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Multidimensional Journal Evaluation

Analyzing Scientific Periodicals beyond the Impact Factor

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ISBN 978-3-11-025494-5
e-ISBN 978-3-11-025555-3
ISSN 1868-842X

Library of Congress Cataloging-in-Publication Data
A CIP catalog record for this book has been applied for at the Library of Congress

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.dnb.de.

Printing: Hubert & Co. GmbH & Co. KG, Göttingen
∞ Printed on acid-free paper

Printed in Germany

www.degruyter.com

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Chapter 1
Introduction

This book focuses on scholarly journals and deals with their role as the primary means of formal communication in the sciences. Their standing in the scientific community is evaluated from the perspective of quantitative informetric indicators. Two main research questions are investigated:

- Are there different dimensions of journal evaluation? If so, what indicators can be applied to represent each dimension of journal evaluation? How do metrics differ and what data can be used to adequately indicate journal impact?
- Various stakeholders of journal evaluation, i.e. scholarly authors, readers, librarians, publishers and editors, have different interests in using methods of journal evaluation. What indicators of what dimensions will each of the stakeholders find most valuable and apply in practice to journal selection?

In the form of a case study, a set of 45 physics journals will be used to demonstrate the various journal metrics and informetric methods in terms of practicability, validity and informative value.

Formal communication in the sciences depends primarily on the publication of research results and comprehensive reviews in the form of journal articles. Since the first scholarly journal was founded in the 17th century, the scientific periodical has become the most important medium in science, technology and medicine (STM). Through its fast and wide dissemination the peer-reviewed journal is the preferred formal publication outlet of researchers in these fields. In the social sciences and humanities its influence is growing. With constant growth in the number of scientists, research institutions and publications, the number of scholarly journals and the number of articles in them increases, too. The academic world has to deal with the problem of massive information overload. The current number of scientific peer-reviewed periodicals is estimated to be approximately 24,000 titles (Tenopir & King, 2009). Researchers are confronted with the impossible task of keeping up with the amount of information available (Moens, 2000; Keller, 2005).

> [I]nformation overload occurs when information received becomes a hindrance rather than a help when the information is potentially useful. (Bawden, Holtham, & Courtney, 1999, p. 249)

Bawden and Robinson (2009) quote a report based on experience from the area of biomedical research in 1986:

> Many medical practitioners have abandoned ‘keeping up with the literature’. They are paralysed by the sheer enormity of the task: more than 20,000 journals in biomedicine are published each year and a consultant in a single medical subspeciality may need to read fifteen to twenty publications a month to keep up to date. (Bawden & Robinson, 2009, p. 183)

Price (1963) claims that "scientists have always felt themselves to be awash in a sea of scientific literature" (Price, 1963, p. 15). He was also the first to provide support for the subjective perception of the information flood in science by objective statistics on the number of scholarly journals. With the emergence of electronic publishing the number of documents available has further increased. With an ever growing output the challenge is to manage this information overload and select the most suitable sources. It is not only the reader who has to choose. Since they are evaluated on the basis of their publications, researchers need to develop a publication strategy and select the best periodicals in their role as authors as well. Scientometric indicators can help with these selection processes.

Informetrics and the sub-areas of scientometrics and bibliometrics represent an approach forcoping with the growing flood of scholarly literature by means of objective statistical methods (Tague-Sutcliffe, 1992; Stock & Weber, 2006; Bar-Ilan, 2008). Bibliometric methods quantitatively evaluate the structure of and processes involved in formal scholarly communication, in which the scientific journal plays a paramount role. Scientometric analysis of periodicals arose out of the need to identify significant sources of information. Initially, journal evaluation was applied with a local focus by librarians for collection management purposes. With the development of the Science Citation Index (SCI) and the advent of systematical journal-based research evaluation, journal rankings have become important and are applied by authors, readers, editors, publishers and research managers alike.

> The evaluation of scholarly journals is important for selection and cancellation decisions by librarians, the evaluation of faculty and librarians for promotion and tenure as well as annual performance reviews, manuscript submission decision by authors, monitoring of their journals by editors and publishers, and familiarizing new doctoral students or outsiders (such as members of a university-wide promotion and tenure committee evaluating faculty from other departments) with a field's journals. (Nisonger & Davis, 2005, p. 341)

> Journal citation measures are designed to assess significance and performance of individual journals, their role and position in the international formal communication network, their quality or prestige as perceived by scholars. Scientific journals may differ with respect to their importance of their position in the journal communication system, their status or prestige. (Glänzel & Moed, 2002, p. 171)

The most widely used indicator for selecting the most influential journals in a scientific field is the impact factor listed in the Journal Citation Reports (Stock, 2001). Developed by Eugene Garfield (1955) as a criterion to select a discipline's core journals for his citation indices, the impact factor has become a popular measure to indicate a journal's standing in the scientific community (Garfield, 1972). Librarians use the impact factor to compile literature within their budget, authors make use of it to choose the best suited journal for publication, readers use it to identify central sources of information, and editors and publishers apply it to analyze the market and observe competitors. The impact factor has become the most popular bibliometric indicator used inside and especially outside the scientometric community (Glänzel & Moed, 2002). As an average citation rate it is, however, not able to reflect all the aspects that contribute to a scholarly journal, not to mention its methodological shortcomings. As the impact factor became popular, so, too, did its misuse. It is often applied directly to the articles a journal contains or even to the contributing authors. Publications in high-impact journals are rewarded financially, and with the help of cumulative impact factors, research grants are provided or careers decided upon (Jennings, 1998; Al-Awqati, 2007).

While alternatives exist and new and improved methods are being created by the bibliometric community, in the evaluation of journals by its users the influence, quality and prestige of a serial are mainly based on the impact factor. The journal's value is limited to a single quantitative indicator which divides the number of received citations by the number of published articles. Further methods and possibilities of journal evaluation are more or less disregarded by users outside the bibliometric community. Journal evaluation is unidimensional and therefore not able to reflect the actual impact of a scholarly periodical (Rousseau, 2002; Coleman, 2007).

This book argues that only a method that incorporates all facets of journal evaluation can adequately represent the journal's standing in the scientific community. Five conceptual dimensions are defined which contribute to the value of scholarly journals and are therefore to be included in a comprehensive and adequate approach to journal evaluation. The goal of this study is to provide the users with a variety of indicators to choose the most suitable method for their individual purpose regarding journal selection. Since the purposes of journal evaluation are individual (Björk & Holmström, 2006), it is not the aim to provide a cure-all or all-in-one device but to systematically review various metrics of journal evaluation including a transparent description of possibilities and shortcomings. The work focuses on the users of these methods, i.e. researchers in their role as authors and readers, librarians, publishers and editors, rather than the experienced bibliometrician and tries to guide them through the "maze of indicators" (Wouters, 1999, p. 128). This book tries to solve the lack of transparency of bibliometric methods and journal metrics, which causes users to restrict themselves to the well-known and readily available but limited and flawed impact factor. Whether or not alternative or complementary indicators are used depends above all on these indicators being known and understood by their potential users.

> What will ultimately determine which of this new battery of measurements succeed and which fail, either individually or as composite measures, is likely to be how strongly they resonate with the communities they serve. The best ideas do not always make the best products, but instead simplicity and transparency can be the difference between success and obscurity. (Craig & Ferguson, 2009, p. 188 f.)

This book tries to provide transparency and lets the user choose from a toolbox of indicators and combine the most suitable for his particular needs, i.e. an author to select the most appropriate publication venue, the reader to select journals to fulfill his information needs, a librarian to compile a collection, and an editor and/or publisher to monitor the performance of his own journals and that of competitors.

In the following, the scholarly journal is defined and its emergence as the most important form of formal scholarly communication briefly described. Afterwards section 1.2 provides an overview of the usage and users of evaluation methods. Section 1.3 introduces the five dimensions of multidimensional journal evaluation, which are discussed and analyzed in detail in the respective chapters. Section 1.4 describes the 45 physics journals which throughout the study function as a test set to apply and compare various indicators.

1.1 The Scholarly Journal

Since the founding of general science journals over 300 years ago, the publishing landscape has grown, specialized and become more and more heterogeneous and unmanagable for a researcher to cover. After an attempt to define what constitutes a scholarly journal (section 1.1.1), a brief historical overview of the emergence and development (section 1.1.2) is given.

1.1.1 Definitions

As this work is based on the evaluation of scholarly journals, a definition of it is due. Although a vast amount of literature exists, an exact, formal definition of the scholarly journal is, however, lacking. Most works assume that it is understood. In addition, the terms 'journal', 'periodical' and 'serial' are used synonymously (Buchet, 2004; Keller, 2005; Mierzejewska, 2008). Page, Campbell, and Meadows (1997) define 'serial' and 'periodical' as follows:

> **Serial**: a publication issued in successive parts, bearing numerical or chronological designations and intended to be continued indefinitely.
>
> **Periodical**: a publication appearing at stated intervals, each number of which contains a variety of original articles by different authors. (Page et al., 1997, p. 1)

In this study, the terms 'journal', 'periodical' and 'serial' are used synonymously and all refer to scholarly or learned journals which, on a regular basis and to a great extent, publish original research articles and/or reviews and apply some form of peer review. Academic journals can be clearly distinguished from popular magazines and newspapers and so-called trade journals which, on the one hand, publish current, non-technical and unscholarly content often written by in-house writers and commissioned journalists and, on the other hand, inform members of one particular industry sector or branch of trade.[1] As electronic journals or e-journals are merely a new form of appearance of the same medium established 300 years ago, no distinction is made between print and electronic journals. Even though future visions of the electronic journal predicted significant changes of scholarly communication tapping the full potential of the digital age, the concept of the academic journal has so far hardly been altered by its electronic form (Keller, 2005). Although the electronic, i.e. PDF, format improves access, searchability and intra- and inter-document navigation, the scholarly article as such, and hence the academic journal, has not changed.

In the area of STM, academic journals play the major role in formal scholarly communication. The extent to which scholarly output is published in journals, varies between disciplines. As table 1.1 shows, over 80% of all scientific output in the biological, chemical, physical and medical research fields is published in journals, while in the social sciences and arts and humanities, where book publications play a more significant role, it is less than half as much. As bibliographical databases such as the Web of Science (WoS) and Scopus are limited to periodical literature and not able to cover the entire scholarly output, the databases' ability to reflect formal scholarly communication depends on the discipline-specific publication behavior, on the one hand, and database coverage, on the other. Due to these field differences, this study

1 http://www.unity.edu/library/scholarly_journal.htm

focuses on physics journals (see section 1.4), but methods and indicators can be equally applied to periodicals in any other STM research field. When evaluating social sciences and arts and humanities journals, one should be aware of capturing only a fraction of the scholarly output. In order to adequately reflect formal scholarly communication in non-STM research, books have to be considered as well.

Table 1.1 Percentage ($P_{\%}$) of references (of articles and reviews published in 2002) per discipline published in journals and covered by WoS (WoS). Source: Craig and Ferguson (2009, p. 163).

Discipline	$P_{\%}$ in journals	$P_{\%}$ in WoS	$P_{\%}$ WoS coverage
Molecular biology and biochemistry	96	97	92
Biological sciences related to humans	95	95	90
Chemistry	90	93	84
Clinical medicine	93	90	84
Physics and astronomy	89	94	83
WoS average	*84*	*90*	*75*
Applied physics and chemistry	83	89	73
Biological sciences (animals and plants)	81	84	69
Psychology and psychiatry	75	88	66
Geosciences	77	81	62
Other social sciences (medicine and health)	75	80	60
Mathematics	71	74	53
Economics	59	80	47
Engineering	60	77	46
Social sciences	41	72	29
Humanities and arts	34	50	17

As major communication channels in STM, academic journals fulfill the four basic functions of registration, certification, dissemination and archiving (Mierzejewska, 2008). Through publication researchers are able able to publish their findings quickly and claim priority. Peer review and editorial processes guarantee quality control and validity of published contents. The journal provides a platform of wide dissemination in the scholarly community and at the same time makes findings permanent through archiving (Mabe & Amin, 2002; Meier, 2002). While registration, certification, awareness and archiving represent the primary functions of an academic periodical, secondary functions can be identified as well. They mainly refer to social aspects of scientific communities, i.e. forming and developing communities by providing a communication platform, identifying and empowering influential authors through editorial board membership and by providing the framework for scientific evaluations (Mierzejewska, 2008).

1.1.2 Emergence and Development

The first scholarly journals emerged in the 17th century in order to make science more efficient. Journal publishing was intended to serve the purpose of avoiding duplication and advance scientific knowledge by building on results of colleagues (Mierzejewska, 2008). Published in France in January of 1665, Le Journal des Sçavans is said to be the first scholarly journal since it published articles and news items on many different topics for scholars. Only shortly after, the first issue of Philosophical Transactions of the Royal Society of London appeared, which had a greater resemblance to the modern scholarly journal since it consisted of 407 instead of 20 pages (Keller, 2005; Tenopir & King, 2009). Philosophical Transactions was launched by the Secretary of the Royal Society, Henry Oldenburg

> to inform the Fellows of the Society and other interested readers of the latest scientific discoveries. As such, Philosophical Transactions established the important principles of scientific priority and peer review, which have become the central foundations of scientific journals ever since.[2]

The emergence of scholarly journals in the 17th century fundamentally changed the entire process of scholarly communication, which up to that point had been carried out through society meetings, books and letters (Price, 1963; Zuckerman & Merton, 1971). Although the latter represented a timely method of publishing results and claim priority for discoveries, scientific letters were still a personal form of communication and thus limited in terms of distribution (Keller, 2005; Tenopir & King, 2009). Price (1963) emphasizes the initial purpose of the newly founded journals as

> monitoring and digesting of the learned publications and letters that now were too much for one man to cope with in his daily reading and correspondence. (Price, 1963, p. 15)

Scientific communication advanced from personal correspondence and became structured and distributed on a regular basis. This made it possible to keep a record of and archive knowledge systematically. In addition, publication in a journal allowed researchers to claim their discoveries (Keller, 2005).

Since the founding years of the scholarly journal, the number of titles has increased, although Price's famous estimations of exponential growth which predicted one million titles in 2000 did not occur (compare chapter 2). Annual growth rates increase gradually rather than exponentially (Mierzejewska, 2008). Mabe (2003) calculated an almost constant annual growth rate of 3.46% of active refereed scholarly journal titles from 1665 to 2001 listed in Ulrich's Periodicals Directory , and Tenopir and King (2009) conclude from listings in the same database that in 2008 61,620 scholarly journals existed (i.e. were still actively publishing), of which 23,973 were refereed. Placing the number of scholarly, peer-reviewed journals at 24,000 seems a conservative but fair estimate of the number of journals available, which is supported by results of other studies (Mabe, 2003; Morris, 2007; Craig & Ferguson, 2009; Tenopir & King, 2009).

Today the landscape of scholarly journals is characterized by its heterogeneity. Further growth and specialization of science demands specialization of publication venues, which contributes to the foundation of new journals or the splitting up of existing ones (Meier, 2002; Mierzejewska, 2008). The increasing specialization and further development of science has led to a flood of information which is difficult for a single researcher to access or manage (Keller, 2005). As it is not possible for a

2 http://rstl.royalsocietypublishing.org/

researcher to read all the relevant literature, it is now more than ever crucial to select the most important resources so that relevant content is not missed. Journal evaluation can help to identify the most suitable journals.

1.2 Application and Developments of Journal Evaluation

Scientometric analysis of periodicals arose out of the need to identify significant sources of information. Bibliometric indicators were first and foremost developed to cope with the flood of information created by an increasing specialization and differentiation of science and the growth of research output. With the amount of literature available, the scientific landscape has become complex and the chances are that relevant content is missed (Keller, 2005). Quantitative methods provide focus (Craig & Ferguson, 2009) and are applied to help researchers in their role as readers and authors to select the most suitable journals satisfying their information needs, on the one hand, and communicating their results, on the other.

At the beginning, journal evaluation was applied locally by librarians for collection management purposes. Gross and Gross (1927) are considered to be the first describing a reference-based journal analysis for managing library holdings by objective, quantitative methods (Archambault & Larivière, 2009). Bradford (1934) further influenced librarians and collection management through his famous law of scattering stating that the majority of documents on a given subject are concentratively published in a few core journals.

With the development of the SCI by the Institute for Scientific Information (ISI), journal evaluation transcended local library collection management and was applied on a global scale. With the impact factor, the first widely applied indicator for journal evaluation was developed, although, initially it was constructed as a means to identify the most frequently cited journals per discipline for the SCI rather than a journal metric on its own. As a multidisciplinary citation index, the SCI was in the first instance not developed for evaluational purposes but for the retrieval of scientific information (Garfield, 1955, 1998).

The SCI has, however, fostered the culture of research evaluation. The impact factor is no longer a simple metric to identify candidates for database coverage, but has become a synonym for journal prestige powerful enough to influence scholarly communication and even researchers' careers. In these times of journal-based research evaluation, the ranking of periodicals is central and the impact factor has become a cure-all indicator used and misused by authors, readers, editors, publishers and research policy makers alike (Adam, 2002; Rogers, 2002; The PLoS Medicine editors, 2006).

As the limitations of the impact factor and its inability to fulfill various information needs and fully represent a journal's standing in the scholarly community became obvious, many alternative metrics were proposed from within and outside the bibliometric community. Figure 1.1 shows the growth of publications on journal evaluation[3] and their impact. During the 30 years between 1980 and 2009 almost 3,500 documents on

3 3,497 documents retrieved in January 2011 from SCI, SSCI, A&HCI and CPCI-S published between 1980 and 2009, matching the following query: ti=("impact factor*" or (journal$ and (evaluat* or analy* or measur* or indicat* or cited or citing or citation* or rank* or scientometr* or bibliometric* or informetric*))).

journal evaluation were published, 10% of which were published in 2009. While new or newly named indicators emerge regularly within the bibliometric community, in applied journal analyses evaluation methods are mostly limited to the impact factor, which is largely due to its simplicity and availability (Seglen, 1997; Glänzel & Moed, 2002; Moed, 2002; Favaloro, 2008).

> Apart from the impact factor, the use of other journal citation measures is rather occasional. [...] All other attempts to improve, substitute or supplement the impact factor have encountered serious obstacles to wider application. On the one hand, the achieved 'accuracy' is often at the expense of simple interpretation. On the other hand, several alternative journal citation measures could not always be rendered accessible to a broader audience, or at least not regularly be updated like in the case of the IF through the annual updates of the JCR. In lack of regular updates, these indicators could not be readily reproduced by other research centres. (Glänzel & Moed, 2002, p. 177 f.)

In order to be used, alternative metrics have to be understood. This work aims to provide a systematic overview of possibilities of multidimensional journal evaluation with a focus on the applicability and limitations of existing indicators. In addition, new data sources such as bookmarks of and tags assigned to journal articles by users of specific web 2.0 platforms are introduced as alternatives to represent the readers' perspective (Haustein & Siebenlist, 2011). It will be shown that one journal metric, such as the impact factor, is not able to fulfill the various requirements for journal evaluation of the different user groups.

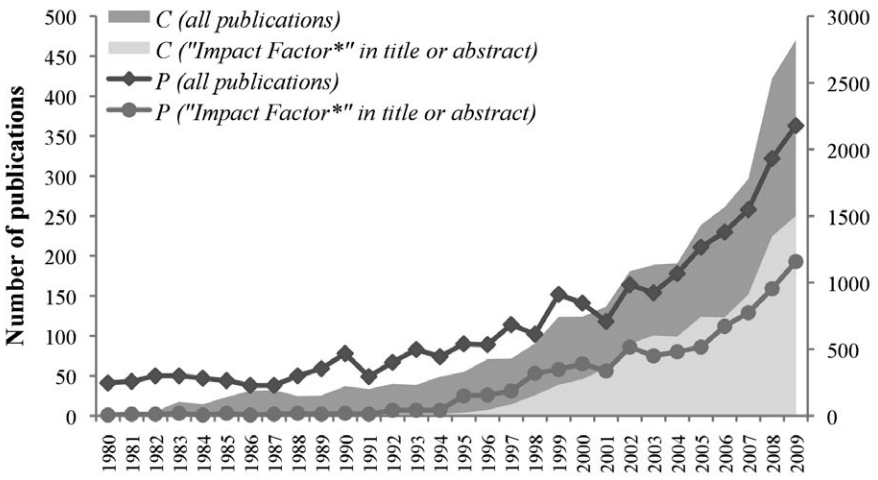

Figure 1.1 Number of publications (*P*) and citations (*C*) of journal evaluation literature 1980 to 2009.

In the journal publication landscape, five groups of participants can be identified: researchers (i.e. authors), gatekeepers (i.e. editors), publishers, libraries and users (i.e. readers). These groups "may significantly influence the functioning and success of academic journal publishing" (Mierzejewska, 2008, p. 7). These participants represent actual and potential users of journal evaluation. In the process of evaluating scholarly journals, four stakeholders can be identified, i.e. academic authors selecting a publication venue, readers choosing a suitable source of information, librarians managing a collection, and editors and publishers evaluating journal performance and observing competitors (Garfield, 1972; Todorov & Glänzel, 1988; Nisonger, 1999; Glänzel & Moed, 2002; Rousseau, 2002). Research evaluators at universities, government offices and funding agencies can be identified as a fifth stakeholder. However, their purpose in evaluating journals is secondary in so far that they rank journals as a means of evaluating the researchers and institutions publishing in them. Thus, policy makers are not treated as a distinct user group in this study.

Each of the four user groups has different requirements for identifying and ranking scholarly journals (Moed, Van Leeuwen, & Reedijk, 1998). Depending on these needs, one indicator might be more suitable for one stakeholder than another. The same set of periodicals might even be ranked differently from the readers' and authors' perspectives.

> The quality of a journal is a multifaceted notion. Journals can be evaluated for different purposes, and hence the results of such evaluation exercises can be quite different depending on the indicator(s) used. (Rousseau, 2002, p. 418)

Journal evaluation depends on the individual purpose and requirements of the user. The four stakeholders are introduced in the following together with the differences and similarities of their positions in journal evaluation.

Readers

Readers of scholarly literature can be divided into two groups, namely publishing and pure readers (Rowlands & Nicholas, 2007). The former can be considered as active researchers who use the scholarly journal as a means to communicate their research by publishing results which then influence and improve further research and technological development. These publishing readers need to select a set of journals to be informed about the research front. In journal selection they give priority to the topicality, scholarliness and high quality of journal content guaranteed through peer review. The group of pure readers includes those readers who do not actively participate in research but read scholarly literature to apply in their everyday worklife and teaching. Students make up a large part of pure readers. Pure readers primarily select review journals to obtain an overview and and be generally informed (Rousseau, 2002).

In general, researchers in their role as readers wish to read as little as possible to fulfill their information needs. Due to the evaluation culture, in their role as authors the same researchers, however, aim to publish as much as possible and to be read by as many people as possible. This schizophrenic behavior (Meier, 2002), described by Mabe and Amin (2002) as 'Dr Jekyll and Dr Hyde', is also reflected in journal selection.

Authors

Publishing research results in the form of journal articles is the final step in the scholarly communication process. In the role of an author, researchers seek to publish in the most suitable publication venue in order to reach out to a particular target audience and diffuse results as far as possible. In general, the target readership can be defined as the scholarly community of the particular field, although sometimes authors may wish to address researchers or practicioners from outside their research area. The target audience can, above all, be identified thematically through the journal's scope and topics published, but also geographically through the nationality of publishing authors and readers. Usually an author chooses a publication venue where he can reach as large an international audience as possible (Swan & Brown, 1999).

A survey by Rowlands and Nicholas (2005) showed that a journal's reputation has become even more important to submitting authors than potential readership. Now that researchers are evaluated on the basis of the periodicals they publish in, the journal's standing, often substituted by the impact factor, plays a paramount role in submission decisions. Authors seek to gain recognition and personal prestige by publishing in high-quality journals, which helps them to advance their careers (Swan & Brown, 2004; Mierzejewska, 2008).

Since authors publish to claim priority of their findings, a fast review process and short publication lag, i.e. time between acceptance and publication, is crucial. Thorough peer review helps to improve the quality of the submission and assures potential readers that quality control has been applied. Journal prices hardly influence an author's decision whether to submit his manuscript to a periodical. The opportunity to publish open access in order to reach as large a readership as possible may, however, influence the author in the journal selection process. Methods of journal evaluation are able to reflect various aspects from journal scope to readership, publication delay, impact and prestige. Journal metrics can help authors to identify the most suitable publication venue from a large number of periodicals and optimize publication strategies (Moed et al., 1998).

Librarians

Libraries are mandated to provide broad access to scholarly information to scientists for them to further develop and improve their research (Meier, 2002). In order to optimize collections, i.e. choose the most useful and suitable sources of information, librarians were the first users of journal rankings. Monitoring usefulness by usage statistics, surveys and citation analysis are applied for purposes of collection management. Confronted with budget cuts and increasing subscription prices, the need to select the best journals within a limited budget is crucial to a librarian. Although citation or reference analyses such as the first one by Gross and Gross (1927), conducted to optimize a college library's subscriptions by objective, quantitative methods, may be helpful to obtain an overview of the scholarly publication landscape, global citation rates may be insufficient to fulfill particular demands by librarians based on specific local requirements (Rousseau, 2002).

> Users of journals read, but many actually publish little or nothing at all. In this context, it is important to investigate the relation between in-house use and citation use. (Rousseau, 2002, p. 419)

Hence, indicators reflecting journal usage at the local institution are particularly important to librarians. Time-based metrics show obsolescence patterns of literature and are thus able to provide information about access to older volumes. As journal prices are crucial to librarians, cost-performance ratios are helpful to maximize purchase in terms of content received (Van Hooydonk, Gevaert, Milisproost, Van de Sompel, & Debackere, 1994; Mierzejewska, 2008).

Editors and Publishers

Journal editors and publishers seek to monitor journal performance from the scientific and economic perspective. Impact factors are regularly discussed at editorial board meetings (Craig & Ferguson, 2009). For editors it is important to analyze the extent to which the periodical is able to attract authors and readers in comparison to competing serials. While commercial publishers want to maximize revenues, non-profit publishers have to monitor financial sustainability.

> From a publisher's perspective, we are interested in pursuing activities which maximize the quality and visibility of our journals, ensuring they reach as many interested users as possible, and are attractive to potential authors seeking to publish their highest-quality research. To this end, scoring highly in various systems of ranking is crucially important to the long-term success of a journal. (Craig & Ferguson, 2009, p. 160)

It was Garfield (1972) who highlighted the potential use of journal citation analysis to editors:

> Editors and editorial boards of scientific and technical journals may also find citation analysis helpful. As it is, those who formulate editorial policies have few objective and timely measures of their success. A wrong policy, or a policy wrong implemented, may have serious effects on revenue and prestige, and the work of regaining readers and reputation can be difficult and expensive. (Garfield, 1972, p. 477 f.)

Besides citation analysis, which indirectly evaluates journal performance in terms of scholarly impact, other metrics such as the rejection rate or publication delay are able to reflect the editorial performance and journal management more directly. The rejection rate mirrors whether the journal is able to choose high-quality manuscripts from a large number of submissions, which increases its attractiveness for readers. Monitoring publication delay can be helpful to optimize the review process and thus guarantee fast publication to authors.

Optimizing such aspects of editorial management means attracting new authors and readers (Nisonger, 1999). Journal performance and rankings are used for advertising and marketing purposes by the publishers (Hecht, Hecht, & Sandberg, 1998; Craig & Ferguson, 2009). Since the impact factor has become a powerful tool which "will influence the future 'success' of [a] journal" (Favaloro, 2008, p. 8), editors and publishers are interested in monitoring the performance of their own titles and observing competitors.

1.3 Multidimensional Journal Evaluation

As journals reflect formal scholarly communication in the sciences and are influenced by many different factors, their evaluation should be multifaceted as well. Citation-based indicators are widely used by the different stakeholders of journal evaluation. However, they only tell a part of the story (Rowlands & Nicholas, 2007). In the following, a brief overview of previous studies of journal evaluation beyond the citation impact is given (section 1.3.1), before the multidimensional approach of this work is introduced and the structure of this book is outlined (section 1.3.2).

1.3.1 Inability of a Single Metric

Various authors have addressed the inability of a single metric to reflect a journal's impact and prestige and the need for a multidimensional approach to research evaluation in general and scholarly journals in particular (Rousseau, 2002; Van Leeuwen & Moed, 2002; Moed, 2005). Rousseau (2002) briefly reviews various aspects of journal evaluation including journal prices and usage and gives an overview of journal citation measures with a focus on different versions of the impact factor from a theoretical perspective. Glänzel and Moed (2002) provide a state-of-the-art report on citation-based journal metrics and Moed (2005) discusses journal citation indicators and explains shortcomings with practical examples.

These authors emphasize that a complex concept such as scholarly impact cannot be reflected by the average number of citations.

> [S]cholarly communication is a multi-phased process that is difficult to capture in citation statistics only. The scholarly cycle begins with the development of an idea, eventually resulting in its publication and subsequent citation. Citations only occur at the end of this cycle [...]. (Bollen, Van de Sompel, & Rodriguez, 2008, p. 231)

Moreover, complex structures and multiple aspects cannot be captured by one indicator, but should rather be represented by a range of metrics. Multiple indicators should be used to reflect the multifaceted notion of journal quality (Glänzel & Moed, 2002; Rousseau, 2002; Coleman, 2007). To preserve the multidimensionality information should not be conflated into one ranking.

> [I]t would not be wise to concentrate too strongly upon developing the single, 'perfect' measure. Journal performance is a multi-dimensional concept, and a journal's position in the scientific journal communication system has many aspects. It is questionable whether all dimensions can be properly expressed in one single index. A more productive approach is to develop and present a series of indicators for the various dimensions, and highlight their significance and limitations. (Moed, 2005, p. 105)

> [S]everal indicators rather than one are needed to provide users of bibliometric journal impact measures in their specific decision making processes with sufficient and valid information. (Van Leeuwen & Moed, 2002, p. 265)

Although there are some studies (e.g., Todorov and Glänzel (1988); Glänzel and Moed (2002); Rousseau (2002); Bonnevie-Nebelong (2006); Bollen, Van de Sompel, Hagberg, and Chute (2009)) which have listed a number of journal indicators, there is no comprehensive multidimensional analysis of all aspects applied to one set of journal indicators. Above all, the existing overviews address experts from the bibliometric community. Users of journal evaluation are confronted with an excessive number of new or renamed indicators. This book tries to solve the lack of transparency causing users to restrict themselves to the well-known and readily available but limited and flawed impact factor. Whether or not alternative and complementary indicators are used, depends above all on them being known and understood by potential users.

1.3.2 Multidimensionality

This work is built upon a conceptual definition of five dimensions reflecting all the factors which make up and influence scholarly periodicals. The concept is based on work by Grazia Colonia (2002), Stock (2004), Schlögl (2004), Schlögl and Stock (2004), Schlögl and Petschnig (2005) and Juchem, Schlögl, and Stock (2006). The five dimensions are journal output, journal content, journal perception and usage, journal citations and journal management. It is argued that in order to appropriately reflect the standing and impact of a journal in the scientific community, methods from all of these dimensions should be considered. Figure 1.2 provides a schematic representation of this conceptual approach. At this point, a brief overview of these five dimensions is given, while the following chapters describe these and related journal metrics in detail.

Journal Output

The dimension of journal output is concerned with the direct evaluation of the periodical in terms of its publication output. It includes an analysis of the journal size with regards to how much and what kind of content is published by whom each year. Possibilities of evaluating journal output are described in chapter 2.

Journal output can be analyzed in terms of the number of issues per year, documents per issue (section 2.1.1) or pages per document (section 2.1.2). Different types of publications serve different purposes. By examining the frequency of document types published, the journal's scope and aims can be distinguished (section 2.1.4). An analysis of the cited references listed in the documents published in a periodical can reveal the structure, diversity and age of its imported knowledge and its level of scholarliness (section 2.1.5). The language of published documents can be analyzed to reveal the national focus of authors and readers (section 2.1.6).

Journal output is shaped by the contributing authors. Authors represent the smallest level of aggregation of contributing units to be analyzed (section 2.2.1). The development from little science to big science describes the development from small to large groups of collaborating researchers which is reflected in an increasing number of co-authors per document. An analysis of unique authors publishing in a periodical reveals whether or not the journal is able to attract the most prestigious authors in the field. On the meso level, the same can be done for research institutions, which provide the infrastructure that is necessary to produce the results described in the publications (section 2.2.2). The highest, i.e. the macro, level of aggregating journal output is the country level (section 2.2.3). By evaluating the distribution of contributions per country, it is possible to determine the level of internationality of the particular journal.

Figure 1.2 Schematic representation of multidimensional journal evaluation.

Journal Content

The dimension of journal content represents the thematical scope of a periodical and the topics covered in its publications. Journals can cover a broad field of science and publish more general topics or focus on a specific area of research. Journal content is shaped by the contributing authors, on the one hand, and by editors and referees, on the other, who decide whether a submission fits the scope of the particular periodical.

Content analysis can reveal the specific topics dealt with in the journal. It helps readers to find the most suitable source of information to satisfy specific information needs. Authors can find out if the journal suffices as an adequate publication venue read by the target audience for their submission.

Various methods of subject indexing can help to analyze and depict journal content. Methods which can be used to reflect various aspects of journal content are described in detail in chapter 3. Section 3.1 provides the theoretical background of different indexing methods, i.e. classification systems and thesauri (section 3.1.1), author keywords (section 3.1.3), citation indexing (section 3.1.4), automatic indexing (section 3.1.5) and social tagging, which is introduced as a new approach to reflect the readers' point of view on journal content (section 3.1.6).

In section 3.2.1 and section 3.2.2, various methods of subject indexing are applied on the journal and article level, respectively. Since journal classification systems put entire journals into broad categories, they provide a general overview, which can help students to enter a new research field and librarians in collection management. Subject indexing on the document level is able to give a more detailed insight as to the particular topics covered by single articles. Aggregated on the journal level, frequency distributions of index terms assigned to single documents provide information about focus areas. If accumulated per year of publication, term frequencies highlight shifts of emphasis over time. Such a content trend analysis is described in section 3.3.

Content similarity can be discovered on the basis of common index terms or through methods of citation analysis such as bibliographic coupling and co-citation analysis through contextual relatedness of citing and cited literature. Journals are analyzed regarding content-based similarity in section 3.4.

Journal Perception and Usage

In order to reflect a journal's impact and prestige in the scientific community, an analysis of its readership is essential. The dimension of journal perception and usage thus focuses on the evaluation of the readers. This is described in chapter 4. In contrast to the dimension of journal citations, which is limited to the evaluation of journal usage by publishing readers only, it fully covers the whole readership including the pure, i.e. non-publishing, readers.

Reading statistics and reading behavior can be collected through reader surveys (section 4.1). Participants can be asked to rank journals by subjectively perceived importance, or which journals they read how frequently and how exhaustively. Moreover readers can be asked to indicate in how far journal content influences their work. Demographic data can provide information about the composition of the readership. Differences in reading behavior of particular groups can be discovered. Conducting reader surveys is, however, time consuming and depends on the participation of readers. It is limited regarding space and time and biased in terms of subjectivity.

Through electronic publishing it has become possible to monitor access to journal content and compute usage statistics based on log files (section 4.2). Almost simultaneously it can be evaluated which article is downloaded where and how many times. Provided that download and click rates indicate usage, reader-based journal usage can be monitored on the local (section 4.2.1) and global scale (section 4.2.2). While local download rates can help librarians to optimize collection management, global usage can help authors to submit their manuscript to the most suitable publication venue. In analogy to citation-based metrics, download indicators are able to reflect the journal's impact on its readership (section 4.2.3). Due to the lack of appropriate and comprehensive statistics of worldwide journal usage, social bookmarking services are introduced as an alternative source for article-based readership data in section 4.3.

Journal Citations

The dimension of journal citations is concerned with the part of formal scientific communication which is visible through citations received. A citation reflects that one source has influenced another. Citation impact is thus a way of measuring scholarly impact. Bibliometric indicators are based on the general assumption that the more citations a publication, an author or a journal receives, the greater is their influence in the scholarly community.

In terms of journal evaluation, the impact factor is the most widely used citation metric. Originally developed as an indicator which, as a ratio of the number of citations received by a journal and the papers published, was to identify the most important periodicals in a scholarly field to be covered by the SCI, it is now used and misused for research evaluation purposes. Although many problems exist concerning the impact factor's construction and methodology, which make it unsuitable to entirely reflect a journal's scholarly impact, the impact factor remains the most widely used journal indicator and other methods are often disregarded.

Chapter 5 describes and applies various indicators. A detailed analysis and comparison make it possible to discover the advantages and disadvantages of the measurements and individually combine different alternatives that best reflect scholarly impact in terms of citations.

There are a number of alternatives for indicating journal citation impact. Chapter 5 distinguishes between basic (section 5.1), weighted (section 5.2) and normalized (section 5.3) journal metrics. Some basic metrics are mean citation rates such as the impact factor, but which try to improve on some of its technical shortcomings by alternating the publication and citation windows or document types covered (section 5.1.1), while others evaluate the citation distributions instead of conflating the information to an arithmetic mean (section 5.1.2). Time-based indicators analyze citedness over time to reflect how long journal content stays relevant (section 5.1.4).

PageRank-like algorithms account for the prestige of the citing sources (see section 5.2) and citing-side normalization approaches such as the fractionally-counted impact factors aim to normalize discipline-specific citation behavior to allow cross-field comparisons (see section 5.3). Due to their complexity, these weighted and normalized approaches are, however, not used very often outside the bibliometric community.

Journal Management

The dimension of journal management subsumes all aspects associated with the management of scholarly journals by editors and publishers. Journal management involves general journal characteristics such as the publication history of a journal, its publisher affiliation and scope (section 6.1). While a long publishing tradition and the publisher can to a certain extent indicate the standing of the periodical in the scientific community, the scope can be regarded as a means of self portrayal trying to attract readers and authors.

Editors undertake the powerful function of the serial's gatekeepers who decide which content is published and which authors' manuscripts are rejected (section 6.2).

Analyzing the composition of the editorial board in terms of size (section 6.2.1) and nationalities represented (section 6.2.2) provides information about the quality of the gatekeeping process and the international influence of the journal.

By analyzing the process from submission to publication, the review process, which represents the quality control of published content, can be further examined (section 6.3). The time between submission and publication is known as publication delay and can be subdivided into the time for the review process and the phase from acceptance to publication that is caused by paper backlog, on the one hand, and the time to put together a journal issue, on the other. Although a thorough review process takes some time, authors and readers are interested that delays are kept to a minimum since they slow down the entire communication process. The length of the time from submission to publication can thus indicate the overall up-to-dateness of the periodical (section 6.3.2).

While the rejection rate indicates whether or not the journal is in a position to reject a certain proportion of submitted manuscripts and is thus able to publish only those of the highest quality (section 6.3.3), the correction rates identifies the share of errata published and can be used to estimate the thoroughness of the review process (section 6.3.4).

The business model and journal prices are addressed in section 6.4. As typical information goods, journals have high fixed and low variable costs. However, the journal market has atypical characteristics, since suppliers, i.e. authors, are not paid and buyers, i.e. readers, only pay indirectly through libraries and are thus isolated from the purchase (section 6.4.1). Two major forms of business models are the reader-pays model, where production costs are covered by subscriptions and pay-per-view, and open access, where the author pays publication fees so that the content can be provided free of charge (section 6.4.2). Journal subscription prices are analyzed in detail in section 6.4.3.

1.4 Case Study

In order to explain, apply and compare different indicators for each of the five dimensions, a set of journals is defined. Since scholarly communication processes vary between different fields and sub-fields of research, it is vital to choose periodicals from a narrow scientific field. There are different journal classification systems which could help to select a set of journals that are similar in terms of publication and citation behavior. However, none of these top-down approaches is perfect (compare section 3.2.1). Thus, a reference-based bottom-up approach was chosen. Due to the differences in publication and citation habits of different scientific disciplines, it is important that compared items are subject to similar processes or that differences in circumstances are compensated for (section 5.3). Since the majority of journal indicators do not apply normalization regarding discipline-specific differences of scholarly communication, the selected journals have to be similar in terms of publication and citation behavior. Since differences occur not only between disciplines but also between sub-disciplines, the area of solid state physics research was chosen.

The selection process consists of a reference analysis of the total number of documents published by researchers at the Institute of Solid State Research (IFF)[4] at Forschungszentrum Jülich between 2004 and 2008. The institute specialized in research into the physics of condensed matter. Its most prominent member is Peter Grünberg, who received the Nobel Prize in Physics in 2007 together with Albert Fert "for the discovery of Giant Magnetoresistance" (*The 2007 Nobel Prize in Physics – Press Release*, 2007). References were chosen as it is believed that these are more diverse and less biased. While an analysis based on publications is influenced by barriers such as manuscripts being rejected, referenced journals are used as sources of information without restrictions.

The main focus of the test set definition was not to analyze the publishing landscape of solid-state research but to select a number of similar journals to calculate journal metrics under realistic conditions. Hence, the test set does not claim to include the most important periodicals of the research field but emphasizes applicability and thus availabilty of data to compute journal metrics. Thus, certain thresholds were applied to narrow the preliminary periodicals to a set for which data was available. For comparable citation information, Thomson Reuters' citation indices were chosen as a database. From the journals referenced by the IFF researchers, non-ISI journals were hence excluded. In order to limit the set to core journals of solid state physics, infrequently cited, i.e. peripheral, periodicals were excluded. The initial set of referenced journals was thus further reduced to periodicals referenced at least 15 times by IFF authors from 2004 to 2008. To avoid the inclusion of multidisciplinary and interdisciplinary sources, the set of frequently cited serials was limited to those filed exclusively under DDC subject group 530 (Physics). The catalogue of the Zeitschriftendatenbank[5] (ZDB) was used to determine the DDC classification. Since electronic usage data plays a significant role in the evaluation of journal perception and usage in chapter 4, the journal set was further restricted to those titles for which local COUNTER statistics were available at Forschungszentrum Jülich.

The final test set of solid-state research journals consists of 45 periodicals. As this particular area of research is not restricted to publications in specialized solid-state serials but is present in broad physics journals as well (Pinski & Narin, 1976), the set under analysis includes both specialized and general physics journals. Bibliographic and citation data for the total number of 168,109 documents published in these 45 journals during a 5-year period between 2004 and 2008 was downloaded from WoS. This data provided the basis for the case studies.

Each of the following chapters investigates one of the five dimensions in detail. Starting with the dimension of journal output (chapter 2), various metrics will be applied to the set of 45 solid-state physics journals per dimension in order to gain comprehensive insight into the informative value, applicability and validity of the impact measures.

4 http://www2.fz-juelich.de/iff/e_iff
5 http://www.zeitschriftendatenbank.de/

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Chapter 2
Journal Output

Scientific output is increasing constantly. In scholarly publishing, growth can be observed in the number of researchers, institutions, publications and journals (Cope & Kalantzis, 2009). The increase in the number of periodicals is always accompanied by a specialization of scientific disciplines. New journals are founded in order to focus on a narrower area of research or one periodical is split into two more specialized ones. The latter is referred to as 'twigging' or 'parenting' and happened to one of the first scholarly journals Philosophical Transactions (compare section 1.1), when it was split into sections A and B in 1886 to focus on the physical and life sciences, respectively.[1] The set of 45 analyzed journals also contains a few 'sibling journals' derived from the same parent (see section 6.1.1), e.g. Phys Rev A, Phys Rev E and Rev Mod Phys, which together with Physical Review B, C, D and Physical Review Letters emerged from the Physical Review (see figure 6.2 in section 6.1.1) founded in 1893, "as the fields of physics proliferated and the number of submissions grew"[2].

Electronic publishing has also contributed to the increase in journal output by speeding up the processes of scholarly communication (Tenopir & King, 2009). It has not only lead to an increase in the number of periodicals with the introduction of purely electronic journals but has also led to growth in the number and length of documents.

As the first to put the increase in scientific output into numbers, Price (1963) estimated the number of scholarly journals in the 1960s and predicted that they would reach one million in the year 2000 as can be seen in his famous figure (figure 2.1) depicting the number of journals founded since 1665 (Price, 1975). Although his prediction has not come true, constant growth in number of titles can still be observed.

Determining the actual number of periodicals is, however, not as easy as it sounds. Estimates suggested as many as 80,000 periodicals in the 1990s (Meadows, 2000). Such high numbers, however, overestimate the quantity of scholarly journals because they include magazines and newsletters. As Mabe (2003) concludes, Ulrich's Periodicals Directory seems the most reliable source when it comes to determining the number of scholarly journals (Mabe, 2003; Tenopir & King, 2009). He evaluated the number of all titles classified as active (i.e. currently publishing), reviewed, scholarly journals from 1665 to 2001 and discovered an almost constant annual increase of 3.46% in the number of titles, which means that the number of active journals doubles every 20 years. Recent evaluations by Tenopir and King (2009) confirm these results and report a total of 23,973 refereed scholarly journals active in February 2008, which account for 38.9% of all 61,620 active titles listed in Ulrich's Periodicals Directory as scholarly or academic. The evaluation of journal output is, however, not restricted to the

1 http://rstl.royalsocietypublishing.org/
2 http://publish.aps.org/about

number of scholarly periodicals but examines differences in the number of publications, publication frequency (section 2.1.1), document length (section 2.1.2), differences in document types (section 2.1.4) and publication language (section 2.1.6). Number of references are analyzed (section 2.1.5) to determine the level of scholarliness and the journals' knowledge import. In section 2.2 the producers of journal output are examined on the micro, meso and macro level, i.e. authors, institutions and countries, in order to analyze the contributors of journal output and the internationality of the particular periodicals.

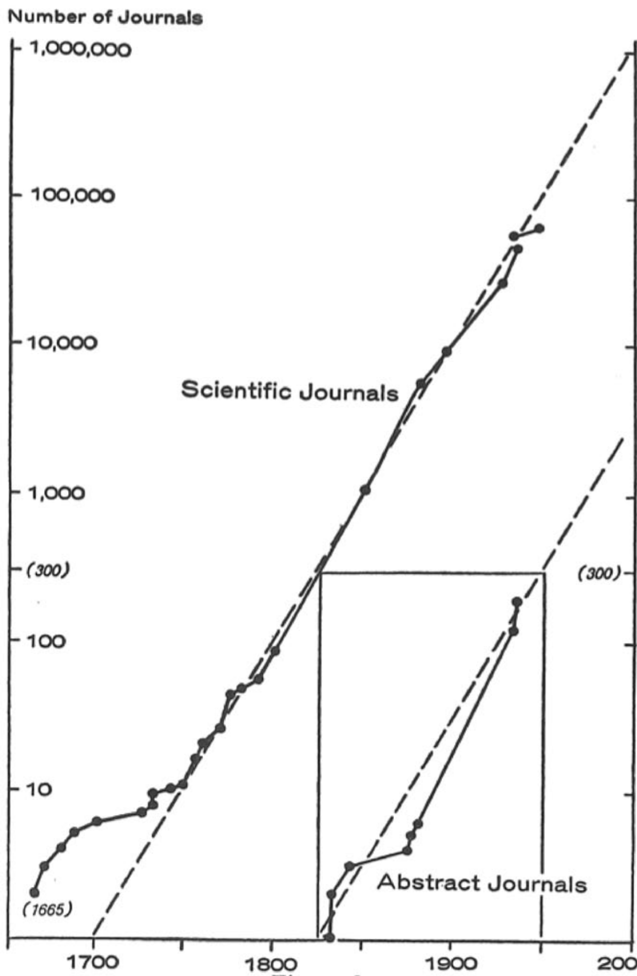

Figure 8.1
Number of journals founded (*not* surviving) as a function of date. The two uppermost points are taken from a slightly differently based list.

Figure 2.1 Analysis by Price (1975) of the number of journals founded per year. Source: Price (1975, p. 166).

2.1 Output Indicators

The most basic and commonly applied indicator in bibliometric studies is the number of publications *P*, which represents the absolute size of formally published research output. Variants of *P* include the disaggregation of or limitation to certain document types or normalization regarding length, number of references or co-authors.

P is usually accumulated over a particular period of time. It can be aggregated on the level of authors, institutions, countries or journals. The simplest but most time-consuming method to determine the number of published output of research is by manual aggregation, e.g. through author's CVs or table of contents of journal issues. Bibliographic databases allow for more convenient data collection but never contain all scholarly publications of all disciplines worldwide. The suitable data source is usually determined by the particular research question.

The set of journals under evaluation has been limited to periodicals covered by the WoS so that all data regarding journal output can be collected without difficulty. A total of 168,109 documents have been published in the 45 journals under analysis. The distribution among journals is, however, heavily skewed: journal output differs in terms of publication frequency, document length and type, scholarliness and producers of output. Therefore journals have to be analyzed in detail regarding output and normalization needs to be applied to allow for a suitable comparison of journal output.

2.1.1 Number of Issues and Documents

Besides the constant rise in the number of active periodicals, journal output has also grown with respect to the number of documents published per year and pages per document. Although the growth of scientific output reflects to a large extent progress in R&D, one can observe certain tendencies in publishing behavior, where the contribution to knowledge is taken to the point of absurdity:

> In physics there has been much discussion of the "least publishable unit" in which efforts are made to subdivide projects and expand personal bibliographies. (Abt, 1992, p. 445)

This phenomenon is known as 'salami slicing' or 'salami publishing', where researchers tend to split their results into many different publications and leave no thought unpublished in order to increase measurable output (Baggs, 2008; Cope & Kalantzis, 2009; Lifset, 2010). This publishing tactic has been criticized for creating redundant papers which do not contribute to scientific progress but waste valuable resources by adding to the flood of information (Spielmans, Biehn, & Sawrey, 2010). However, some have also argued in favor of publishing small units due to timeliness (Refinetti, 1990, 2011). On the one hand, reasons for salami publishing can be found in the author's wish to enlarge his or her publication output for evaluative purposes, to gain visibility and present results to a broad audience by using different publication venues (Buddemeier, 1981; Lifset, 2010). On the other hand, editors encourage least publishable units by limiting article length (Roth, 1981; Tzamaloukas, 2002).

During the five years under analysis the 45 journals published 168,109 documents. The number of publications per journal is highly skewed: with a total of 173 documents Rev Mod Phys generated the smallest output, while Appl Phys Let had 25,983 publications. Cope and Kalantzis (2009) do not only report an increase in the number of scholarly journals but discover that the average output per journal increases as well. Although the analyzed time span was limited to five years, an increase of overall output by 14.9% can be observed from 2004 to 2008 for all documents . While the number of documents was almost constant in 2004 and 2005 an increase can be registered in 2006 and a decrease in 2008 (figure 2.2).

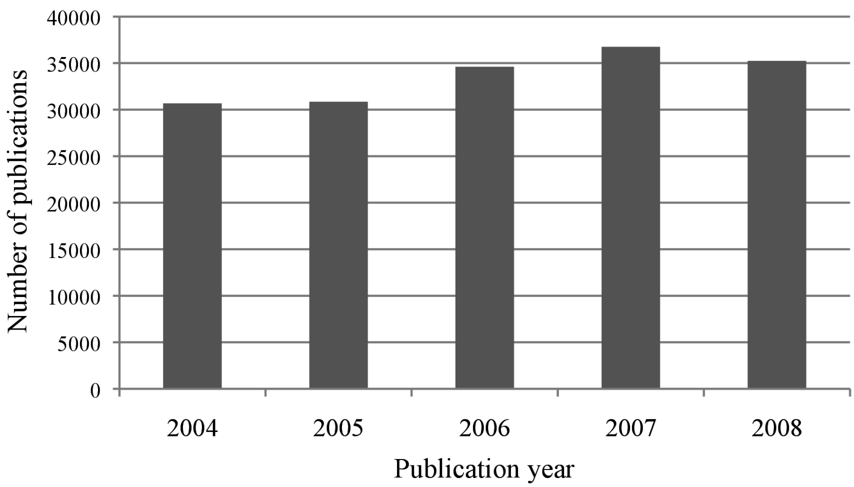

Figure 2.2 Number of publications per year in all 45 journals.

Annual growth rates differ considerable between the journals from 2004 to 2008. Comput Mater Sci, J Phys D, J Stat Mech, Nanotechnol and New J Phys more than doubled their annual output from 2004 to 2008. As the only journal founded during the period of analysis in 2005, Soft Matter started out in its founding year with only 58 documents and reached an output of 298 in 2008. In terms of growth from 2004 to 2008, the 45 journals can be divided into three groups: 18 periodicals which increased output over time (> +10% growth), 17 journals, which showed a large negative growth rate from 2004 to 2008 (> -10%) and 10 that showed only minor changes (+/-10%) of output (table 2.1). Although there are almost as many journals that showed a strong decrease in output in 2008 compared to 2004 as there were periodicals with positive growth rates, the latter showed much higher values. While J Magn Magn Mater was the journal that showed the highest decrease (-64.4%), there were seven journals that increased their output by more than two thirds of the initial number of documents published in 2008. Soft Matter, which was founded in 2005 showed the highest increase of output of 413.8% from 2005 to 2008, which is probably a phenomenon typical of newly founded periodicals.

Table 2.1 Total number of documents (*P*) from 2004 to 2008, publication frequency, i.e. number of issues per year and mean number of documents per issue.

Journal	***P***	**Issues per year**	**Mean number of *P* per issue**	**Growth rate of *P* from 2004 to 2008**
J Magn Magn Mater	7549	24	63	-64.4%
Physica C	3947	31	25	-54.1%
Phys Rep	341	60	1	-52.4%
Nucl Instrum Meth A	7670	42	37	-48.7%
J Vac Sci Technol A	1580	6	53	-44.4%
Ann Phys	296	12	5	-34.1%
Supercond Sci Technol	1685	12	28	-29.5%
Hyperfine Interact	1006	28	7	-26.5%
Phys Stat Sol B	2691	12	45	-25.1%
Solid State Ion	2270	24	19	-19.1%
Nucl Instrum Meth B	5973	22	54	-18.8%
Rep Prog Phys	220	12	4	-18.6%
Act Cryst A	326	6	11	-17.2%
Pramana	1258	12	21	-16.0%
J Rheol	347	6	12	-15.2%
J Stat Phys	1049	12	17	-10.1%
Appl Phys A	2685	12	45	-10.1%
Phys Today	1780	12	30	-7.3%
Phys Stat Sol A	2721	15	36	-6.0%
Phys Solid State	1970	12	33	-5.0%
Phys Scr	2543	15	34	-2.1%
Eur Phys J E	707	12	12	+2.2%
Act Cryst B	493	6	16	+2.3%
Phys Rev E	12117	12	202	+2.8%
Phys Fluids	2702	12	45	+5.9%
JETP Lett	1487	24	12	+6.2%
Eur Phys J B	2056	24	17	+6.7%
Physica B	5561	24	46	+18.5%
J Phys A	5244	50	21	+20.9%
J Phys Condens Matter	7427	50	30	+22.9%
J Low Temp Phys	1260	12	21	+24.8%
Rev Mod Phys	173	4	9	+32.3%
Phys Lett A	5328	52	20	+41.7%
Int J Thermophys	757	6	25	+44.0%
Appl Phys Let	25983	52	100	+46.5%
Phys Rev A	11027	12	184	+48.7%
EPL	3291	24	27	+52.1%
J Appl Phys	17827	24	149	+55.4%
IEEE Nanotechnol	519	4	26	+67.6%
Comput Mater Sci	1299	12	22	+140.5%
J Phys D	4554	24	38	+171.6%
J Stat Mech	958	12	16	+175.0%
Nanotechnol	4852	50	19	+206.5%

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Journal	P	Issues per year	Mean number of P per issue	Growth rate of P from 2004 to 2008
New J Phys	1926	22	18	+236.5%
Soft Matter	654	12	14	+413.8%

Apart from the size of annual output, periodicals also differ in frequency of issues per year. Publication frequency ranges from four issues per year (IEEE Nanotechnol and Rev Mod Phys) to more than one issue per week (Phys Rep). The most common frequency of publication is, however, monthly. 17 journals appear once a month, 8 every other month and 5 twice a month. The advantage of high frequency publication is its speediness. The time from acceptance (i.e. after successfully passing the review process) is not artificially prolonged, but information is passed on to the reader as soon as possible.

In times of electronic publishing, journals do, however, make preprints available online before the actual publication date. These 'online first' versions eliminate delays and reduce the importance of the actual publication of journal issues. Output statistics are, however, still based on the documents which are actually published. Regardless of the publication format, i.e. print, electronic or both, publication counts rely on the year of publication as determined by the particular volume and issue of the journal (Meier, 2002). So a document which was published online in October 2007 but appeared in the January issue of 2008 will be counted for 2008. The publication delay, i.e. the period between online availability and actual publication date, is evaluated in section 6.3.2.

2.1.2 Document Length

One can argue that the number of publications is a somewhat arbitrary measurement because a document can vary in length from one to several dozens or even hundreds of pages. Apart from number of documents, number of pages can also be the unit for measuring journal output.

Differences of average paper length can be observed between fields of science, i.e. an average medical journal publications has 4.6 pages, while an article in mathematics is on average 12.6 pages long (Abt, 1992). Of course, differences can also be observed within disciplines and even within one periodical. This variations can be explained by different kinds and aims of documents, e.g. research article, review, editorial or short communication (compare section 2.1.4).

It can be argued that counting pages is a measure of output as arbitrary as counting publications because even the content printed on one page can vary to a certain extent as well. An average mathematical journal publication is reported to contain 510 words while a document in an astrophysical periodical contains 1190 words on average (Abt, 1992). These differences do, however, not only occur between disciplines but, influenced by formatting, page length varies from one journal to another as well. This argumentation can be taken ad absurdum: should one count words or even letters? How is non-textual material to be treated? How are figures and tables to be weighted? Due to these problems page counts seem the best alternative especially because these statistics do not have to be elaborately extracted from the full text but – on the basis of the first and last page – are already available through the bibliographic information of the particular documents.

For the 168,109 documents published in the 45 journals between 2004 and 2008 the mean article was 6.9 (median = 5) pages long with a large deviation (standard deviation = 6.97). The longest publication contained 431 pages and was a review about boost-phase intercept systems for missile defense published in Rev Mod Phys in 2004 by a group of twelve authors from ten US institutions. It has not been cited.

Table 2.2 Mean, median and maximum number of pages per document and standard deviation per year.

Publication year	**Mean**	**Median**	**Max.**	**Std. dev.**
2004	7.0	5	431	7.67
2005	7.2	6	387	7.90
2006	6.7	5	312	6.96
2007	6.8	5	202	6.38
2008	6.8	5	241	5.99
all years	*6.9*	*5*	*431*	*6.97*

Due to the above-mentioned differences, the values for article length differ between journals. Cope and Kalantzis (2009) and Tenopir and King (2009) report an 80% growth in document length from 1975 to 2007 due to the need to manage the flood of information. The average length of documents published in the 45 journals between 2004 and 2008 did not increase during the five years but stayed almost constant, as can be seen in table 2.2.

A low maximum number of pages and standard deviation characterize typical letter journals: for Appl Phys Let, EPL and JETP Lett article length did not exceed 4, 7 and 12 pages, respectively. Publications were longest for Phys Rep, Rep Prog Phys and Rev Mod Phys. High mean, median and maximum page numbers and high values of standard deviation characterize them as typical review journals. The median number of pages of a document published in Phys Today is only 2 pages. This can be explained by the large number of news items published in Phys Today.

The number of pages per journal correlates highly positively with the number of documents published (Pearson's $r = 0.836$), figure 2.3 does, however, reveal differences for particular journals. Appl Phys Let, which is the journal with the largest output based on number of documents ($P = 25,983$), does not publish articles longer than four pages and is thus placed behind J Phys Condens Matter, which published 7,427 documents with an average of 9 pages. With a median of 63 pages, Phys Rep publishes the longest documents and is thus ranked 17th if output is based on pages, while it is 41st in terms of document count (figure 2.3).

Table 2.3 Total number of pages (∑) and mean, median, maximum (Max.) and standard deviation (Std. dev.) of pages per document by journal.

Journal	**∑**	**Mean**	**Median**	**Max.**	**Std. dev.**
Phys Today	4,166	2.34	2	125	4.224
Appl Phys Let	76,984	2.96	3	4	0.248
J Magn Magn Mater	26,450	4.43	4	48	2.781

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Journal	∑	Mean	Median	Max.	Std. dev.
Physica B	18,558	4.76	4	23	2.437
Physica C	33,422	4.70	4	41	2.472
Appl Phys A	6,914	5.47	5	30	2.079
J Appl Phys	10,002	5.86	5	103	2.952
JETP Lett	14,686	4.65	5	12	1.223
Nucl Instrum Meth A	34,507	6.60	5	82	4.620
Nucl Instrum Meth B	18,061	5.78	5	32	2.544
Phys Scr	13,574	5.34	5	48	2.972
Phys Stat Sol B	50,650	6.71	5	47	3.915
Supercond Sci Technol	104,500	5.94	5	27	2.563
EPL	19,766	6.01	6	7	1.202
Hyperfine Interact	32,930	7.00	6	48	3.489
IEEE Nanotechnol	13,994	6.70	6	21	2.673
J Low Temp Phys	3,475	9.61	6	81	7.811
J Phys D	30,383	7.22	6	49	3.803
J Vac Sci Technol A	9,593	6.07	6	30	2.495
Nanotechnol	11,646	6.26	6	23	2.124
Phys Lett A	7,037	6.18	6	19	2.325
Phys Solid State	32,864	5.91	6	36	2.456
Phys Stat Sol A	17,187	6.32	6	56	3.366
Solid State Ion	12,114	6.16	6	20	2.309
Comput Mater Sci	5,011	8.00	7	33	3.456
Eur Phys J B	10,391	7.64	7	39	3.579
Phys Rev A	15,707	7.44	7	42	3.959
Soft Matter	82,063	7.66	7	28	3.674
Act Cryst A	2,743	8.41	8	23	4.132
Act Cryst B	6,315	8.74	8	43	3.752
Eur Phys J E	4,310	8.93	8	29	3.741
Phys Rev E	98,723	8.15	8	43	4.116
J Phys Condens Matter	11,543	10.65	9	103	6.418
Pramana	79,097	9.18	9	31	4.541
Phys Fluids	27,951	10.34	10	34	5.246
Ann Phys	4,021	13.58	11	147	13.574
Int J Thermophys	10,130	13.38	12	49	5.723
J Phys A	72,463	13.82	12	109	8.278
New J Phys	30,504	15.84	14	89	7.818
J Stat Mech	18,333	19.14	16	102	10.821
J Rheol	6,574	18.95	18	70	7.211
J Stat Phys	26,067	24.85	22	161	15.513
Rev Mod Phys	7,701	44.51	48	431	37.198
Rep Prog Phys	11,790	53.59	51	269	30.639
Phys Rep	25,008	73.34	63	387	56.131

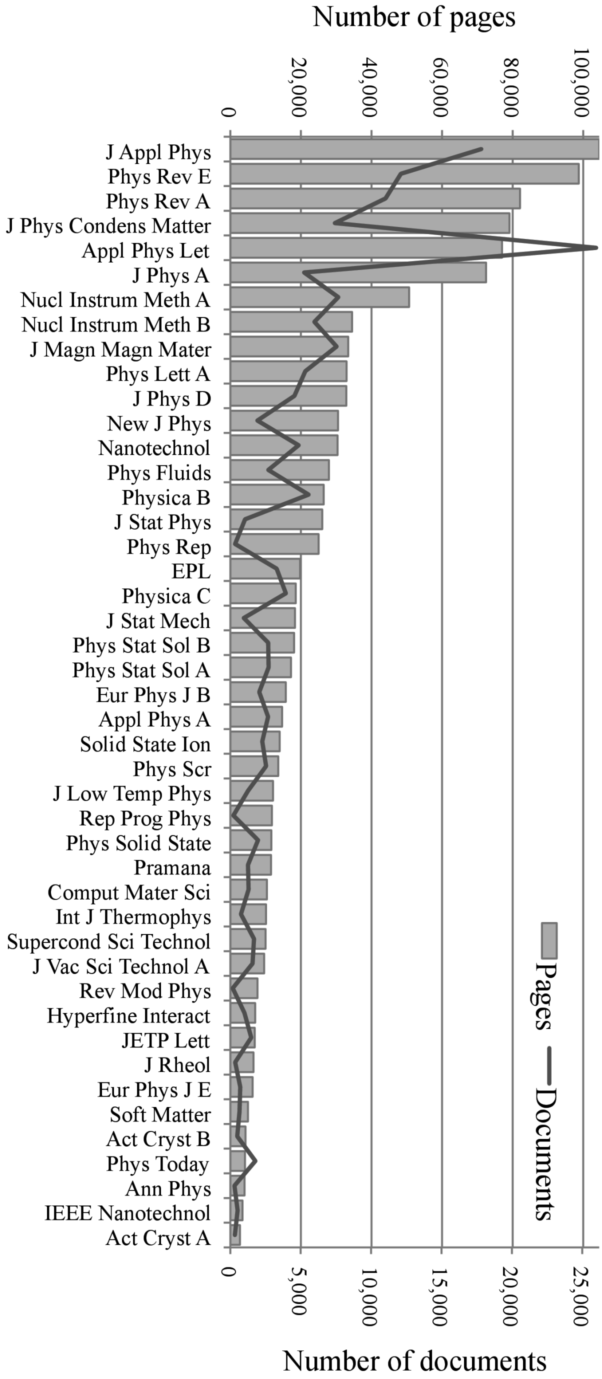

Figure 2.3 Differences in journal output based on document and page count.

2.1.3 Document Titles

A number of studies have focused on the structure of the titles of documents as they are the most important factor to attract readers.

> [I]n order to gain the required and desired attention amongst the scientific recipients, there are a number of conceivable mechanisms that can be employed. One such mechanism comes from classical marketing and advertising and consists of choosing an attractive, attention-grabbing heading. (Ball, 2009, p. 668)

Studies on article titles examine title length in relation to the number of co-authors (Kuch, 1978) and document length (Yitzhaki, 2002) or evaluate the usage of special characters such as question marks (Ball, 2009), hyphens, parantheses or colons (Hartley, 2007; Buter & Van Raan, 2011). Most studies aim to analyze title structures with regards to information retrieval and expected citation impact in order to make recommendations for authors to improve visibility through a specific phrasing of titles. Sagi and Yechiam (2008) examined the degree of amusement of titles of documents published in two psychological journals and showed that the most amusing titles were cited significantly less than average.

Buter and Van Raan (2011) showed that for a 5% sample of documents published between 1999 and 2008 listed in WoS, the most frequently used non-alphanumerical characters were hyphen, colon and comma, followed by parantheses and semicolon. In contrast to previous findings they found that the share of documents with at least one non-alphanumerical character in the title remains almost constant (66% to 68%) over the ten years analyzed and that the effect of using them in terms of citation impact depends on the discipline. While in clinical medicine documents with non-alphanumeric characters in the title have a higher citation impact compared to those without, the effect is reversed for biological publications.

2.1.4 Document Types

Journals publish different kinds of documents. Document types primarily vary in terms of purpose, which entails diversity in length, number of references and authors. The main distinction with respect to purpose can be made between documents presenting and discussing new research results (i.e. articles, proceedings papers, letters), documents reviewing and summarizing previous research (i.e. reviews, literature reviews, bibliographies) and news related items rounding off the journal's contents, which are usually written by journal editors and in-house authors (i.e. editorial material, news items, biographical material).

Table 2.4 shows the eleven different types that occurred in the 45 journals as labeled by WoS . The number of documents P emphasizes the skewness of their occurrence. The research article is by far the most important document type: 76.2% of all publications are classified as 'article', followed by 'proceedings paper' with 19.7%. 'Review' (1.1%), 'editorial material' (1.0%), 'corrections' (0.9%) and 'letters' (0.6%) play only a secondary role in terms of publication count. The other five document types, i.e. biographical and news items, reprints, bibliographies and book reviews, can be largely disregarded, since together they merely comprise 0.4% of the total.

Table 2.4 Differences of document length between document types: number of publications (*P*), total number of pages (∑) and mean, median, minimum, maximum and standard deviation (Std. dev.) of number of pages per document type.

Document type	**P**	**∑**	**Mean**	**Median**	**Min.**	**Max.**	**Std. dev.**
Article	128131	906982	7.1	6	1	161	5.08
Bibliography	3	84	28.0	33	3	48	22.91
Biographical Item	341	879	2.6	2	1	29	2.58
Book Review	3	6	2.0	2	2	2	0.00
Correction	1513	1851	1.2	1	1	23	1.20
Editorial Material	1721	3804	2.2	2	1	29	1.67
Letter	1067	2388	2.2	2	1	12	1.81
News Item	322	583	1.8	2	1	6	0.82
Proceedings Paper	33175	173472	5.2	5	1	64	3.20
Reprint	8	47	5.9	5	1	17	5.06
Review	1825	69812	38.3	26	3	431	36.98

Moreover, table 2.4 shows significant differences between the publication types in terms of document length. Due to their lengths review articles increased in influence: they account for 6.0% of output in terms of page count as opposed to 1.1% in terms of publication count. Proceedings papers, on the contrary, are less influential if journal output evaluation is based on the number of pages. The median of five pages per document shows that the length of proceedings papers is often limited. The value of 64 pages thus seems rather unusual for a document that appeared in conference proceedings. As the page count depends on the beginning and end page of the particular document as listed in WoS, inconsistencies (i.e. typing errors in the bibliographic data) can cause erroneous page counts. The median number of pages per document can thus be regarded as a more reliable measure since it is not affected by outliers.

As mentioned in section 2.1.2, the longest review article does indeed contain 431 pages. With 26 pages, the median length of reviews is significantly higher than that of any other document type. This divergence can be explained by the intended purpose of a review: it functions as a summary of a whole area of research and thus needs to consider a large number of published results. Due to their overview function, review articles address a particular large audience and are thus often heavily and in comparison to other document types more frequently cited (Moed, Van Leeuwen, & Reedijk, 1996). Garfield underlined the importance of reviews by comparing them to “an important opinion rendered by the chief justice of the Supreme Court” (Garfield, 1987, p. 5).

Although reviews do play an important role when it comes to reaching paradigmatic consensus, it is problematic to compare them directly with articles and proceedings papers, which contain new research results and thus contribute to the further advancement of science and the knowledge base. Since basic citation indicators like the impact factor do not further differentiate between the share of document types, they always rank review journals higher than periodicals that primarily publish research articles (Moed et al., 1996; Bensman, 2007; Craig & Ferguson, 2009). For a detailed comparison of citation indicators refer to chapter 5.

The 45 journals differ regarding their particular shares of types of publications. Through the analysis of document type distributions, one can distinguish different kinds of journals. Although only 0.2% of all 168,109 documents were classified as news items, Phys Today published almost all of them: 16.4% of its 1,780 publications belonged to this category. Phys Today thus differs to a great extent from the other journals.

Table 2.5 Percentage of document types per journal by page count. "Others" includes Bibliography, Biographical Item, Book Review, Correction, Editorial Material, Letter, News Item and Reprint.

Journal	**Article**	**Proceedings Paper**	**Review**	**Others**
Appl Phys Let	99.3	0.0	0.0	0.7
EPL	99.3	0.0	0.0	0.7
JETP Lett	99.2	0.0	0.1	0.7
Phys Lett A	99.0	0.1	0.1	0.8
Phys Rev A	98.5	0.0	0.7	0.8
Phys Rev E	98.4	0.0	1.0	0.6
J Rheol	97.8	0.6	1.1	0.5
Phys Fluids	97.1	1.7	0.1	1.2
Act Cryst B	96.4	0.2	3.2	0.3
New J Phys	96.1	0.0	3.9	0.0
J Stat Mech	95.9	0.1	2.7	1.3
Appl Phys A	95.9	3.6	0.4	0.1
Eur Phys J B	95.7	3.0	0.9	0.4
Eur Phys J E	94.0	3.1	1.3	1.6
J Stat Phys	93.0	5.1	1.7	0.2
Nanotechnol	92.2	6.8	0.7	0.3
J Appl Phys	91.2	7.1	1.5	0.2
Phys Solid State	90.0	8.2	1.6	0.1
Act Cryst A	87.3	4.9	6.9	1.0
J Phys A	86.6	8.9	4.0	0.5
J Phys D	82.2	8.9	8.4	0.5
IEEE Nanotechnol	81.4	16.8	1.1	0.8
Ann Phys	81.2	6.7	8.2	3.9
Supercond Sci Technol	71.6	23.6	4.4	0.4
Comput Mater Sci	71.1	27.9	0.3	0.8
J Phys Condens Matter	70.5	18.9	10.0	0.7
Soft Matter	70.1	0.0	28.1	1.8
Phys Scr	69.3	28.4	0.7	1.6
J Vac Sci Technol A	59.6	37.9	1.8	0.7
Solid State Ion	59.5	38.9	1.4	0.3
J Magn Magn Mater	58.2	39.6	1.1	1.1
Int J Thermophys	55.7	42.5	1.5	0.2
Physica B	53.6	45.2	0.9	0.3
Nucl Instrum Meth A	53.1	45.4	0.8	0.7
Phys Stat Sol B	51.6	43.2	4.5	0.7
Pramana	51.6	47.2	0.4	0.8

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