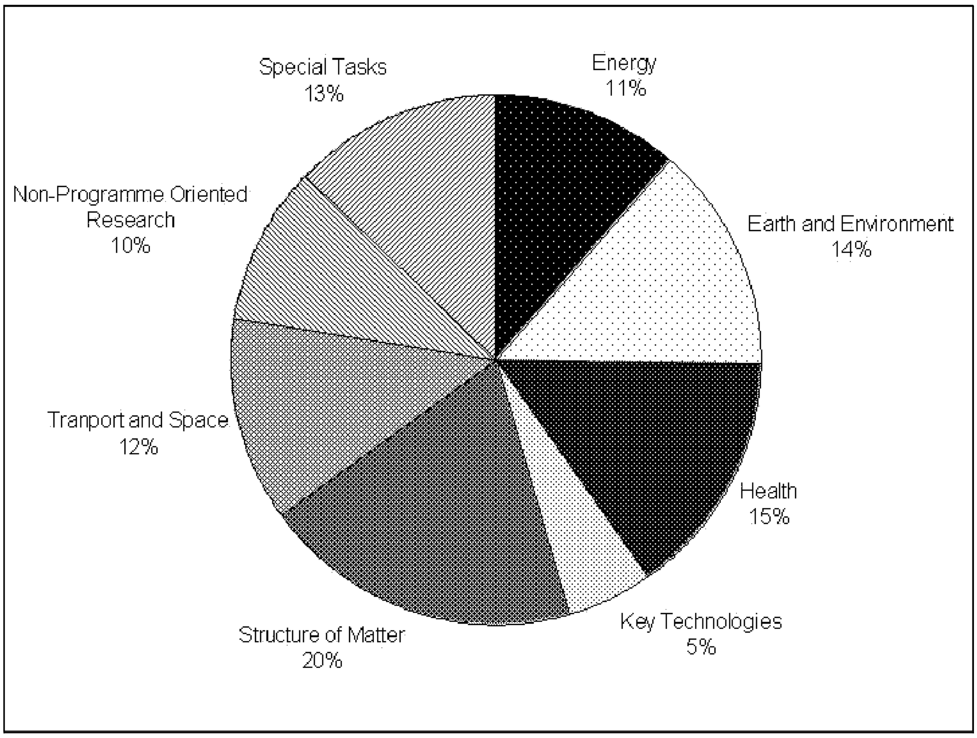

Fig. 2: Distribution of the budget of the Helmholtz Association (2003: 2.2 billion Euros).

The experts evaluate the scientific quality by international comparison. They examine the strategic importance of the programmes concerning science, society and economy. Besides they analyse expertise and competence of the scientists for programme topics to figure if the efforts are in proportion to the possible results. Promotions of programmes based on strategic examination by international experts - Helmholtz is relying on the fertile tension between co-operation and competition to become one of the more important actors in the European and international research scene.

The Helmholtz Association is introducing the programme oriented funding step by step. Starting with 2002 the first two research areas: "Health", as well as: "Transport and Space" are being promoted. In 2002 approximately 100 internationally reknowned scientists took part in the evaluation of these two programmes - over 50% of these from abroad. This year evaluation of: "Earth and Environment", as well as:

"Energy", has followed, and then in 2004 "Key Technologies" and "Structure of Matter" will be done (HGF, Programmes - Numbers - Facts, 2003).

"Operationalisation" of the evaluation

Since in 2002 the first two research fields were already to be evaluated, an "operationalisation" of the programme oriented funding, especially of its evaluation was developed early on. In co-operation with the consulting firm KPMG a detailed paper was drawn up serving as a basis for the concrete implementation. In the paragraph "Perspective of the Procedure of Programme Oriented Funding" of this paper, the first details about bibliometric examination of research results are being published.

> The processing of quantitative data in science, like for example publications, patents, using full capacity of large equipment, is quite normal. Insofar there are no new contents derived from the programme oriented funding but primarily the structuring of existing information. ...
> Besides contents, results and financial quantity, other information concerning the research performance (i.e. publications, patents, dissertations) are shown. Scientific evaluation, programme controlling and procedures of business management for the centres are depicting the basis for the progress reports.

(KPMG, Operationalisation of POF, 2002).

It is true though that already at the time when this paper was drawn up it was known which problems were carrying quantitative statements with regard to comparability and interpretation. In the paragraph "Basics and Predominant Definition" is emphasised that methodology of data information is to be introduced into the evaluation process.

> To represent the scientific competence, involved scientists and/or existing scientific institutions and procedures, especially the results of the internal evaluation of the centres as well as their quality regarding contents and methodology are to be consulted.

(KPMG, Operationalisation of POF, 2002).

Especially the last citation seems to transfer much self-responsibility into the hands of individual research centres, concerning quantitative representation of their research results. However in the implementation of the chapter: "Definition and Calculating Instructions for Quantitative Information" this idea is being quite thought in relative terms. "Calculating Instructions" are being presented in a legally seaming depth of detail. For example:

> If one of the contemplated objects, for instance publications, were to be assigned to more than one programme section by these "Calculating Instructions", this object will be counted for each programme section. While aggregating the number values within one centre and programme multiple counts are to be avoided (for example: aggregation of programme sections to one programme within one centre). Multiple counts within one programme and among different centres are permissible (for example: one cooperative publication by two scientists from different centres). By establishing this, a systematic fault is being created that raises the number values for cooperative activities of the centres. Is such an aggregation of programmes in research fields implemented, multiple counts within one centre must be excluded. ...

(KMPG, Operationalisation of POF, 2002, attachment 1).

Already a certain contradiction appears in regard to the KMPG paper that states that "quantitative entries can by no means replace qualitative entries on principle" These counting methods are aiming at a very "exact" quantification which by all bibliometric experience expresses little about the quality of the publications or their authors.
The quality of publications is to be insured by limitation to refereed publications. This criterion is to be insured by an entry in the Journal Citation Report of the Institute of Scientific Information (ISI).

> "Refereed publications" are those which are published in those journals that are registered in the "Journal Citation Report" of ISI (Institute for Scientific Information). "Postdoctoral Theses" and "Dissertations" are counted on the condition of being a written, accepted thesis.
> The values in the individual categories are determined by the unvalued addition of individual publications or written theses. When being counted, there is no qualitative differentiation between individual publications and written theses.

(KMPG, Operationalisation of POF, 2002, attachment 1).

Similar quantifications and categorisations are being demanded for lectures, committee work, prizes, patents and licenses as well as for appointments and establishing of companies. A concrete citing or even a valuation of the individual objects is not carried through.

First concrete experiences in the Forschungszentrum Karlsruhe

In face of the size of the research fields to be evaluated first: (Earth and Environment: 303 million Euros; Health: 332 million Euros) it was imperative for the expert committee to stem the flood of information early on by compression and abstraction of the data. Also it became evident that it was hardly possible to evaluate the individual programmes of the research fields in their complexity. Thus Heads of Programmes in the Forschungszentrum Karlsruhe were asked to keep their programme descriptions and applications rather informal except for the formalised information.
As a basis of bibliometric data, scientists in Karlsruhe, as well as in other Helmholtz Centres, are provided with a publication data bank by their respective libraries. While trying to use the contents of these data banks, Heads of Programmes ran into a series of problems:

- Assignation of the publications to projects and programmes
  So far the publications recorded in the data bank had two assignments, namely the author or authors plus the so called R&D number. With introduction of the centralised programme oriented funding it became imperative to develop a system as centralised for all the research centres as the POF. The development of this systems as well as its introduction into the individual Helmholtz Centres has not been concluded. For the publication data bank this means a respective editing of all data records. The following are the most frequent difficulties:

  - For a considerable number of publications (in the respective programme starting approx. 2000) it is not sufficient to use an automated Thesaurus simply replacing the R&D number with the new HGF nomenclature (POF key). Many publications have to be assigned to the new HGF programmes - if possible by the involved scientists(s).
  - Generally there exists the dilemma whether a publication is to be assigned to the "past" (project reports) or the "future" (project applications). Many publications point out programmes/projects that differ between the past and the future.
  - All-embracing publications need to be assignable to several projects/programmes. This is not tolerable by the calculating instructions. Example: technology assessment under the aspect of energy generation by straw incineration. Assignment possible to "Energy" and "Earth and Environment".
  - "Pioneer" publications can only be assigned afterwards.

- Significance of the term "refereed journals"
  In the KMPG paper the term "refereed journals" is exclusively used for the listings in the Journal Citation Report of the ISI. From European view this data bank only

covers part of the journals counting as "refereed". ISI mainly serves the US market. Furthermore it mostly covers basic research oriented areas. German language periodicals are considerably under-represented. Thus applied research from the Helmholtz Centres is by nature under-represented.
The librarians within the HGF have realised these limitations of the term "refereed journals". The following definition alternatives are being used or applied:

- The term "refereed journals" is defined not only by ISI data banks but by a whole portfolio of bibliographic data banks, for example: STN of the FIZ Karlsruhe.
- The scientists themselves decide if a journal containing their publication is considered "refereed". It is assumed that the disclosure towards the expert committee already takes care of a significant and verifying characterisation.

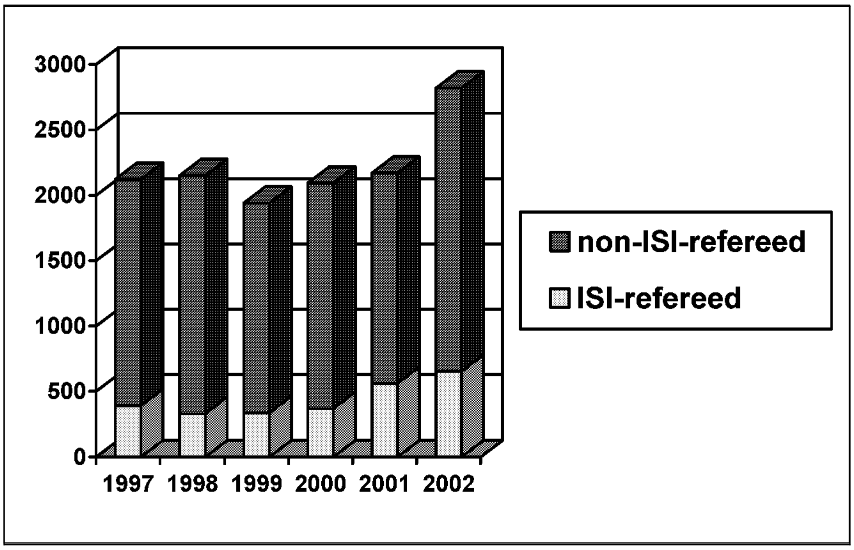

Fig. 3: Publications of the Forschungszentrum Karlsruhe.

- Valuation of publication activity by number of publication (in refereed journals)
  - Monographs are not being taken into account, are however of distinct consequence.
  - Additional bibliometric parameters, like impact factors, are not being observed. Independent of the discussion about its problematic meaningfulness, the impact factor should at least be considered since it appears in the publication data banks of several Helmholtz Centres.

Resume after the first rounds of expert evaluation 2002

The quantitative information is considered far less than originally expected. This applies particularly to the bibliometric parameters. Thus an alternative suggestion was picked up from the KPMG paper providing for the citing of the five publications most important to the individual programme section.
Furthermore the heads of programmes felt encouraged by another passus of the KPMG paper where their publication activities can be presented to the evaluators in programme plans and/or drafts of their own criteria.

In individual cases programme- or specific research field deviations can be justified concerning the following calculation instructions. When naming the number values, deviating definitions including their reasons as well as their influences on these number values are to be documented.

(KPMG, Operationalisational POF, 2002, attachment 1).

At the end of the year 2002 this step to a more qualitative bibliometric information was officially formalised by the HGF Corporate Office, and was adopted into the "Working Paper for the Installation of Programme Drafts":

4. Data necessary for the evaluation (to be displayed in the appendix, for the definition of indices it is referred to the paper for the operationalisation of programme oriented funding, version 8.)				
	Pro-gramme	Pro-gramme share	Pro-gramme subject	subject share
Scientific Data				
a. Name, Centre of the person responsible for the subject and citing of the subject field as well as short-CV (no longer than 1/3 page)			X	
b. Names of the group leader of organisational units, considerably contributing to a subject share, and mentioning of the subject field as well as short-CV (no longer than 1/3 page)				X
c. Mentioning of the 5 most important publications for each scientist mentioned under a and b during the last 5 years (complete citation)				X
d. Number of habilitations of the last 5 years chronologically	X	X		
e. Number of dissertations of the last 5 years chronologically	X	X		

From the view of librarians or bibliometry however this means a complete turn-about. As questionable as number constructions might have been, carried out strictly by the calculating instructions of the KPMG paper, the purely qualitative bibliometric query also remains problematic. Particularly questionable is the turn from the programmatic to the personal approach. Is it the quality of the programme draft or the quality of the participating scientists that needs to be documented.

Prospects

The HGF libraries have critically observed the attempt to introduce a mostly number oriented bibliometry into the evaluation proceedings. They all agree that with the help of their publication data banks a by far more differentiated bibliometric basis could be created, taking into account especially the networking of the individual centres.
In a first step the individual data banks - similar to a library consortium catalogue - could be linked after harmonising their systems and with the help of a "meta-search engine", be published in the internet. The experts could easily verify information

pertaining to publication in the programme applications, and access data on abstracts or full texts.

A further step could be the merger of the bibliographical data of the meta-data bank with bibliometric information like references to international data banks (ISI, Chemical Abstracts etc.). Such a task could be partly taken over by the FIZ Karlsruhe. Since FIZ does not belong with the HGF the necessary integrity and neutrality in the treatment of these data would be granted.

The two libraries of the Research Centres in Karlsruhe and Juelich have decided upon taking a first step: the creation of a joint data bank in the internet. A common study group is currently engaged to organise the subject co-ordination as well as create the technical pre-conditions to accomplish this.

Bibliometric analysis and private research funding

Simon Sommer

Introductory remarks

In light of the dramatically increasing complexity of science and technology, the accelerating pace of change within science, technology, and society, the difficult situation on the international capital markets, and the stagnating or even decreasing public funding for research institutions, private institutions, and foundations funding higher education and research are facing a difficult situation. The growing demand for private money encounters limited available funds. These financial constraints consequently lead to a stricter selection process, a re-thinking of funding policies and strategies, and last but not least to a re-configuration of organisational structures and funding portfolios.[1]

This paper firstly outlines how private institutions and particularly foundations contribute to the furtherance of higher education and research, and it secondly depicts what role bibliometric analysis can or cannot play in foundations' private research funding and in the process of strategic realignment under above mentioned financial constraints. It is a view by a practitioner hoping to provoke some discussion.[2]

The example I will draw upon is the Volkswagen Foundation in Hanover, Germany. At present the total assets of the Foundation amount to some 2 billion Euros. On average the Foundation allocates about 100 million Euros of funding per year, making it the largest private institution of its kind in Germany. The focus of this paper mainly is on large- and medium-scale grant-making foundations (such as the Volkswagen Foundation). There are of course other kinds of foundations, such as individual or family foundations, non-charitable trusts, and governmental foundations to which different characteristics (especially concerning organisational culture) apply.[3]

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[1] The different approaches and reduced-asset strategies of large foundations are described in: Draper 2002 and in Hartnell & Millner 2003.

[2] This is a preliminary version of the paper to be extended for presentation at the conference.

[3] The arguments given in this paper apply to large and medium-scale foundations such as the Compagnia di San Paolo (total assets in 1999 4.8 billion €), Gulbenkian Foundation (2.5 billion €), Volkswagen Foundation (2 billion €), The Bank of Sweden Tercentenary Foundation (1.2 billion €), Hertie Foundation (800 million €), or the Fondation Roi Baudouin (280 million €). Larger organisations such as the Wellcome Trust or US-American foundations have other possibilities to establish large scale

Role and function of private research funding

Private foundations – unlike publicly financed agencies which have to provide equal opportunities for all institutions and which operate within a framework that involves rather peculiar and tedious procedures – can act more freely, flexibly, and quickly (Krull 2000) Since they do not have to reach a political consensus (or wait for it), they can act autonomously, for example in supporting new research areas, fostering risky research, providing incentives for trans-disciplinary, non-traditional approaches, concentrating their funds on the creation of centres of excellence, or in bringing forward institutional reform.

What foundations cannot do, however, is compensating deficits in public spending. Just a few numbers to illustrate this point: of the approximately 10.000 foundations in Germany less than 15 % devote their funds (or at least a part of them) to science and research.[4] The funds annually provided by these foundations amount to less than 500 million Euros. Compared to public spending this is an almost negligible sum.

However, with this relatively small amount of money, a lot has been achieved – the Bosch, Thyssen and Volkswagen Foundations, for example, together funded the first thematic graduate programs (the so-called "Graduiertenkollegs") at German universities (sometimes against considerable opposition from the public sector). With its program "Junior Research Groups at German Universities" the Volkswagen Foundation paved the way for the "Juniorprofessur" and for future tenure-track models to be introduced in Germany, one of them being the "Lichtenberg-Professuren" – a program that gives young academics the chance to apply for a tenure-track professorship together with a university.[5]

Lots of new research areas that are central today have been brought on the agenda by foundations – two of the most striking examples in engineering and science are photonics and single molecule research. Both were boosted, if not initiated, in Germany by funding initiatives of the Volkswagen Foundation. Moreover, in the 1970ies the Volkswagen Foundation was among the first to develop a program supporting research on and in China. In the last 15 years the foundation has been focussing some of its funds on research on and in Central and Eastern Europe and in 2000 – before the war in Afghanistan and the world-wide terrorism created attention

evaluation and review systems. Small scale and family foundations, on the other hand, often do not have the (personal and financial) means to make extensive use of peer review and evaluation. Their funds are often spent based on rather arbitrary decisions.

[4] Figures according to Bundesverband Deutscher Stiftungen, *Zahlen, Daten, Fakten zum deutschen Stiftungswesen*, Berlin, 2000.

[5] Further information on the current funding initiatives of the Volkswagen Foundation can be obtained from the website <http://www.volkswagenstiftung.de>.

on the region – the foundation introduced a funding initiative on Central Asia and the Caucasus.

As a rule, the Volkswagen Foundation terminates its funding initiatives, whenever publicly funded organisations substantially start to work in the same area. The idea is to strategically support high-risk initiatives or unorthodox areas for which it is difficult, if not impossible to gain public support.

In other words: ideally, as opposed to public funding, private research funding is anti-cyclic and non-mainstream funding. It aims at making a sustainable impact on public policy by introducing new concepts, research areas and organisational structures and demonstrating their feasibility.

Is bibliometric analysis helpful for private research funding?

Can bibliometric analysis as a part of an evaluation process help research funding foundations in achieving its aims? The answer is: no – and yes!

When Michael Power in 1997 described the emergence of an all-embracing "Audit Society" in which audit and evaluation serve as mere "rituals of verification" (Power 1997), he argued that these processes emerged as a response to the increasing need to process risk and to legitimise political and administrative acts. This is not the place to discuss Power's theses in detail; however, I do think that today, six years after "The Audit Society," bibliometric analysis still contributes significantly to an ongoing technocratic approach in research funding aiming mainly at risk avoidance and legitimating. Uncertainty and risk characterise the work of science administrators and program officers in research funding organisations; moreover, the system of peer review reaches its limitations when reviewers more and more often declare that they do not feel comfortable or even qualified to review proposals for either trans-disciplinary or very specialised disciplinary projects. What would be more convenient and reliable than to base a decision on a calculation conducted by a computer? This would be sneaking out of one's responsibility, and keeping in mind the idea and advantages of private research funding I mentioned above, it seems inappropriate for foundations to make use of bibliometric analysis.

Of course this is not the case: reviewers, experts, and program officers do use publication counts or the reputation and the impact of journals in which an applicant has published in the process of their decision making (Willms-Hoff 2003)[6].

But as Caroline Wagner and Ann Flanagan have argued, bibliometric analysis provides little if any guide to identifying "areas where science is underfunded" (Wagner & Flanagan 1995) – or where it is not funded at all, one could add.[7]

[6] For a discussion of the review procedures of private foundations see Willms-Hoff 2003.

[7] The Volkswagen Foundation, for example, commits itself to funding research and technology in higher education in natural and engineering sciences as well as in the

Performance assessment, Irwin Feller from the American Association of Scientists notes, is in the main a retrospective activity that provides little guidance for future activities. In his paper Feller mainly talks about theory and practice in the use of indicators in making budgetary decisions about US governmental S&T-programs, but his conclusions aptly describe the situation for private foundations, which besides determining their broad research agendas have to

"[…] make a myriad of decisions about how they conduct their activities. They must construct portfolios comprised of research areas, research performers, modes of research support and selection criteria. They must decide, for example, on the optimal mix of big- and small-science, the optimal award size, the optimal length of research award, and the optimal mix of research with other desired outputs (such as education, diversity, technological innovation, etc.). No single or simple answer exists to these questions. But performance assessment as the field and work are currently construed, even allowing for refinement of metrics, by itself does not provide answers to these questions. Effective management consists of experimentation with alternative choices, evaluating them in terms of their contribution to overarching agency missions and national objectives. Performance assessment is thus more appropriately seen as the culminating data collection and measurement phase of a process of learning and improvement." (Feller 2002).

It is in this process of learning and improvement where I see possible roles of bibliometric analysis for private research funding foundations:

- Not only when foundations under financial constraint are re-thinking their funding strategy and portfolio, are bibliometric indicators essential to determine the programs to be terminated. This is probably a somewhat peculiar use of bibliometric analysis: at a private research funding foundation the candidates for termination would most likely be the funding initiatives with the highest publication count and impact – because that would mean that the aim to establish a field on the research agenda has been achieved;
- Bibliometric analysis can help to prevent grantmakers from throwing their funds into bottomless pits by indicating fields in which the national or regional research system is not able to compete internationally;
- Science mapping techniques are useful instruments for private foundations in helping them to generate ideas and to determine "emerging fields" in which an impetus could be needed;

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humanities and social sciences. This is not the place to start another discussion about C. P. Snow's "Two Cultures," however we have to admit that there is simply not enough reliable data and no appropriate methodology to make funding decisions in the humanities based on bibliometric analysis.

- And finally, bibliometric indicators can also serve to determine the areas where a foundation has or has not reached its strategic goal by comparing publication patterns and analysing communication processes in funded areas before, during and after the funding through the foundation. Being such a part of a learning organisation, bibliometric analysis can help foundations to make better decisions – but it should not adjudicate on the decision itself.

Contribution and dedication – vital for private research funding

It sounds all too easy, but it is a central point: without funders there would be no foundations. Currently, a research team at the Bertelsmann Foundation is conducting a study on the motivation that makes wealthy people setting up foundations or giving their money to foundations. From talking to funders in Germany I think that one of the main motivations they have is that they want to create an added value with their funds compared to public money. That means a single Euro in a foundation should have more impact than a Euro spent by the public administration (Porter & Kramer 1999). It might sound obvious, but as a consequence, (and in their own interest) foundations visibly have to do whatever they do in a different way than the public sector does: they have to ensure and make public that the money they receive is not spent in a "mechanical" way.

The inclusion in strategic development, search conferences, and decision processes is also the only way to ensure the participation of eminent researchers or practitioners as trustees, reviewers, or in expert panels, which is vital for research funding foundations. In order to achieve their essential contributions to a foundation's work they have to feel that they are not only a "small wheel in a machine," tacitly agreeing with the proposals prepared by the staff solely based on peer review and bibliometric analysis. We should, therefore, not underestimate the value of intrinsic motivation: experience shows that the willingness to participate in our advisory panels or in our board is extremely high, because the foundation is a place where one is not bound by awkward mathematical procedures, juste retour considerations, or funding quota.

One of the best ways to capture this special atmosphere is the concept of competing organisational values by Kim Cameron and Robert Quinn (1999). In this framework the ideal foundation[8] and its organisational culture would be best described with the organisational value of *adhocracy* (see figure 1). As the vertical and horizontal axes show the *adhocracy* aims towards decentralisation, differentiation, transformation, and towards contributing to a competitive position of the overall system. The glue that holds the organisation together is commitment to experimentation and innovation. Therefore, it heavily relies upon external input.

[8] „Ideal foundation", in this context, means an entire system of stakeholders, including funders, experts, management, staff, and applicants.

The exact opposite is the internal process model – the hierarchy culture, which is in my eyes equivalent to governmental funding of research and higher education: it has a distinct internal focus and aims at the maintenance of the sociotechnical system, towards consolidation, equilibrium, and integration (all of these being important tasks!) In order to achieve this, the organisation needs stability and control, measurement and documentation – therefore, much more than the others, it needs bibliometric analysis.

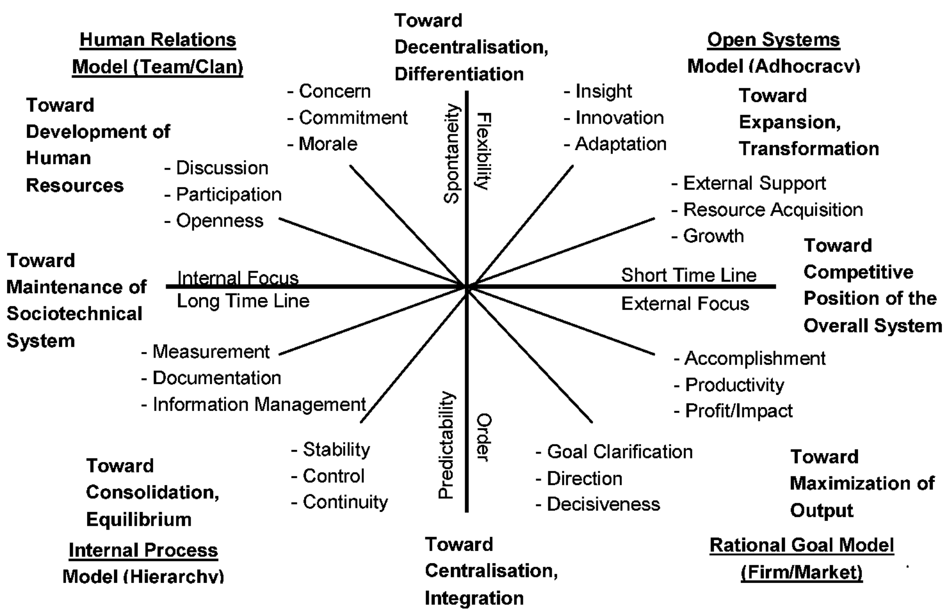

Fig. 1: The competing values framework: organisational culture.

It is the commitment to experimentation and innovation, the atmosphere of mutual trust (as the word "trustee" indicates!) and responsibility that characterises the work of an ideal foundation. A lot is at stake if we decide to base decisions solely on indicators. Doing so would probably move foundations' organisational culture in Cameron's and Quinn's framework from the open systems model (*adhocracy*) towards internal process and rational goal models (*hierarchy* and *market cultures*) – reducing flexibility, discretion, and differentiation in order to gain stability, control, and integration: The advantages of private research funding mentioned earlier – freedom, flexibility, and spontaneity – are incommensurate with indicator-based decision making processes.

Conclusion

My conclusion is fairly simple: an ex-ante bibliometric or indicator-based approach towards decision making is an instrument to ensure continuity, stability, and control. In the field of private research funding such an approach ignores and endangers the very special characteristics of private foundations and the adhocracy culture in (ideal) private foundations. Rather, bibliometric analysis as a strategic instrument can help foundations in evaluating their programs in the process of strategic realignment and as a means of foresight and priority setting in detecting emerging fields to be considered for future funding.
To serve theses purposes, bibliometric analysis has to be embedded into a long term, comprehensive evaluation and learning process. Irwin Feller's dictum that performance assessment without evaluation is "like pizza without cheese or sauce" (Feller 2002, 98) applies just as well to bibliometric analysis for private foundations – if we do not manage to put it in an overarching context: not only would it be rather ineffective, if not detrimental, it would also be quite dry...

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On the opportunities and limitations in using bibliometric indicators in a policy relevant context

Wolfgang Glänzel and Koenraad Debackere

Introduction

Bibliometrics has become a standard tool of science policy and research management in the last decades. As a consequence, a vast array of indicators to measure and to map scientific and technological activity, their progress and their outcomes, has been developed. All significant compilations of science indicators heavily rely on publication and citation statistics and other, more sophisticated bibliometric techniques. Nowadays, bibliometrics is much more than a simple publication and citation based gauging of scientific performance or than compiling of cleaned-up bibliographies on research domains extended by citation data. In fact, scientometrics is a powerful, multifaceted endeavour encompassing subareas such as structural, dynamic, evaluative and predictive scientometrics. Structural scientometrics came up with results like the re-mapping of the epistemological structure of science based, for instance, on co-citation, "bibliographic coupling" techniques or co-word techniques. Dynamic scientometrics constructed sophisticated models of scientific growth, obsolescence, citation processes, etc. Most recently, there are also applications at the borderline of bibliometric research, for instance, in the context of studying the linkage between science and technology, or applications to related fields such as library and information science and most recently also Webometrics.

Unfortunately, power and value of bibliometric methods and indicators are also contrasted by negative aspects, which are often – unintentionally or sometimes even deliberately – ignored.

The present paper, which is based on a 23-year experience made in building and applying bibliometric indicators at ISSRU (Budapest, Hungary), RASCI (Germany) and KU Leuven (Belgium), will provide a systematic discussion of limitations and the pitfalls related to the use of bibliometric indicators in a policy relevant context.

What is bibliometrics dealing with and what can bibliometrics not be responsible for?

From the above-mentioned general description of the main task of the research field *Bibliometrics* (*Scientometrics*), the following statement becomes quite obvious:

Bibliometrics can be used to develop and provide tools to be applied to research evaluation *but is not designed to evaluate research results.* Moreover, bibliometrics does *not* aim at replacing *qualitative* methods by *quantitative* approaches. Consequently, bibliometrics is *not* designed to correct or even substitute peer reviews or evaluation by experts but qualitative and quantitative methods in science studies should complement each other.

Publications: target groups and fields of application

Traditionally, bibliometric research is aimed at the following three main target-groups, which clearly determine topics and sub-areas of 'contemporary bibliometrics'.

(i) *Bibliometrics for bibliometricians*
This is the domain of basic bibliometric research and is traditionally funded by the usual grants. Methodological research is conducted mainly in this domain.

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

(iii) *Bibliometrics for science policy and management (Research evaluation)*
This is the domain of *research evaluation*, at present the most important topic in the field. Here the national, regional, and institutional structures of science and their comparative presentation are in the foreground.

Although the second target-group might still be the largest one, the third group is nowadays clearly dominating. There is a certain conflict in the needs and demands of the two groups. While the interests of the second target-group are focused on possible completeness, the third group is mainly interested in the high-end of research performance. Its interest is also focused on 'prompt' and 'comprehensible' indicators, while the state of knowledge would sometimes allow the application of more sophisticated methods. It is clear, that this group is interested in the results of recent and not of past research. Nevertheless, availability of database up-dates, the cleaning-up of bibliographic data, processing them to indicators and, above all, allowing the observation of the reception of published results by the scientific community through collecting citations requires a time span of at least 3-4 years from the year of publication.

In what follows, we will show important opportunities and limitations in using bibliometric indicators in a policy relevant context. We will also briefly discuss the mutual effect of the scientists' publication and citation behaviour and science policy originated by bibliometrics, that is, beyond the contribution of bibliometric tools to decision-making in science policy and research management also the – direct or indirect – influence of science policy and research management through promotion and funding on publication, citation and collaboration behaviour of scientists (both positive and negative), including the potential effect on the problem choice behaviour of scientists. In this context also the influence of the needs of science policy on the bibliometric community will be described.

Limitations in using bibliometric indicators

Sources of errors in bibliometric indicators and their possible consequences

Bibliometric indicators are subject to a variety of *errors* (systematic, random errors and built-in data errors) that are usually not taken into account to the necessary extent when bibliometric data are applied in research evaluation.

Random errors have usually effect on the micro level where publication and citation data of individual scientists are concerned. This phenomenon, well known in mathematical statistics, is less relevant at higher levels of aggregation. These errors are, for instance, caused by not unique identification keys, incidentally overseen or incorrectly assigned data (e.g., corporate address, subject delineation) , etc.

The same applies to built-in data errors that have usually three main sources: the authors themselves, the editors of the journals and the database producer. The extent of errors is, however, unpredictable and differs among individual papers. At the level of individual papers, such errors might result in certain distortions.

The following example for errors caused by citing authors might illustrate this quite dramatic effect. The paper by Schubert, Glänzel and Braun entitled "Scientometric datafiles. A Comprehensive set of indicators on 2649 journals and 96 countries in all major science fields and subfields, 1981-1985" published in *Scientometrics*, vol. 16, 1989, pp. 3-478, has received 137 citations till September 2003. Among those 141 citations are 115 correct citations, whereas 26 citations were incorrect. The error caused by citing authors amounts to 18.4%(!). All variances of the cited work that occurred in the Web of Science database are presented in Figure 1.

Cites	1st author	Journal	VOL	BP	PY
115	SCHUBERT A	SCIENTOMETRICS	16	3	1989
3	SCHUBERT A	SCIENTOMETRICS	16	3	1988
1	SCHUBERT A	SCIENTOMETRICS	16	3	1987
2	BRAUN T	SCIENTOMETRICS	16		1989
13	SCHUBERT A	SCIENTOMETRICS	16	1	1989
1	SCHUBERT A	SCIENTOMETRICS	16	8	1989
1	SCHUBERT A	SCIENTOMETRICS	16	18	1989
1	SCHUBERT A	SCIENTOMETRICS	16	218	1989
1	SCHUBERT A	SCIENTOMETRICS	16	239	1989
1	SCHUBERT A	SCIENTOMETRICS	16	432	1989
1	SCHUBERT A	SCIENTOMETRICS	16		1989
1	SCUBERT A	SCIENTOMETRICS	16	3	1989

Fig. 1: Example for build-in errors caused by citing authors. Source: Web of Science (ISI – Thomson Scientific, Philadelphia, PA, USA).

Unlike the above-mentioned random and "built-in" errors, systematic errors occur at all levels of aggregation, and may cause, for instance, serious damage in those applications where otherwise the strength of bibliometric indicators lies, namely, in providing reference standards for evaluative purposes. Figure 2 presents an example for an erroneous calculation of journal impact factors. The chart at the bottom gives the correct values (Braun & Glänzel (1995), van Leeuwen et al. (1997), Garfield 1999). Further examples can be found in Glänzel & Moed 2002.

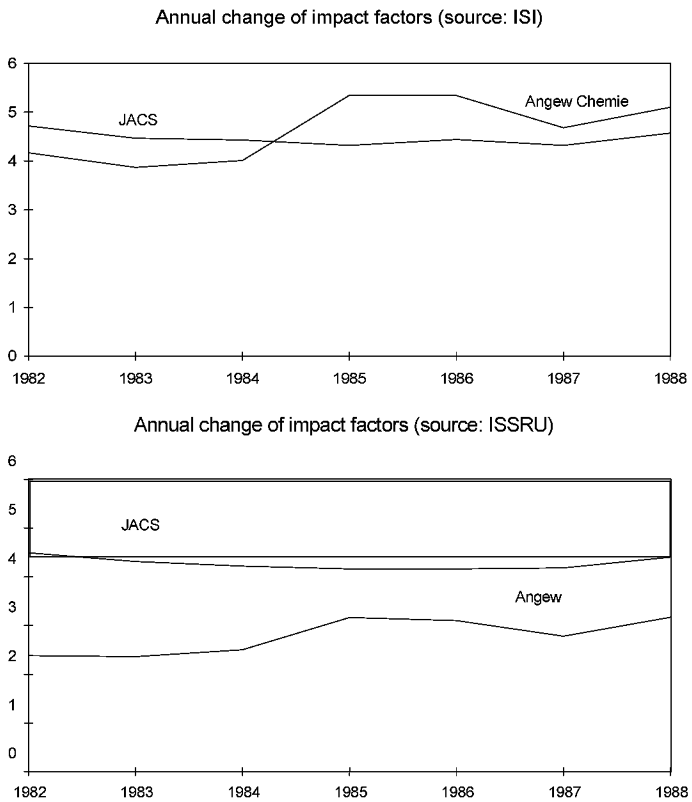

Fig. 2: Annual change of the impact factors of the journals *JACS* and *Angewandte Chemie – International Edition in English* (1982-1988) according to ISI and ISSRU.

Questions of validity

The issue of *validity questions* is twofold. It has a structural aspect, namely, it is not always proved that bibliometric indicators really do measure what they are assumed to measure. The questions, under which conditions and in how far, for instance, publication indicators reflect "scientific productivity", co-authorship measures the extent of collaborative research and citation-based indicators that of the impact of research on the scientific community have already been discussed at length.

In research evaluation, citations became a widely used measure of the impact of scientific publications. Citation-based indicators are the favourite bibliometric measures for the use of scientific literature. Although citations cannot describe the totality of the reception process, they give a formalised account of the information use, and can be taken as a strong indicator of reception at this level. As a consequence, the concept of citation can be interpreted as "one important form of use of scientific information within the framework of documented science communication" (Glänzel & Schoepflin 1999). This interpretation applies to basic research in life sciences, natural and technical sciences and also in part in social sciences. It does not contradict the application of citation-based indicators to research evaluation studies at higher levels of aggregation, since frequently (or rarely) used information disseminated, say, by the scientific community of a country or institute is certainly symptomatic for the research performance of the community in question. However, if one takes the characteristics of the process of giving and receiving citations essentially deviating from the above formula in several social sciences and humanities into account the limitations of the use of citation-based indicators as universal 'quality measures' of research publications becomes immediately obvious.

The inadequacy of co-publication indicators for measuring collaboration at the level of individuals has been shown, among others, by Katz and Martin 1997. According to Katz and Martin co-authorship can never be more than a partial indicator of research collaboration between individuals. However, at higher level of aggregation, co-publication activity proved an appropriate measure, for instance, for international or inter-institutional scientific collaboration (e.g., Glänzel and Schubert 2003).

Similarly, the interpretation of the role of author self-citations also depends on the level of aggregation. Self-citations can certainly be considered a natural part of scientific communication at the meso or macro level (Aksnes 2003, Glänzel et al. 2003). According to the latter study there is consequently no reason to excluding self-citations, say, from national science statistics. However, at the level of individual authors, self-citations might heavily distort or even falsify the evaluation of an author's role in the network of scientific communication. This illustrates again that different levels of aggregation might imply the use of different methodological approaches.

Beyond these rather standardised measures, a variety of indicators the adequacy of which is not always clear have been defined for occasional use in evaluative studies. We just mention the fact without giving further examples.

The question of validity has also a second, a data-analytical aspect. In particular, bibliometric raw data are often used as input to (multivariate) statistical analyses although the data do not always meet the necessary conditions. The validity of the sometime spectacular results such as the celebrated mapping of the structure of science is thus questionable. Bibliometric data are usually not randomly sampled from Gaussian populations (e.g., Haitun 1982). Standard methods of mathematical statistics can only be applied to bibliometric indicators if those are based on sufficiently large data sets and if those also meet further conditions like independence where necessary.

Statistical reliability of bibliometric indicators

Most bibliometric indicators can be interpreted as statistical functions, and can under certain conditions be analysed with the tools of mathematical statistics. This has severe consequences on the popular ranking of bibliometric indicators. Changes in ranking lists are not always significant (see, for instance, Schubert & Glänzel 1983). Conclusions drawn from ranking bibliometric indicators or from short-time trends might thus be precipitate.

Lacking standards in bibliometric research and technology

The lack of standards is recently one of the main sources of incompatibility of bibliometric indicators produced by different agencies. These incompatibilities proved to result in even contradicting conclusions.
The demand for validity of indicators and reliability of methods has already been formulated (see, e.g., Moed et al. 1996), but incompatibility will persist unless those institutes which are producing and scientists who are regularly using bibliometric indicator sets come to terms on general, technical and statistical basic questions (see Glänzel 1996).
Although considerable effort has been made towards standardisation in bibliometric research and technology, indicators produced by different bibliometric centres are by far not 100% compatible. Mixing up and compiling indicators from different 'sources' might result in invalidity (see Moed 1996). An example will be given below.
The following comparison of subfield rankings based on indicators produced by three different institutes (ISI, ISSRU and CHI) may serve as a typical example of the consequences of lacking standards and non-informed use of bibliometric data (see Figure 3).

Questionable ranking

The question, in which sub-fields of biomedical research GDR authors have been most frequently cited in the 80s, has been answered by three sources in a different way:

Science Watch (ISI)[1]	Scientometrics (ISSRU)[2]	CHI Research[3]
1. Virologie	1. Anatomie und Morphologie	1. Mikroscopie
2. Genetik	2. Parasitologie	2. Hygiene
3. Mikrobiologie	3. Mikrobiologie	3. Insektenkunde
4. Dermatologie	4. Pharmakologie und Pharmazie	4. Meeresbiologie
5. Biotechnology und angewandte Mikrobiologie	5. Biophysik	5. Genetik

Fig. 3: Weingart's example of contradictory subfield ranking of East-German citation impact (Source: Weingart 1993).

Weingart (1993) has raised the question of a consistent methodology and the responsible treatment and interpretation of bibliometric data but he has not uncovered the causes of the observed incompatibilities. The main causes are summarised below.

1. The simultaneous application of different and in part contradicting bibliometric methods is the most striking inconsistency of the comparison. These comparisons can necessarily not be valid. For example, the *Science Watch* data have been ranked according to Mean Observed Citation Rates, whereas ranking of the ISSRU data is based on Relative Citation Rates, that is, on the ratio of Mean Observed Citation Rates and their *expectations*.

2. ISI, ISSRU and CHI use different subject classification. Though classification is based on similar journal assignment procedures, subfields are in part defined based on strongly differing journal sets. Thus seemingly identical subject categories defined by different institutes may not necessarily cover the same set of publications.

3. ISI, ISSRU and CHI use different techniques to determine citation rates.

4. Different publication periods and citation windows have been used.

5. The ISI list is based on the publication year 1984. The size of the papers sets in several subfields is already critical. East-German scientists have published less than 15 papers each concerned with parasitology and biotechnology, whereas their publication output in other fields amounts about 150 papers (dermatology) or

[1] *Science Watch*, 1 (4), 1990, 2.
[2] *Scientometrics*, 16, 1989, 3.
[3] Science Literature Indicators, CHI Research, 1989.

more. That means the size of the subfields is of different order, and the East-German parasitology/biotechnology indicators may already regarded as microdata, and are therefore excluded from meso/macro level studies at ISSRU.

The question of composite indicators

Recently, attempts have been made to combine different bibliometric indicators (e.g., productivity measures and citation-based indicators) or to combine bibliometric indicators with peer reviews.

The question of constructing composite indicators is even more problematic than the previous question was. There seems to be a need for 'comprehensive' indicators in science policy. This need results in a trend towards combining several bibliometric aspects in one single nonetheless complex indicator. Such composite indicators are usually the combination of different statistical functions and/or of the same functions of different variables. They are practically based on weighted sums of relevant bibliometric components. The definition of weights is, however, often arbitrary. Arbitrariness, in turn, opens the way for tendentious use, and impedes the *reproducibility* of results. Moreover, collapsing dimensions through building composite indicators practically means a projection into the one-dimensional space involving a loss of relevant information.

On the other hand, a combination of bibliometric indicators with peer reviews seems to be challenging – of course not in form of a composite indicator. In fact, evaluation by peer reviews should not be replaced by bibliometric tools as bibliometrics was never designed to serve as such a substitute. On the contrary, both methods should complement each other. The often-heard complaint that the correlation between scores based on peer reviews and bibliometric indicators is rather weak and conclusions drawn from the two methods sometimes contradict must not lead to the conclusion that bibliometric tools are of low reliability, or should even be rejected. The real challenge is the analysis of the background of and the reasons for the deviating results.

Uninformed, tendentious use and misuse of bibliometric data

Another but perhaps more serious issue concerns a very important problem of bibliometric application: their application by users in science policy, research management and scientific journalism. This ranges from unintentional, i.e., uninformed use, over selecting and collecting 'most advantageous' indicators to the obvious and deliberate misuse of data.

The main forms of *uninformed use* are characterised by 1. unintentionally incorrect presentation, interpretation of bibliometric indicators or their use in inappropriate context caused by insufficient knowledge of methodology, background and data sources and 2. generalisation (*induction*) of special cases or of results obtained at lower levels of aggregation.

The main forms of *misuse* are characterised by 1. intentionally incorrect presentation, interpretation of bibliometric indicators or by their deliberate use in inappropriate context, 2. tendentious application of biases, 3. tendentious generalisation (*induction*) and 4. tendentious choice of indicators.

The following example for the tendentious choice of indicators has been taken from an unpublished study of the research performance of research groups at national universities. Since the example is quite general, we can use the source here anonymously. In the study in question, a university research group was found to have an extremely high productivity of papers but their publications received not many citations. The group's citation rate was thus low. The author of the study argued that in such cases the mean citation rate would not be a good measure of the impact of the group. He suggested that the use of an alternative measure such as the mean citation rate over persons instead of papers would result in a higher rank of this group.

Uninformed use and misuse are not always beyond the responsibility of bibliometricians. Due to the rising costs of bibliographic data and the monopoly of vendors, many bibliometric projects cannot be funded any more by usual grants. Nowadays contract work for science policy and research management has become one of the preferred forms of bibliometric studies (Glänzel & Schoepflin 1994). Unfortunately, bibliometricians do not always resist the temptation to follow popular, even populist trends in order to meet the expectations of the customers.

Distorted behaviour based on policy use and misuse of bibliometric data

In the wake of the previous remark, an additional issue concerns the changes in the publication, citation and collaboration behaviour of scientists (both positive and negative) that the consistent policy use of bibliometric indicators might potentially induce. Of course, if bibliometric tools have an effect on decision-making in science policy and research management and the scientific community recognises the feedback in terms of their funding, then there might be measurable repercussions on their behaviour, too. This process is visualised by Figure 4.

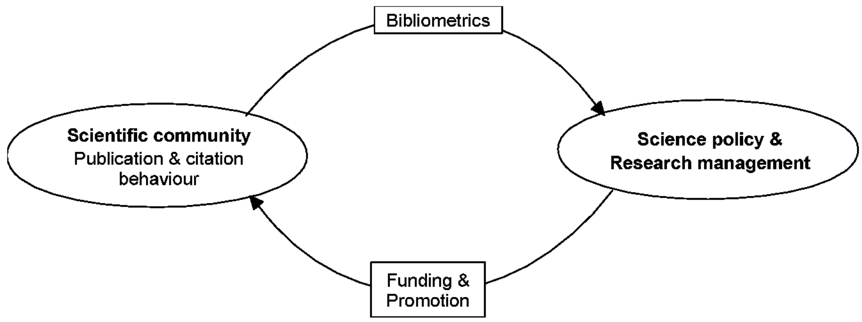

Fig. 4: Schematic visualisation of the feedback of policy use of bibliometrics on the scientific community.

Studies on the problem choice behaviour of academic scientists have revealed that a varied mix of both cognitive and social influences determines the manner in which scientists go about choosing the problems they work on (Debackere & Rappa 1994). Hence the issue should be raised to what extent the policy use of bibliometrics might or could affect this behaviour. For instance, scientists might recognise that scientific collaboration and publishing in high-impact or even top journals pays. Also their publication activity might be stimulated. These are of course positive effects. Nevertheless, there might be as well a negative, undesired feedback that can be considered distorted behaviour. Among these distortions, one finds 'inflationary bibliometric values' such as exaggerate collaboration, even trends towards hyper-authorship, inflating the publication output by splitting up publications to sequences, inflating citation impact by self-citations and forming citation cliques, etc. Also a certain trend towards replacing quality and recognition by visibility at any price might be a consequence of using bibliometrics a mean for the evaluation of research.
The future will show in how far these negative effects will become reality. Similar trends could, however, already be observed before bibliometrics has been used for the evaluation of science: striving after visibility and reputation is part of human nature. However, artificially inflating strengthening an authors' or a research team's own position in the scientific community by simply changing publication and citation behaviour will probably be hindered or prevented through the natural competition among researchers. The only negative feedback from policy use and misuse of bibliometric data might on the long run results in general 'inflationary values' described, among others, by Cronin (2001) and Persson et al. (2003). However, bibliometricians have the tools to normalise and standardise in indicators under such conditions, and thus in principle to cope with this problem, too.

Conclusions

Several of the discussed problems can certainly be overcome through the strict application of research methods according to the usual standards in the sciences and social sciences. Nevertheless, other limitations will remain since those are beyond the control of data providers and bibliometricians. These limitations have always to be taken into consideration whenever bibliometric indicators are used as a possible basis for interpretation and decision-making in a policy relevant context.

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