CHAPTER ONE

# Changes in Scientific Publishing

## A Heuristic for Analysis

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### 1 Introduction

It is obvious: academic publishing is currently the topic of diverse discussions in science, science policy as well as among the general public. The main issues are the crisis of the 'library' as an institution, the repercussions of performance evaluation in connection with research evaluations on publications in general, and digital publication, which some consider a blessing while others view it as endangering the progress of science. There are controversial debates about open access, impact factors and peer review, about the increasing share of retracted articles as well as complaints with regard to the overly large influence of highly renowned journals such as *Science, Nature, Cell* and *PLoS*. These debates with their diverse topics, challenges and positions are complex. This leads to the question whether the discussions are mere coincidence, resulting from simultaneous developments, or whether there are diverse causes why the topic of academic publishing is being raised on many different occasions.

Two aspects of these debates are significant: first, public discussions, science policy control and research on the phenomenon merely focus on individual facets and aspects. In doing so, the breadth of the dynamics of change and the diversity and interconnections of different developments are neglected. Second, in large parts of the discussion, one motif is recurrent. In view of the dynamics of the development, the concern is that the process of change could affect publication in general so that processes internal to science – announcing and recognising research results – could be distorted by external factors. The

main fear is that scientific/academic publishing could be in tension with the main objective of science, namely the production and testing of new truth claims.

This chapter focuses on the development of an analytical heuristic, which takes the dynamics of change and its complexity into account. This should not only serve to summarise individual aspects, but it should also be shown that different structural dynamics influence and change publication in general. An analysis relating to whether and how publishing in science is influenced by the abovementioned factors will be provided.

In a first step, the basic concepts are introduced. For the analysis of the current processes of change, it is helpful to redefine key terms. Aside from clarifying 'formal communication system', 'infrastructures of publication', and 'service organisations', the focus is on the communication system with regard to its functions for science. In a second step, the structural dynamics that cause concern and change within the formal scientific communication system are described. These are the *digitisation* of the system (see 3.1), the *economisation* of academic publishers (see 3.2), the increasing *observation* of publication activities by means of formal quantitative characteristics or bibliometric indicators (see 3.3), and the observation of the scientific communication system by the mass media (*medialisation*) (see 3.4).

In a third step, the effectiveness of the unfolded perspective is demonstrated. In view of the complexity of the process of change, it can, of course, not be the objective to analyse it entirely. Instead, by using different examples, it will be shown which effects the overlap of several of the mentioned structural dynamics has on the scientific communication system. Examples are the crisis of the libraries and the change towards freely accessible publishing (open access) (see 4.1), the diversity and growth of publications (see 4.2), as well as trust in published research results (see 4.3).

## 2 Functions of the formal communication system of science

Science is a collective endeavour, and the state of knowledge in a respective subject or field of research is the result of collective work.[1] The standards for the exchange of research results stem from this basic fact. On the one hand, there is need for a free and easy circulation and order of research results. These are necessary in order to detect gaps in research, to identify innovative research questions, to test newly gained insights after successfully conducting research

1 On this, see also the norm 'communism' of the scientific ethos developed by Robert K. Merton (Merton 1942: 121–124).

and to present them to the respective scientific community. The process of communication that achieves this – in the following referred to as 'communication system' – consists of two parts. One part is the informal communication which serves to develop research designs, to organise processes of research, to take interpretations of research results into consideration and to reject them as well as to develop truth claims. The other part is formal. In this part, truth claims are evaluated by colleagues (peer review), which are then occasionally circulated within the community in the form of publications.[2] On the basis of publications, the internal scientific communication differentiates between 'old' and 'new' knowledge (Luhmann 1990: 220; Stichweh 1979: 96).

Truth claims and research results are not only evaluated in a professional and timely manner; they are also considered in the social dimension as an achievement of the respective researcher, which, in turn, adds to his/her reputation. The attribution of reputation takes place in the informal communication system, where it can be found in face-to-face situations in the form of appreciation towards renowned colleagues, as well as in the formal communication system in the form of citations. In particular this institutionalised form of recognition is the foundation for the emergence of a social structure in scientific communities, namely a reputational hierarchy.[3] Reputation as well as the respective hierarchisation has the function to steer attention[4] in the sense that it guides members of a discipline towards relevant topics as well as towards the most competent colleagues in that discipline. It acts as a 'symptom for truth' and pre-determines the flow of information insofar as it increases the chances of being noticed and thus being recognised by members of the discipline (Luhmann 1970: 237). Trust in the reliability of the internal scientific evaluation and the recognition of the reputational hierarchy depend on and strengthen each other.

The reputational hierarchy is also essential for the presentation of scientific knowledge to society as it provides the non-scientific audience with orientation. If politics, the economy or media want to make use of science, then they also orient themselves towards science. The world of science, with its highly

2 In the literature, a distinction is made between informal communication within science, which includes private exchange among scientists, internal discussions in research groups and similar forms of exchange, and formal communication, which is understood as the public presentation of research results in scientific communities. For an overview of different forms of scientific communication, see the handbook *Forschungsfeld Wissenschaftskommunikation* (Bonfadelli et al. 2016). The distinction between the two kinds of communication is not sharp. For example, talks held at conferences represent borderline cases (see, for example, Garvey & Griffith 1967: 1013). On the transformation processes of research results on their way from the laboratory into formal communication, see Knorr-Cetina (1984: 175–209).

3 This differentiation between an informal and formal level already plays a role in Hagstrom, who distinguishes between institutionalised recognition in the form of citation and the personal or elementary recognition in face-to-face situations (Hagstrom 1965: 23 f.).

4 Aside from steering attention, reputation also plays a role as a means of motivation (Luhmann 1970: 239). This dimension is of lesser interest here.

specialised languages, is otherwise not accessible to outsiders who have not undergone the same processes of training and socialisation. In a sense, the reputational hierarchy communicates the internal scientific interpretations to laypersons and makes the social structure, at least in part, comprehensible to the outside. Reputation can thus be used to disseminate the material resources that are necessary for the system of science to operate efficiently.

The two-fold role of circulation and order of truth claims and the attribution of reputation requires that the formal communication system comprises four sub-functions (Andermann & Degkwitz 2004: 8; Hagenhof et al. 2007: 8; Kircz & Roosendaal 1996: 107–108):

- *Registration* means that the time of submission and publication of a contribution can be verified. It is decisive for reconstructing the progress of knowledge in a field as well as for attributing the priority of truth claims to one or more persons.
- *Certification* refers to the recognition of a contribution as part of a collective state of knowledge, usually by means of evaluation. Only then is a contribution considered accepted by the scientific community, included in the stock of knowledge and worthy of reputation.
- *Dissemination* means the availability of information within a scientific (communication) community. Insufficient dissemination means the exclusion (without reason) from circulation of information within science, and can thus lead to hindrance of further research processes as well as distorting the recognition of research performance.
- *Archiving* describes the ongoing stabilisation of a knowledge inventory, so that further research activities can follow it in the near or far future. Moreover, archiving is the precondition for the cumulative research achievements of a unit of the system of science (for example, a scientist, a research institution or a research programme) to be evaluated.

Each of the four sub-functions is a prerequisite for the formal communication system to be able to fulfil its dual role of circulating and disseminating information and attributing reputation.

The formal communication system with its basic units – publications – is an important part of the system of science and connects central functions. It is therefore not surprising that science studies focus solely on internal scientific components when dealing with communication processes within science. This has proved to be very productive in the past, and is appropriate for a large number of questions. This perspective, however, does not take into consideration those preconditions on the level of media technology and organisations that enable registration, certification, dissemination and archiving in the first place. In

particular, when focusing on processes of change in connection with digital publishing, it becomes obvious that the ways in which the functions of the scientific communication system are put into practice technologically and organisationally have consequences for the system. Such issues go beyond the traditional focus and cannot be described or analysed in this framework – the traditional perspective is too narrow. For that reason, two components are added here that lie outside of science and that are prerequisites for the fulfilment of the abovementioned functions: publication infrastructure and service organisations.[5]

### 2.1 Publication infrastructure

The term 'publication infrastructure'[6] describes all those technological components and rules regarding their use, which make the formal scientific communication system possible. The components of the publication infrastructure therefore show a direct connection to at least one of the four functions. Looking at the different kinds of components, the publication media are striking at first. Traditionally, these are printed journals, monographs, anthologies, conference proceedings and review literature. Recently, other media have emerged. These include repositories,[7] newspaper banks and repositories for research data, as well as social network platforms, such as ResearchGate and Academia.edu, which, aside from the exchange of research results, contribute to a network of scientific communities via their Web 2.0 functionality. Other technological components of the publication infrastructure serve the utilisation of publication media. These include classifications embodied in catalogues, abstract and subject databases, search engines, registries and citation databases, which make it possible to find and select as well as access publications. These components of the publication infrastructure first of all serve scientists as a means of orientation. They can, however, also be used to observe the scientific communication system by means of formal characteristics. The information provided by the databases can be used in more or less highly aggregated form in order to gain access to the elements of the system of science or to the formal communication system in general.[8]

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5 On this extension, see Taubert (2016).

6 A competing term is 'publication system'. In the literature, the term is used similar to our use of 'publication infrastructure' since it refers to rather technological aspects of publication, its production and reception. This goes for science-political (for example, Hochschulrektorenkonferenz 2002) as well as science-reflexive literature (for example, Hanekop & Wittke 2006: 202). We prefer the term 'publication infrastructure' as it is more comprehensive and emphasises the integration of individual components into a functioning whole by means of the word 'infrastructure'.

7 An overview of repositories can be found in the Directory of Open Access Repositories (http://www.opendoar.org/), which lists 195 repositories for Germany.

8 The effects on the scientific communication system will be described extensively in section 3.3.

Two characteristics of the publication infrastructure should be pointed out. On the one hand, it becomes obvious, especially during phases of media change, that the components of the publication infrastructure vary historically and depend on the development of media technology. Currently, this is visible in the rapid development of digital technology. On the other hand, the design of the publication infrastructure is always influenced by factors and developments within science. Thus, there is currently a change in perception as to what is considered research worthy of publication, and some fields of research consequently include data. In parallel, an infrastructure is emerging that allows the publication of research data and which thus takes the changing standards into account.[9]

### **2.2** Service organisations

With regard to the development and maintenance of their usability, the publication infrastructure as well as the individual technological components are dependent on the services provided by organisations. Organisations maintain the publication infrastructure, provide resources for its operation and ensure that the infrastructure is able to fulfil the respective tasks for the formal scientific communication system. The term 'service organisations' summarises different types.

*Publishing companies*, in cooperation with specialised scientific communities as well as independently, produce publications. They frequently hold the rights to publication media, operate technological components, such as content delivery platforms,[10] and provide systems for organising review processes (online editorial management systems). In their operation, they have to take into consideration standards of communication in science as well as economic aspects.[11]

*Libraries* traditionally provide access to research literature by acquiring, collecting, systematising and indexing publications. They are the most important units on the demand side with respect to academic publications, and they acquire them through public funding. Libraries thus ensure continuous funding of the publishing companies and are a central element in the financing of the publication infrastructure. Since very recently, however, libraries also act as operators of publication media. This is done, first of all, via repositories in which copies of publications (that otherwise have limited accessibility) can be

9 See 'Future of the information infrastructure' (Kommission Zukunft der Informationsinfrastruktur 2011).

10 The platforms SpringerLink, ScienceDirect (Elsevier) and Wiley Online Library are well known examples.

11 Decision-making in publishing companies thus takes place in the power relations between scientific and economic rationality (Volkmann et al. 2014), whereas different constellations of the two rationalities can be observed (Schimank & Volkmann 2012: 177 f.).

deposited in order to ensure free access. In addition, libraries also host digital open access journals on platforms like Open Journal Systems (OJS).

Other significant organisations are the editorial offices of publication media, especially of journals that are responsible for deciding on the worthiness of the publication of submitted manuscripts. As will be shown later on, the kind of service organisation and its financing have a strong influence on the characteristics of the publication media they operate.

The considerations on extending the focus of study can be summarised as follows. In contrast to the classic perspective of science studies, the one taken here is not limited to internal scientific processes of communication. The focus is broader and takes on a tripartite structure consisting of components that are only at first glance heterogeneous: a specific form of communication – the formal science communication, a technological infrastructure as well as service organisations. To understand the object of study as a structure is thus not only appropriate because of the similarity of the components and the fact that they would fall into the same area of the social system – quite the contrary.

The image of a tripartite structure is used here because the three components are connected through a relationship of making something possible. As noted above, the service organisations ensure the development and maintenance of the publication infrastructure, while the latter is a prerequisite for the formal communication system with its four functions. In spite of their differences, all three components are social phenomena, which can be subjected to sociological analysis: the service organisations with their organisational logic and typical decision-making processes, the publication infrastructure with its institutionalised patterns of action, and the formal communication system of science with its institutionalised rules. The processes of change that are of interest here refer to all three components. While the cause of change can be attributed primarily to one of these components, the consequences and side-effects can frequently be observed in another component.

## 3 Four structural dynamics as sources of change

In this section, the focus will be on the causes for the abovementioned dynamics of change.

In the following, four structural dynamics will be presented. The examination of these four factors is necessary to be able to show how a complex interaction between them leads to specific structural problems within the scientific communication system.

## **3.1** Digitisation

The term 'digitisation' describes developments on the level of the publication infrastructure. These developments are based on innovations in the field of information and communication technologies. Digitisation began in the early 1980s at the latest and led to significant changes. One characteristic of digitisation is that it is not completed. It does not begin with a starting point which – analogous to a revolution – reaches an endpoint after a phase of dramatic change. Rather, one digital wave of innovation is followed by another, and leads to extensive and continuous change.

If the focus is limited to digitisation in the formal scientific communication system, it can be said that it changes the production process of texts, the resulting publications as well as pathways of dissemination and forms of reception. Already the availability of a personal computer at the workplace has led to the fact that research results and texts can be digitised immediately. 'Digital' is increasingly a native characteristic of texts, not one that is added later on. More transformations follow via the Internet. With regard to the production of publications, the introduction of online editorial management systems changed the working relationship between researcher and publisher (Taubert 2012). Whereas not long ago, researchers were invited via letter and later email to review a manuscript, online editorial management systems connect all people involved in the production process – the researchers involved in reviewing and deciding on the worthiness of publication of a manuscript as well as the employees of the publisher. This forms the basis for a reorganisation of working processes. With regard to the collaboration between researchers and publishers, it leads to a disadvantage in workload on behalf of the former, while within the publishing company, these systems are the prerequisite for an internationalisation of the division of labour.

Digitisation, however, also transforms the result of the production process, that is, the publications and publication media. New and not so new electronic publication media accompany the traditional printed formats, and – in part – even replace them. In this context, pre- and post-print servers and journal databases with retro-digitised publications have a supplementary character. Replacements and substitutions can especially be observed in the transformation from printed journals to electronic formats. Digitisation also leads to changes in the pathways of production and dissemination. In the case of electronic publication, the provision of a publication no longer occurs via a local library but via databases and dissemination platforms that have global reach through the Internet. Thus, from a technological viewpoint, it appears to be possible that every researcher at every place in the world at any time can have access to electronic publications via an Internet connection. The function of providing

access to publications at least in part seems to shift away from libraries and towards the publishers. In the course of this process, however, local conditions do not lose relevance. As digitisation progresses, how extensive the collection of literature at a given place is becomes less important. More important is the extent of licences that grant access to journal or publication databases from a given place. The entailing stringency of technically available possibilities of dissemination leads researchers to digitise their publications themselves. Circulation of pre-, post- and offprint versions via mail is replaced by electronic publications sent via email or depositing of a copy in a repository or on Web 2.0 platforms.

Finally, the reception of publications, including the search, access and reading (Hanekop 2014: 5; Hanekop & Wittke 2007: 215), is transformed in the course of digitisation as well. Libraries also lose their importance because publications are more and more searched via engines such as Google or Google Scholar, or the search is conducted by means of specialised repositories. Publication no longer only takes place via printed form but also through tablets, e-book readers and computers. In addition, publications are evaluated through text and data mining procedures. It is an open and interesting question what influence these new forms of reception have on the creativity of research and the development of knowledge in the different disciplines and fields of research.

### **3.2** Economisation of publishers

The second structural dynamic – economisation – refers to developments at the level of the service organisations. Economisation becomes possible through certain properties of publications. If they are viewed from an economic perspective as goods that are sold by the publisher to libraries after a process of commodification,[12] one thing becomes obvious. Due to the standards of the major journals to publish original research exclusively (and not research that has already been published somewhere else), publications and journals are individual and unique goods and cannot be substituted. If a publication medium is not accessible, researchers can make use of other publications – but the results published in the inaccessible publications remain closed to the researcher. This characteristic of publications is the basis for libraries to claim a fully comprehensive provision of information according to the needs of researchers in the respective institutions. The practical consequence is an inelastic demand. If prices increase, libraries are not able to shift to cheaper

12 On commodification and de-commodification in the chain of information provision, see the model by Hanekop and Wittke (2006: 203–204; 2013: 151).

goods but have to hold on to the publication media until their financial resources are spent in order to fulfil their task of providing information.

Another attribute of economisation is a process of concentration, which has led to the formation of large publishing companies that are steered by financial investors. As a result, these publishing companies are strongly oriented towards economic criteria, such as shareholder value and an increase of the company's market value, so that the investors are able to sell the company at a profit. In turn, this results in the growth in size of the publishing companies and in changing ownership. One example is Elsevier whose pathway to a globally operating publishing company began in the mid-1980s. After the acquisition of Pergamon Press (in 1991), which led to a strong increase in the number of scientific journals, Elsevier merged with the British media enterprise Reed International and became Reed Elsevier Group plc in 1993. In 1999, Cell Press was bought, followed by the academic publisher Harcourt in 2001. By 2011, the company held more than 1 250 journals in science, technology and health science. In 2009, Elsevier made a profit of USD 1.1 billion, a profit margin of 36%, in 2011, a turnover of GBP 2.058 billion,[13] and in 2013, a profit margin of 39%.[14] The concentration processes in the case of Wiley and Springer are similar.[15] Concentration in the area of scientific journals has de facto led to the emergence of an oligopoly in the market for scientific publications on the side of the providers.[16] This is especially true with regard to the publishers in the area of science, technology and medicine (STM). The departments for journals in the humanities and social sciences are smaller. However, here, too, transformation processes towards enlargement of the publishing companies are apparent.[17]

13 See Arnold and Cohn (2012).

14 See http://poeticeconomics.blogspot.de/2014/03/elsevier-stm-publishing-profits-rise-to.html and http://www.reedelsevier.com/investorcentre/reports%202007/Documents/2013/reed_elsevier_ar_2013.pdf

15 See the contribution by Niels Taubert in this volume.

16 The overall number of scientific journals is currently estimated at around 28 100. A proportion of 40.5% of the journals belong to merely six publishing houses (Ware & Mabe 2015: 45). One gets an even higher number if focusing only on the most important journals indexed in the Web of Science. Of these, 10 900 journals, 50.1% are owned by one of the five largest publishing houses (Morris 2007: 307). These ownership proportions have led some to speak of an oligopoly.

17 See, for example, the result of the acquisition of Walter de Gruyter (http://www.degruyter.com/staticfiles/pdfs/1410_Fact_Sheet_Imprints_de.pdf) and the acquisition of the Campus Verlag by the Beltz Rübelmann Holding (Handelsblatt, 6 February 2015. See http://www.handelsblatt.com/unternehmen/it-medien/buecherbranche-beltz-schluckt-campus-verlag/11338350.html).

### 3.3 Observation of the communication system by means of formal characteristics

A third source of the dynamics of change is institutions and instruments that allow an observation of the scientific communication system via formal characteristics (such as the number of publications and citations). This first became possible with citation databases such as the Science Citation Index (SCI), the Social Science Citation Index (SSCI) and the Arts and Humanities Citation Index (AHCI). Thus, they became possible as a result of the digitisation of publications in general. At first, they were supposed to serve researchers as a helpful tool for orientation in the communication system. The possibility to use these data for the analysis of research networks, their historical development as well as the early identification of 'hot' fields of research and for the evaluation of research was noticed early on. The performance of different units of the science system, such as nations, organisations, research groups or persons, can be observed and evaluated. With the introduction of publication databases and research information systems as well as the accessibility of automatic evaluation instruments, on the one hand, and regular evaluations, rankings and ratings, on the other, the frequency of utilisation of such instruments has increased. Meanwhile, aside from science policy and science administration, other actors, such as publishers and libraries, also make use of these opportunities.

A second development led to repercussions on the scientific communication system. Since the beginning of the 1990s, the governance of universities and research institutions in all European countries and the United States has shifted to new public management (NPM). As a result, rankings and evaluations were introduced in which bibliometric indicators are used. The apparently inevitable introduction of this new method of management is the result of a crisis of trust in the self-regulating mechanisms of science that started at the latest at the end of the 1980s. Some authors view this crisis more generally as a crisis of trust towards all societal institutions that has led society to become an 'audit society' (Power 1997) in which all institutions are subject to reporting, transparency, efficiency, and market orientation. The methods of NPM have also become the mantra of higher education policy. NPM reacts towards the specific political expectations of legitimation with respect to science: it is to serve the democratic control on behalf of the public through being transparent regarding internal practices, and to ensure efficiency through management, that is, the economic use of public funds (Weingart 2013).

Since the specific performances of science are frequently inaccessible from the outside, it is appropriate to focus on those processes that are responsible for the internal dissemination of reputation and that are simultaneously

quantifiable.[18] The usage of citation databases makes the implicit processes of the internal scientific attribution of reputation visible and comprehensive from the outside. The creation of transparency through the introduction of performance indicators is therefore viewed positively.

The instruments with which the scientific communication system is observed by means of formal characteristics are further developed and refined, and their application has recently intensified. The reception of publications is no longer measured by citations only, but also in form of activities at a lower scale. The term 'usage-based metrics' summarises activities such as clicks, downloads and bookmarking. These characteristics, too, are supposed to determine the impact or the significance of a publication.[19] The mentioned indicators are no longer used in the context of research evaluation only, but also in decision-making processes regarding the allocation of funds in research organisations, the hiring of personnel (in particular professorships) and in decisions about third-party grant proposals. An additional dynamic results from the fact that the same large publishing companies that develop these data into bibliometric indicators and disseminate them, also control and organise their further production. Moreover, the publishers use metrics to advertise their products and scientists to represent their services. Since these data are suitable to conduct such self-marketing, they are widely accepted in spite of their fungibility for control purposes.

### **3.4** Observation of the system of science by the mass media

The external observation by the mass media, the fourth factor, also primarily affects the scientific communication system. Increasingly, scientific events as well as developments (and failed developments) in the system of science are the topic of mass media communication. In contrast to the influences described in 3.3, it is not an observation of the communication system by means of formal characteristics, but an observation of content and interpretation of its relevance for society and politics. As a topic of mass media reporting, science has experienced a boom in Germany since the 1990s. There were several science magazines, and the mass media extended their departments of science journalism. Even though this development has meanwhile been reversed due to the economic crisis of the print media, reports on important progress in research, on results in rankings or the Excellence Initiative continue to have

18 Aside from observing publication in general, the acquired funds as well as invitations to keynote speeches or the number of doctoral students are commonly used as such measures.

19 See Bollen and Van de Sompel (2008), Brody et al. (2006) and Shephard (2007). Another newer development that is noteworthy involves the services of companies like PlumX and Altmetric, which visualise and evaluate activities that refer to publications like downloads, reads, shares and mentioning of articles by using data from social networks, blogs, Facebook and Twitter as well as academic networks (Mendeley and CiteULike).

news value (Schäfer 2011). This corresponds to the expectation on behalf of politics that science as a whole, but also universities, research institutions and scientists, are open to the public and report about themselves. In part, even specific instruments have been introduced that promote and reward communication with the public.[20] The implication of this science policy expectation with respect to the scientific communication system is extensive. If the audience of the 'internal' communication of science is the respective disciplinary community, the general public now, too, is one of the addressees. This development has the potential to evoke conflicts between the new standards and scientific norms such as 'organised scepticism' (Merton 1942: 126) or the order of humility (Merton 1963: 250). The orientation of science towards the general public can be driven by two motives. First, it can be done by informing the public in an enlightening way. This is achieved by traditional science journalism in the role of 'translator', or earlier as 'populariser'. This form of science journalism, although not entirely vanished, has been replaced by a more investigative and critical reporting (Blattmann et al. 2014). In principle, it includes reports about science policy, even though this still rarely takes place. On the other hand, and at the same time, science itself conducts in part enlightening, in part persuasive, science communication. Publications such as *Public Understanding of Science (PUS)* or *Public Engagement with Science and Technology (PEST)* attempt to evoke the public's interest in science. The assumption underlying this form of communication (meanwhile disproved) is that a higher level of information among the public entails a higher level of support.[21]

Second, the competition for attention is motivated by expectations of advantages in the struggle for public funds. In practice, neither of the two motives are clearly separated, they overlap in part, strengthen each other and thus form a special constellation. The accountability and publicity called for in the democratic discourse supports the competition for attention mandated by science policy without the latter being critically distinguished from enlightening communication. Consequently, the boundaries between the respective formats of communication, between public relations, marketing and journalistic informing of the public become blurry. The number of employed science journalists is decreasing while that of professional communicators specialised in persuasive communication (PR) goes up. In the past years, a significant number of trained science journalists have moved to the field of science PR, on whose reports the media depend. Editorially controlled

20 For example, the programme Agora of the Swiss National Fund (SWF) or the Communicator Award of the German Research Council (DFG).

21 On the questionability of this assumption and on the development of this type of communication, see Bauer (2007), and on the effects on the attitudes of the public towards science, see Bauer et al. (2012).

reporting is replaced by advertisement communication, which is increasingly less recognisable as such.[22] Because of the described conjunction between the legitimating mandate of publicity and the attention management in the context of the competition for funds, science becomes 'medialised'. This means that the orientation of researchers or that of scientific organisations towards the criteria of relevance of the mass media (i.e. news values) can come into conflict with the code of truth of science (Weingart 2001: Ch. 6). What effects medialisation has on science is disputed, not least because of the different interpretations of the concept (Peters et al. 2013). It is important to differentiate between repercussions on the presentation of science, as it is apparent in the described PR communication of universities, and repercussions on the actual development of science, that is, its research agendas and the communication behaviour of scientists (Weingart et al. 2012).

## 4 Current structural problems of the scientific communication system

The four structural dynamics described above do not affect the scientific communication system individually but cause changes as a complex network of partly parallel, partly contradictory effects. The development of an appropriate understanding of the current problems and challenges in the formal scientific communication system thus requires taking several of the previously described factors and their interaction into account. The analytical power of the perspective that is developed here shall be demonstrated by means of three structural problems. Examples include the crisis of the library, which, from the perspective of the operators, is seen as a financial problem, and from the perspective of science, as a problem of accessibility of literature (see 4.1), the growth in size of the formal communication system (see 4.2), and the impact of the structural dynamics on the trust in published research results (see 4.3).

### 4.1 The crisis of the library and open access

One structural problem seems at first glance to have been caused primarily by the economisation of the publishing landscape. The increasing significance of the orientation to economic profit among large academic publishing houses, as described above, in connection with the characteristic of 'publication' as

22 On the role of medial self-presentation of higher education institutions in Germany, see Marcinkowski et al. (2013). The number of professional 'communicators' conducting PR communication at German universities and research institutions, is estimated to be around 800 to 1 000. The German academies have pointed to the problems of this development in 2014, and have formulated recommendations (Nationale Akademie et al. 2014).

not being a substitutable good, since the 1980s has led to an explosion of costs on the side of the libraries. For the period 1975–1995, the rise in the price of scientific journals is indicated as being between 200% and 300% (European Commission 2006: 16), for 1986–2006 an average increase in price of 5 to 8% per year was noted (Kirchgässner 2008). After that, they are similar, thus in 2008 prices increased by between 9% and 10% and in 2009 and 2010 by 7% to 9%, respectively (Boni 2010). The budgets of the libraries, however, did not grow to a similar degree during the same period, so that the increase in price could not be absorbed. As a consequence, libraries were and are forced to restrict their activities in acquisition and collecting.[23]

The causes for the crisis of the libraries have not changed; only their form of appearance has evolved during the past three decades. In order to understand these changes, a second factor – digitisation – has to be taken into account. The most striking development is the transformation towards electronic publications that started in STM in the 1990s. One hope was that prices would go down as several phases of the work process, such as printing and distribution, were no longer necessary. Instead, publishers raised their prices by up to 15% per year, referring to the high costs of the development and provision of digital production and dissemination platforms. The change towards electronic publishing also affected the business model of the academic publishing companies. The trend was towards a diversification of the product. While in times of print, the research contributions collected in an anthology represented a 'natural' form of the good 'publication', in times of electronic publication, a commodification in diversified forms takes place. The sale or rental of accessibility to individual PDF files is smaller in size than the classic model of subscription. The access to larger or even entire collections of journals of a publisher via a respective platform is more encompassing.

Especially the latter form of commodification leads to changes in the market. For libraries, the advantage of buying access to the entire collection of the publisher lies in significant price reductions in contrast to buying access to individual journals. The disadvantage is reduced flexibility since cancellations are limited to a certain percentage. For large publishing companies, such a 'bundle deal' is attractive since they can take up large parts of the library budget. One effect of this business model is that the publishing companies, depending on the size of their portfolios, can protect themselves against cancellations to varying degrees. Cost savings hit small publishing houses with smaller collections of journals or a programme that is dominated by books and anthologies.

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23 The restrictions not only affect journals but also monographs and anthologies (Kopp 2000).

As a reaction to the library crisis, researchers, libraries and organisations promoting science demand free access to scientific publications in which results of publicly financed research has been published. In order to realise such an open access, digitisation is a prerequisite. This is already visible in the text of the Budapest Initiative of 2002, which shaped the meaning of the term 'open access' (OA). The introductory passage reads:

> An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the world-wide electronic distribution of the peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds.[24]

To realise this objective, two strategies are suggested which have also been pursued since then. On the one hand, the provision of free access and use of hitherto restricted publications by means of an electronic copy in a repository – known as 'green open access' – and, on the other hand, free access at the original place of publication, the so-called 'gold open access'. Free access for the reader can, in a practical sense, only be realised if an infrastructure such as the Internet exists, which allows the creation of copies of a text and their global dissemination at negligible costs.

At first it seemed as if the call for open access stood in contrast to the interests of the renowned academic publishing companies. They did, however, quickly take it up and re-interpreted it in economic terms. The demand for open access is realised via two business models that are compatible with the publishers' expectations of making profits. One model includes charging publication fees for all contributions of a journal or so-called 'article processing charges' (APC).[25] All contributions of a journal are then freely accessible via open access, and the journal is entirely financed by publication fees. APCs are due when an article is accepted for publication and are usually paid by the research organisation for which the author works.[26] A second model is based on the notion to offer free accessibility as an option. Here, access to the contributions of a journal on the side of the reader generally costs money. An

24 See http://www.budapestopenaccessinitiative.org/read

25 For more detail on this model, see Björk and Solomon (2014).

26 This is done via so-called 'publication budgets'. See the working group Open Access 2014. An overview of the current flow of funds from publication budgets in German-speaking countries can be found in Pampel (2014).

author can, however, decide to make an individual article freely accessible after paying an APC. This optional model is often criticised, the suspicion being that the publishing companies charge money for their services twice – once from the authors, and once from the readers. Therefore, it is often referred to as 'double-dipping'. While these models solve the problem regarding access to publications, the financial problems that are at the core of the crisis in the library in the form of inflated prices, are not necessarily solved.

The current situation is characterised as follows. The transformation towards a strong degree of open access has only been successful in individual areas through green open access.[27] The proportion of freely accessible work at their original place of publication is thus around 9.0% to 16.9%.[28] This means that the model of subscriptions is still the more important model in comparison to the financing of journals via publication fees. The repositories, through which green open access is realised, provide a new and second level of publication, which supports the circulation of research results within scientific communities (dissemination function). However, certification remains dependent on the evaluation of the contributions at the original place of publication. Moreover, the versions available in the repositories can only be used to a certain extent as pagination is sometimes missing and there is often uncertainty whether the version concerned corresponds to the one in a journal. This is especially true in disciplines in which the practice of citation requires the exact page numbers. Therefore, a dependency on the original journals, which often are only accessible via subscriptions, remains.

The ongoing crisis has led to a number of reactions on behalf of scientists and the libraries. One that received the most attention was the boycott against Elsevier (Lin 2012), which was initiated in 2012 by mathematicians under the heading 'The cost of knowledge', and supported by almost 15 000 scientists. The protest was based on the claim that there was an imbalance with respect to the work of the scientists (provided to the publishers for free) in the form of submitted manuscripts as well as editorial work of the editors and reviewers, on the one hand, and the unusually high costs of journals and the resulting profits, on the other hand. The boycott was against Elsevier because it was viewed by the protesters as the 'worst offender' among the large publishing companies. Since then, several universities (among them also German universities such as the

27 The proportion of green OA publications varies between the disciplines. A study of publications in 2010 revealed that chemistry, with 9.3% of self-archived publications, is last. The largest number can be found in mathematics (40.8%). Throughout all disciplines, the proportion of green open access is 21.9% (Gargouri et al. 2012: 8).

28 The study by Laakso and Björk on publications in 2011 revealed a proportion of 9% freely accessible publications in gold OA journals in the Web of Knowledge and 11% in the citation database Scopus. Taking into account articles that are freely accessible with delay (a so-called 'moving wall') and the proportion of freely accessible articles in the optional OA models, the overall proportion in the Web of Knowledge is 16.2% and for Scopus 16.9% (Laakso & Björk 2012: 6).

Technical University Munich and Konstanz University) have reacted by ending their subscriptions of Elsevier products. In November 2014, the Dutch union of universities (VSNU) cancelled negotiations with the company regarding renewals of subscriptions for 2015 and the introduction of open access. Already in April 2012, Harvard University (2012) released a Faculty Advisory Council Memorandum on Journal Pricing, which states:

> We write to communicate an untenable situation facing the Harvard Library. Many large journal publishers have made the scholarly communication environment fiscally unsustainable and academically restrictive. This situation is exacerbated by efforts of certain publishers (called 'providers') to acquire, bundle, and increase the pricing on journals.

The university called upon its members to save their respective articles on the university's repository (DASH), to publish articles in open access journals and to strengthen the reputation of those journals, to withdraw from editorial boards of journals that do not support open access. A first success of the boycott was that Elsevier did not support the 'Research Works Act', a judicial initiative in the US Congress, which was supposed to prohibit mandates on OA publication of government-funded research results. 'The bill was declared dead by its sponsors in Congress on the very same day' (Arnold & Cohn 2012: 832).[29]

The analysis of the crisis of the libraries and its change over time can only be successful if both dynamics of economisation and digitisation, and their entanglements are taken into account. Only then does it become clear that the large publishing companies, increasingly characterised by economic imperatives, and scientists and libraries interpret and make use of the opportunities and potential of digitisation for their own good. So far, it seems as if the publishers have the upper hand in this process, even though – as shown by the 'The cost of knowledge' boycott – digitisation leads to new opportunities for networking and organisation regarding the articulation of interests within scientific communities.

### **4.2** Growth in size

The second example, which should serve to demonstrate the potential of our analytic perspective, is the growth in size of the scientific communication system. From the beginning, complaints about such a growth – and especially

29 The development continues. At the beginning of November 2015, the six editors of the journal *Lingua* as well as the entire editorial board withdrew and announced the founding of a new OA journal (Ingram 2015).

the problems that result from it – on the side of the recipients are side-effects of modern science. The growth of science in general, and of the communication system in particular, leads to a narrowing of the scope of absorbed literature since researchers' attention and time for reading are limited and cannot be extended arbitrarily. Growth is thus a driving factor for the specialisation of science, at first in disciplines, then in specialties with a tendency towards focusing on ever-smaller objects and research areas. This exponential growth of science, already described by Derek de Solla Price in 1963, that is, the simultaneous growth of research funds, institutions and number of scientists, is additionally accelerated by other factors within the communication system. They have different, partly interacting causes and concern different dimensions of the communication system. These developments lead to a structural problem, namely that the system becomes overly complex due to its growth.

One of the external factors that contribute to this growth is the observation of the communication system by means of formal characteristics. Studies on unintended consequences have shown that research evaluations could influence the publication behaviour of scientists under certain conditions (Espeland & Sauder 2007). If the number of publications (or that of a certain type of publication) plays a role in the measuring and evaluation of performances in research and is directly connected to incentives in the form of an indicator – as, for example, via the allocation of third-party funds – scientists react by adapting their publication strategies. They publish research results in as many individual publications as possible ('least publishable units') in order to influence the performance measures to their benefit. This strategic 'salami slicing' leads to an inflationary growth (Bornmann & Daniel 2007; Geuna & Martin 2003: 283) in the number of publications without creating a larger amount of research results. Linda Butler (2003) analysed this kind of reaction in the introduction of the Australian Research Evaluation System and found an increase in the number of publications, albeit only in a segment of journals of average quality. Scientists thus turned to less prestigious journals in order to increase their number of publications (Butler 2003: 41). This effect can be observed in all systems that have introduced purely quantitative measurements. Butler (2010: 137) concludes:

> Increased publication output appears to be a common impact of PRFS,[30] irrespective of the model used, and this has generated a great deal of attention. Much of the discussion is anecdotal, but it is the one impact on which there is considerable bibliometric analysis, accompanied by a belief that it is possible to demonstrate the causal effect of the assessment systems.

30 Performance-based research funding systems.

The United Kingdom, Australia, Spain and Norway have been the focus of detailed studies.

According to more recent estimates, the volume of scientific publications increases annually by approximately 9%, which means a doubling every nine years (Bornmann & Mutz 2014). Based on the present findings, it cannot be said how large the proportion is that results from research evaluations.

Economisation also leads to effects that are relevant to growth. As a result of their journals' increasing relevance, academic publishing companies in the fields of science, technology and medicine (STM) respond by enlarging the respective journal and increasing the frequency of its appearance. The economisation to which the large publishers are subject, however, also leads to an expansion of the communication system to include less innovative, less relevant contributions of lesser quality. Two developments in particular should be noted: cascading peer review and predatory open access journals. The former[31] refers to the transferring of rejected articles (including their reviews) from one journal to another. This procedure, which has been practised for a number of years now, is based on the view that in many areas of science, a hierarchy of reputation exists among journals, and that authors follow this hierarchy in the submission behaviour. If an article is rejected, it is often submitted to a journal that is ranked much lower in the hierarchy. The manuscripts are then reviewed once again. The professed goals of cascading are, on the one hand, to use the capacity of reviewers more efficiently by passing on their reviews (Hames 2014: 10), and, on the other hand, to accelerate publication of a manuscript. With regard to the form of organisation of cascading peer review, there are large differences. The procedure can be organised within a publishing company as well as between journals of different publishers.[32] Other differences concern how far the transfer of manuscripts occurs automatically or via the author or editor. Cascading peer review can, under certain circumstances, accelerate growth in size since it is not only of use for science but also for the large publishing companies (Barroga 2013: 91). The transfer of manuscripts to journals of the same publisher is an appropriate means of binding a large amount of submissions to the company, and in case of negative reviews, to be able to publish them still. For this purpose, the cascade of journals consists of less renowned journals, and the author of a rejected article is given the opportunity to publish the article in one of those.[33] In particular, with regard

31 The reference is not clearly defined. Occasionally, not the review but the manuscript is in the focus and it is referred to as 'automated manuscript transfer'.

32 See the example of the International Neuroinformatics Coordinating Facility (INCF) in De Schutter (2007).

33 This is visible regarding the criteria for accepting a manuscript. Such mega journals require consistency in methodological and formal standards, but criteria such as novelty or relevance do not play a role.

to the financing of cascading journals, there are incentives to lower the criteria for accepting a manuscript. 'However, publishers may be tempted to condone low-quality research that is unworthy of scientific investigation in return for an article that can be published in their cascade journals' (Barroga 2013: 91). It is obvious that the growth of the communication system depends on how far the criteria for accepting an article for publication in the framework of such cascading systems are lowered.

The opportunities for publication at the lower spectrum of noteworthy research contributions are also increased by the founding of so-called predatory open access journals, a development that has been accelerated since 2012 (Butler 2013: 434). Predatory publishers aim at exploiting the publication fees in the framework of the gold OA model (Beall 2010: 15). They are financed by APCs, claim that they have a rigid review process, but often publish articles without evaluation and seldom guarantee listing or long-term accessibility.[34] The authors are most likely not always victims of the business practices but might consider the journals as an opportunity to publish their research, which could not be published in other places. Estimations with regard to the size of this phenomenon differ. At the end of 2016, Beall's list comprised 1 155 entries of 1 000 'potential, possible or probable predatory scholarly' open access journal publishers.[35] While Beall assumes that 5% to 10% of all OA articles are published in such journals and endanger the reputation of the gold OA model in general, the managing director of the Directory of Open Access Journals (DOAJ), Lars Bjørnshauge, assumes that less than 1% of all articles financed by APCs appear in a predatory OA journal (Butler 2013: 435). The effect this development has on the scientific communication system is described by Beall (2010: 16) as follows:

> Finally, one of the negative impacts of these predatory Open-Access publishers will be the avalanche of journal articles they are creating. This abundance will make it harder for scholars to keep up with research in their fields, and it will cause online searches to be filled up with links to low-quality research.

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See, for example, a guideline for authors for the journal SpringerPlus: http://www.springerplus.com/sites/10283/download/A00834_SpringerPlus_authors.pdf.

34 See the experiment by Bohannon (2013). He submitted rigged and erroneous manuscripts to OA journals that are financed via publication fees. Of 225 journals, 157 accepted the articles for publication; 106 journals (70%) did not have the articles reviewed and accepted them right away. The immediate acceptance as well as publication after review suggests deficits in the journals' decision-making process. The selection of the journals was based on the Directory of Open Access Journals (Bohannon 2013: 64), supposed to have a 'quality control system to guarantee the content' (see doaj.org/about).

35 Beall's list of predatory open access journals was removed from the Internet in January 2017 due to threats of a lawsuit against Beall. An archived copy of the list is still available. See https://clinicallibrarian.wordpress.com/2017/01/23/bealls-list-of-predatory-publishers/.

In the humanities and social sciences, such a recycling of publications of lower quality takes on a different form. The pressure on scientists, caused by evaluations and performance measures, to publish as much as possible, and the opportunistic attitudes of publishing companies to make profits from additional funds for printing costs, has led to a boom in anthologies (Hagner 2015: 176).[36] By skipping the review process and selection driven equally by competition and affirmation based on the *do ut des* principle, it is risky for the editors to tell those authors who the editors themselves have chosen that their texts do not meet the expected quality requirements. Renowned authors are usually asked to contribute to anthologies so that their names attract a large readership. In view of the frequency with which opportunities for publication are advertised, it is hardly surprising that many contributions are merely a recycled version of previously published work. As a result, quality and coherence of an anthology suffer, as does the reputation of this type of medium in general.[37] The handbook, which is experiencing a boom, especially in the social sciences, has similar problems.[38]

The possibility to deposit articles in repositories, a result of digitisation, also leads to growth of the communication system. Here, two effects can be observed. Whereas operators of repositories emphasise that self-archiving is primarily about creating accessibility to high-quality, reviewed publications, many repositories are used as original place of publication in order to publish grey literature or research reports. Moreover, publication in a repository results in the dissemination of two or more digital versions of the same publication. The causes for multiple digital availability can be diverse. It is possible that authors archive their publications not only in repositories but also in social networks, such as ResearchGate or Academia.edu, or that co-authors deposit the same work in another repository, or that operators of repositories search the web for freely available content and aggregate their findings. Here, too, this form of growth can only be described but not quantified.

This growth in the volume of publications, which is not matched by a respective growth of research results, is caused by the concurrence of the observation of the communication system by means of quantitative

36 On the dilemmas of quality assurance of anthologies, see Kemp (2009: 1019–1020).

37 General statements on quality of the medium 'anthology' are not always appropriate as there is, of course, still the carefully conceptualised anthology, whose contributions are reviewed by external reviewers and commented on by the editors.

38 For example, Springer lists 229 books in the social sciences that contain 'handbook' in the title or subtitle (searched 30.10.2015). While 'handbook' suggests that the book summarises the state of knowledge of a larger field, the following titles indicate an advanced and small differentiation of the focus: *Handbuch Kulturpublikum*, *Handbuch Kriegstheorien*, *Handbuch Spitzenpolitikerinnen*, *Handbuch NGO-Kommunikation*, *Handbuch militärische Berufsethik* (in two volumes) and *Handbuch standardisierte Erhebungsverfahren in der Kommunikationswissenschaft*. The *Handbuch nicht standardisierter Methoden in der Kommunikationswissenschaft* is noteworthy as well.

performance measures as well as economisation and digitisation. Looking at the consequences for science while ignoring questions of the financing of the system via public funds, it becomes clear that the growth in size has a inhibiting effect on the functionality of the system, especially on the side of the readers. In the search for literature by means of search engines, the problem is not to find contributions that fit thematically. Rather, the inflation of the communication system makes it difficult to decide whether a selected publication is worth looking at. This difficulty with regard to selection and evaluation is likely to be especially apparent in fields that do not have a well-ordered communication system, with a clearly visible core of publication media in which relevant research results can be found. On the other hand, the phenomenon of different versions of a text leads to the question whether other versions than that of the original place of publication can be received or whether these deviate significantly from each other. This can easily be the case when a pre-print version is deposited in a repository. Here, the recipient needs to make sure that he or she cites the version of the original place of publication. In addition, several of the mentioned forms of growth in size can hinder or distort the internal scientific mechanisms of attributing reputation.

### **4.3** Trust in published research results

Our final example of how the interaction of several of the structural dynamics described above leads to structural problems pertains to trust in published research results. By trust, we do not mean a naïve belief in science that research is always conducted with care and according to the standards of a discipline, that scientists never make mistakes, that research results are always presented in a professional manner, and results are never interpreted subjectively. Rather, trust here is considered as the result of an operation that is in principle based on mistrust. This paradox becomes understandable when we take a closer look at the responsible mechanism – the review process. The scientific norm of scepticism (Merton 1942: 126) does not accompany claims of truth from their emergence in research processes to publication and reception but has its primary location in the peer-review process. In the course of this process, reviewers who are mostly selected by an editor check the plausibility of research results and the adherence to methodological and argumentative standards. Naturally, such an evaluation can never be complete and extensive, and even the most dedicated reviewer needs to end his or her work at some point due to practical reasons.[39] In the end, it is not so much the substantive reasons and arguments raised in the review process that create trust – not

39 Thus, the evaluation is not entirely led by mistrust, but is partly based on trust itself.

least because in the traditional blind review, reviewers remain unknown to the reader. Rather, trust emerges from the fact that such an evaluation procedure has taken place at all and the article has passed through it successfully.[40]

The trust provided by the procedure is only ever provisional. In the course of reception and further research, doubts on the accuracy of a certain claim could emerge, which then leads to additional evaluations. The shift from trust to mistrust is the typical consequence of inconsistencies. In spite of its tentativeness, the preference of trust has consequences in social respect. It is one of the conditions of far-reaching division of labour within science and a prerequisite for increasing the capacity of the overall system since scientists no longer have to deal with the evaluation of all prerequisites of their research.

All of the structural dynamics mentioned in section 3 of this chapter influence the constitution of trust, whereby trust-eroding as well as trust-supportive effects can be observed. If these are viewed with regard to their connections, indications can be found for the thesis that the basis of trust is currently changing.

A number of trust-eroding phenomena are brought into connection with the immediate implementation into incentives during the observation of the communication system by means of formal characteristics. There are indications that the use of publication-based indicators in the framework of research evaluation, the performance-oriented allocation of funds, the grant proposals for third-party funds as well as hiring procedures lead to pressure in publishing and reactions among scientists that put strain on trust in research results in general.

One relevant phenomenon here is publication bias, which is apparent especially in quantitative experimental research in medicine and psychology (Scargle 2000). The strong orientation in these fields towards the journal impact factor and the observation that experiments providing evidence for a connection between two variables are more often cited than those indicating no connection, causing editors of journals to tend to publish positive results. Negative results, which also have the value of insight, are not published to a similar extent. These systematically higher chances of publication of positive results give rise to a distorted picture of the state of knowledge in the literature and thus put strain on the trust in published research results.

Not surprisingly, other scientists often cannot reproduce published findings, which undermines trust in research and wastes huge amounts of time and money. These practices also create a shaky knowledge base for science, preventing scholars from effectively building on prior research (Nyhan 2014).

40 Loosely alluding to Luhmann, one can speak, with reference to peer review, of the creation of a provisional 'trust by procedure' (*Vertrauen durch Verfahren*) (Luhmann 1969: 37).

While publication bias represents an erosion of scientific standards, the pressure to publish (resulting from the role of bibliometric indicators) leads to questionable, undesired or illegitimate behaviour. Thus, agencies offer academic authors support in successfully manoeuvring their articles through the peer-review process. This service is not restricted to language editing of a manuscript before submission. Some agencies also try to manipulate review processes by suggesting reviewers that do not exist and provide editors with reviews. A study by BioMedCentral identified and retracted 43 articles where manipulation in the review process was proven.[41] It remains unclear, however, whether the agencies acted alone or whether they acted with knowledge or even on behalf of the authors.

Furthermore, there are clear cases of fraud and softer forms of scientific malpractice that can be traced to the pressure to publish and eroding trust. These include not only manipulation of data, fabrication of results as well as more sophisticated or banal forms of plagiarism, but also practices such as selective choice of cases, adding 'fitting' measurement data or choosing 'convenient' model specifications (Plümper 2014: 4). Advantages in the competition for reputation and thus jobs gained by fraud promise material profit (Franzen et al. 2007) and increase chances in the acquisition of third-party funding. It is not clear whether the number of fraudulent cases has increased with the number of publications. It is certain, however, that the problem has received attention within science as well as the public and that trust in the functioning of scientific control mechanisms therefore has been damaged.

Another source of erosion of trust is the increasing medialisation of science. As mentioned above, medialisation has a legitimating function as well as one related to management of attention. One consequence is the communication of research results via mass media, circumventing regular peer-review processes or delaying them. Perhaps the most spectacular case was the television news about the discovery of so-called 'cold fusion' (Weingart 2001: 254–261). Only after several weeks was the scientific community able to disprove the results of these experiments as the original set up remained unknown. There is a structural problem. Editorial decision-making programmes of high-ranking multidisciplinary journals, which are oriented towards scientific quality as well as societal relevance (keyword: breakthroughs), create conflicting expectations on the side of the authors, who then tend to exaggerate their results. These conflicts seem to increase with the extent to which visibility in the media has become a performance criterion of scientific research. It is striking that the increase of ex-post public scrutiny of research results leads

41 See the blog by Elizabeth Moylan 'Inappropriate manipulation of peer review' from 26 March 2015 at http://blogs.biomedcentral.com/bmcblog/2015/03/26/manipulation-peer-review/

journals more often than hitherto to correct editorial decisions in the form of retractions of manuscripts.[42] The increase of such retractions is a consequence of the orientation of science towards attention by the mass media, and this can be damaging to the image of the journals involved, the research institutions involved or even entire fields of research.

The image of eroding trust painted here is bleak and characterised by pathologies. Without taking into account the developments that strengthen trust and which are especially connected to digitisation, however, this image remains incomplete and one-sided. Effects that strengthen trust can originate in changes in the review process or in the characteristics of a publication. It has already been mentioned that the digital format of submitted manuscripts and of documents that have emerged during the review process together with connecting all those involved, provides the opportunity to organise the review process anew. This and a higher degree of openness and comprehensiveness of the process seem to be the answer to the challenges of eroding trust. The currently tested innovations of the procedure point in three directions:

- A first innovation refers to publication bias and is oriented towards the traditional procedure of scientific control. The innovation lies in a review process, which remains anonymous but is divided into two stages. In a first step, the research is registered and the experimental design is evaluated, as it is practised, for example, by the American Economic Association with its RCT (randomised control trials) Registry.[43] In a second step, only the practical conduction of the study is evaluated; not the type of results. This is supposed to exclude bias on the side of the editors or the scientists (Nyhan 2014).
- A second innovation lies in the efforts to archive data underlying a publication and to make these transparent. Here, archiving is not only about making datasets re-usable in the context of subsequent research questions but – with regard to the review process and further reception – an improvement in the understanding of published research results (Wissenschaftsrat 2012: 14). The connection with research data could also be considered an extension of the traditional procedure of quality assurance and is thus closely oriented towards the classic model.
- A third innovation relates to alternative procedures that replace the traditional review process. Examples are open peer review, public peer review, post-publication peer review and open discussion, which,

42 See the increase of retraction rates that correlate with the journal impact factor. http://www.nature.com/news/why-high-profile-journals-have-more-retractions-1.15951; http://retractionwatch.com/category/by-journal/nature-retractions/.

43 The registry can be found at https://www.socialscienceregistry.org/.

although they have been established in some journals, are not yet standard procedures (Ware 2008: 18). The journals *British Medical Journal (BMJ)* and *Atmospheric Chemistry and Physics* as well as the publication platforms *Faculty of 1000 (F1000)* and *ScienceOpen* are pioneers in this context.

Presenting individual procedures and honouring their potential goes beyond the scope of this chapter, however. Instead, the focus here should be on the fact that new mechanisms of evaluation are being realised.

First, some procedures are characterised by extending the number of those involved in the review process. The persons involved are no longer selected by the editor but participate in the process via self-selection. Second, editorial confidentiality is in part, sometimes even entirely, given up so that the arguments emerging in the course of the review process can be tested. In addition, it is made transparent who was involved in the decision-making process. Third, the certification of quality is not provided before publication but after reception according to the principle 'publish then filter' (Hunter 2012: 2). Not all of these approaches are suitable for every journal and every research field. These innovations are interesting nonetheless because they entail a high degree of transparency and comprehensiveness of the assessment of quality. Returning to the abovementioned classic form of peer review, these innovations can be interpreted as an attempt to change the foundations of trust. The mechanism of creating trust via procedure is replaced by trust through transparency. In other words, the innovations are based on a tendency towards stronger reconnection of trust to facts.

## 5 Conclusion

The formal scientific communication system is currently undergoing far-reaching change, which is far from over. The aim of this contribution was to provide a heuristic which supports the analysis of this change. Four factors (digitisation, economisation, medialisation and the increased use of quantitative, bibliometric indicators) have been identified, whose effects are rarely taken into account in their combined interactions. They influence the formal communication system of science, the technological infrastructures and service organisations and lead to changes and, in part, structural problems. The complexity of the analysis of current processes of change is due to two things. The first challenge is to penetrate the abovementioned, very heterogeneous factors analytically in their interaction. We have attempted to do this to a certain extent in this contribution. The second challenge is the heterogeneity

of the subject. On a high level of abstraction, unified structures can be observed for science as a whole. For example, the formal communication system is characterised by its orientation towards the medium of truth and the medium of reputation (Luhmann 1990: 244–251; Schimank 2012: 234), and the four functions of the communication system described above are universal. One level below, however, there is a high degree of diversity in all three dimensions. The structure of the formal communication system, the publication infrastructure and service organisations differ strongly among different disciplines and fields of research; consequently, similar pathways of development can only be observed partially. Even in areas where there are similar developments, they occur at a different pace. With respect to the analysis, the heterogeneity of the subject should lead to caution in terms of generalisation of findings on scientific publishing. Regarding the design of the formal communication system of science, it can be expected that developments that have proved to be appropriate in certain disciplines or fields can only to a certain extent be useful in other fields. They can fail to achieve the goal under other circumstances, or even cause unintended and undesired effects. In view of the heterogeneity of scientific publishing, universal recipes do not promise much success.

For the analysis reflecting on science, the dynamic development of the subject is ambivalent. On the one hand, it continuously nourishes the fields of research involved in the reflection with new and relevant issues. On the other hand, reflection is aimed at a fast-moving goal. In view of the high pace of development and the fact that reflection takes time, studying recent processes of change always entails the danger of falling behind the developments. In guiding reflection, the heuristic offered here cannot solve this problem of time but might at least soften it. There are good reasons to assume that the factors focused on here will continue to influence the evolution of the publication system in the future.

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