What Scientists Can Learn from the Penguin?
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Open Access and Open Source

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Abstract

Sir Isaac Newton himself emphasized that "if [he had] seen far, it [was] by standing on the shoulders of giants" (Scotchmer (1991), p. 29), clearly stressing the cumulative character of research and innovation. Building upon and borrowing from the ideas of other researchers positively defines a prerequisite for scientific progress. Thus, access to academic works is crucial to achieve efficiency in resource allocation. However, predominant price discriminating practices of journal publishers raise concerns to this access issue. The copyright that enables publishers to engage in such price settings, meanwhile, seems not to be required to provide incentives for scientific research. All of this pushes forward a discussion on a possible shift towards the new upraising star in scholarly publishing in the digital age: Open Access. This asks: What would an economist say in regard to the open and closed doors for scholars to create incentives for scientific research?

This work seeks to contribute to the recent discussion whether the copyright law creates incentives for scholars to contribute in the production process of academic works. In particular, an analogy between the open access regime in science and the open source movement in the software industry addresses the lessons to be learned for rethinking the traditional publishing model in science. Standing on the shoulders of the authors in the open source literature, conclusions to the role of open access in science are drawn. In the end, new ways of scholarly publishing are discussed, giving reasons for a change in law for academic works and providing with a promising avenue for further research.

Keywords

Cumulative Research, Publishing Model, Open Access, Open Science, Open Source, Scientific Research

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1. Introduction

It was Sir Isaac Newton himself to acknowledge that "if [he had] seen far, it [was] by standing on the shoulders of giants" (Scotchmer (1991), p. 29), clearly stressing the cumulative character of research and innovation. Obviously, a major fraction of innovations can be traced to the ideas of earlier inventors, marking an evolutionary process of knowledge accumulation. This is especially true for the mechanisms in scientific research. Building upon and borrowing ones ideas positively defines a premise for scientific progress. As a matter of fact, a crucial aspect in this regard appears to be the issue of appropriate access to new knowledge and information.

Access to the results of scholarly research is generally provided by disseminating the works throughout journal publishing. The predominant model for scholarly publishing, meanwhile, reverts to copyright privileges as a lever for the emergence of commercial publishers and printers, providing an infrastructure for scholarly communication and hence for knowledge diffusion.[1] However, a recent discourse in the economic literature shows a growing dissatisfaction with respect to the prevailing "closed-access" model. In this respect, the role of copyright for scholarly communication appears to be ambivalent in many ways, "since neither authors nor the entities that compensate them for their authorship are motivated by the incentives supplied by the copyright system" (Litman (2006), p. 104). Particularly a recent paper by Steven Shavell (2010) has relumed this discussion on the reasonability of the traditional publishing model in science. The basic intuition of Shavell's model, meanwhile, is fairly easy to grasp: While the scientific community provides both the supply and demand for academic works, journal publishers take the position of a mediating party, sandwiched between authors and readers of scientific research (where to a large degree the group of authors and readers contains a community of the very same individuals).[2] Copyright in this respect provides journal publishers with an exclusive right to earn significant profits,[3] whereas the activity provided by publishers (i.e. the reviewing (selection of works by quality), editorship tasks and typesetting tasks) could be provided by the scientific community itself. As a matter of fact, most of these activities are already provided by voluntary reviewing activities among the group of scholars. Moreover, the basic economic reasoning to provide

[1] Cf. Litman (2006), pp. 101 et seq.; Bernius et al (2009), pp. 104 et seq.; Hunter (2006), p. 768.

[2] Cf. Watt (2010), p.2; Mueller-Langer/Watt (2010), p. 45.

[3] As such, commercial journal publishers frequently practice 3rd third degree price discrimination when discriminating between individual and institutional subscribers (dual pricing) or bundling print and electronic versions to different packages (bundling), allowing for an increase in prices over marginal costs. Copyright in this respect creates a situation of a so called monopolistic competition. As a matter of fact, the vast increase of library subscription prices throughout the last decade has induced a severe threat and crucial constraint to the budget of (university) libraries, restricting libraries from subscribing and hence researchers from access to new knowledge – also known as serial crisis. A recent empirical assessment is provided by Ramello (2010).

copyright law, i.e. to allow for an internalization of financial gains, is no driving force for scholars to produce an academic work. Obviously, following Merton (1973) academic authors are primarily interested in indirect gains which accrue through reputation and CV effects.[4] Shavell's radical thesis is as such just straight forward: An abolishment of copyright in academic works is socially efficient as an open access to scientific writings is likely to increase its readership and hence scholarly esteem. Thus, while copyright seemed reasonable to induce publishers to establish an appropriate infrastructure to disseminate the results of scientific research, recent discriminating practices of commercial publishers in the digital world may already have become too expensive to bear.[5] This asks: Does the open access model fit better to the norms, incentives and organization structure of scientific research?

This work seeks to contribute to this intriguing question. In particular, an analogy between the open access regime in science and the open source movement in the software industry addresses the lessons to be learned for rethinking the traditional publishing model in science. So what can scientists learn from the penguin? Standing on the shoulders of the authors in the open source literature, conclusions to the role of open access in science are drawn. In the end, new ways of scholarly publishing are discussed, giving reasons for a change in law for academic works and providing with a promising avenue for further research.

2. The Role of Open Access in Science

Finally, several reasons seem to abound why scholarly publishing should shift towards open access (journals) with a distribution via the worldwide web. Nevertheless, a comprehensive analysis regarding the role of open access in science still remains unacknowledged. Economic theorizing on the adequacy of the mechanisms of open access publishing, finally, will have to approach the applicability of such a paradigm to the norms, incentives and organizational structures in the science. In this context, we may profit from some experiences in open initiatives in other fields of innovation activities. In particular, an open access regime in the sciences reveals parallels to the open source movement in software engineering.[6] Accordingly, there are obviously some lessons to learn from building an analogy between free software and free science. This asks: What role does an open access paradigm play in science? And: What is to learn from the success in open source software for open access in science?

[4] See Watt (2010).
[5] Cf. Litman (2006), p. 104; Conley/Wooders (2009), p. 71; Hilty (2007), p. 325, European Commission (2006).
[6] See Kelty (2005). Besides, Lerner and Tirole (2002, 2005a, 2005b) note the options to learn from the economics of knowledge sharing beyond the initiative of open source.

2.1. Free Software and Free Science: An Analogy

Economic theorizing on the role of open access in science requires a deeper understanding of how the process of innovation in science is organized. In this context, the economic literature generally reveals two distinct models of innovation in organization science: (1) The "private investment"-model and (2) the "collective action"-model.[7] In 1997, the software engineer Eric Raymond broke with the traditional categorization, turning the notion of (intellectual) property right on its head and initiating a new way of thinking software development: The Open Source Software (OSS).[8] While there was a broad consensus among software engineers that the development of software was to follow the rules of construction like those of a cathedral until the mid 1990's, Raymond (1999) drew a new and revolutionary[9] picture of a bazaar with peer production. Raymond (1999) argues that software development should not proceed in small isolated teams based on secrecy before the final publication (*"the cathedral"*), but rather on the basis of an open peer production. Accordingly, an open source project is the result of a large and informal collaboration of volunteers, providing different modules for the aggregation of a new public good (*"the bazaar"*). Finally, it is not very difficult to see the immanent parallels between the open source in software and the open access in scientific research. Indeed, both open initiatives can eventually be seen as a necessary response to the restrictions to the sharing of information by the system of intellectual property rights. Building an analogy between these two open initiatives may hence reveal a good grounding on the essentials and the role of an open assessment in software engineering and scientific research, respectively. This asks: What can be learned from the track record of the Open Source Software (OSS) movement?

In building an analogy between the open source in software development and open access in scientific research, we may borrow from Weber (2004) who identifies three basic issues disclosing the core challenges in open source software: (1) The motivation of the individuals,

[7] While the "private investment"-model gears to a financial-based reward by granting a property right to encourage private investments in innovation, the "collective action"-model seeks to encourage the provision of a public good by some other form of reward system. See Hippel/Krogh (2003), pp. 212 et seq. A formal analysis balancing the benefits and costs associated to a reward system in contrast to an IPR regime provide Shavell and Ypersele (2001).

[8] Hippel/Krogh (2003) argue that the open source software movement satisfies for a third category of a so-called „private-collective"-model of innovation, combining aspects of both traditional models of innovation in organization science. See Hippel/Kogh (2003).

[9] Revolutionary in so far, as the open source movement dissociates itself from the traditional organizational models founded by Coase: The market and the hierarchy. As such, this paradoxon is known in the literature as "Coase's Penguin". The penguin, meanwhile, refers to the mascot of Linux who is a first mover in open source software development. See Benkler (2002) on Coase's Penguin.

(2) the organization and coordination of the contributions and (3) the complexity of the software development process.

Expanding on the first core challenge, Lerner and Tirole (2002) frame the issue of motivation by the essential question to cope with in open innovation: "Why should thousands of top-notch programmers contribute freely to the provision of a public good?" (Lerner/Tirole (2002), p. 198). The answer to this crucial question may come from an understanding of the economics of the open source movement. Accordingly, the economic intuition of open source is just straight forward and follows the behavior patterns of the traditional economic model. That is, a programmer will decide to contribute to an open source software project if, and only if, the net benefits derived from participation exceed its costs. The economic sound to the story then even fortifies the appropriateness of the previous question. As the individuals contribute freely to the development of a new open source software, how come that the bill shows positive net benefits at the end of the day.[10] In particular, the literature on the economics of open source emphasizes three basic incentives or motives that drive the decision making of the programmer: (1) The simple enjoyment, (2) career concerns and (3) ego gratification.[11] Expanding on this similarity, a programmer may first decide to contribute due to an enjoyment-based intrinsic motivation[12]. In this context, Csikszentmihalyi (1974) – one of the pioneering scientists to study the dimension of enjoyment – stresses the relevance to reach a so-called "state of flow" that maximizes the enjoyment derived from a contribution.[13] A state of flow occurs if the skills of a single person are matched to the challenges of the task. In particular, a programmer may select an OSS-project that matches his skills with the level of difficulty of the project – a choice which might not be available to the programmer in his regular job.[14] Finally, this in fact relates strongly to the set of norms in (open) science which emphasize the academic freedom in research activities. The concept of academic freedom ensures that scientists have the right to pursue independent lines of research and scholarship.[15] Building upon the previous argument scientific researchers will hence choose the optimal

[10] Despite the obvious similarities in the motivation structure of software developers and scientific researchers, the two groups still differ in regard to one crucial fact: While software developers in open source projects contribute to the production of a piece of source code by the price of their own leisure time, researchers are employees paid for their research. As such, scientific researchers do not spend their leisure on the production process.

[11] Cf. Lerner/Tirole (2005b), p. 56 et seq.; Lerner/Tirole (2002), pp. 212 et seq.; Rossi (2006), pp. 16 et seq.

[12] In general, two different types of motives are distinguished: intrinsic and extrinsic motivation (See Deci/Ryan (1985) and Deci/Koestner/Ryan (1999)). In addition, Lindenberg (2001) distinguishes between enjoyment-based and community-based intrinsic motivation (cf. Lakhani/Wolf (2005), pp. 4 et seq.). Rossi/Bonaccorsi (2006), p. 86, give an overview on the types of intrinsic and extrinsic motives that are being discussed in the literature on open source software.

[13] Cf. Lakhani/Wolf (2005), p. 4.

[14] Cf. Lakhani/Wolf (2005), p. 5.

[15] Cf. Willinsky et al. (2007), p. 604.

zone of activity in which their states of flow are maximized. Researchers as well as programmers may then derive positive net benefits from the enjoyment that – in the literature on the economics of science – is called the enjoyment from solving the puzzle. Adding a new algorithm to the source code in the development of a software, or advancing the knowledge to a particular problem in one's academic discipline, may finally come along with the pure enjoyment of exhibiting the "fun factor" in problem solving. Lerner and Tirole (2005) bring these considerations to the bottom line when they emphasize that "a 'cool' open source project might be more fun than a routine task" (Lerner/Tirole (2005), p. 58). In accordance, to puzzle at the forefront of an exciting field of research might involve an additional satisfaction.

The latter two aspects – motivation by career concerns and ego gratification – are closely connected to each other. As such, programmers participate in free software development for future career concerns. That is, by participating in peer production each programmer may advance his chances for future job offers. The reason behind this is easy to grasp. In particular, activities in problem solving and contributing to the improvement of a software product may rather improve than reduce the performance of each participant. Contributors may demonstrate their ability to solve specific questions in software engineering and accumulate additional competences and skills which improve chances on future income opportunities. Furthermore, programmers seek peer recognition among the group of their peers and are hence driven by the aspect of an ego gratification incentive. This motivation factor eventually approaches two issues: First, an aspect that can be referred to as a community-based intrinsic motivation. Accordingly, a programmer may seek to be a member in the group of peers and hence strives for a socialization in his community of software experts. The assignment of the term of a "hacker" can thus be seen as a reward or honor within the OSS community.[16] Second, this accumulation of reputational capital by peer recognition may serve as a job market signal of one's standing within the peer group and one's specific competences and skills. That is, peer recognition may serve the claims of both, reputation-based rewards and – by a form of market signaling – future monetary rewards. As a result, an economic perspective may allow to "group the career concern incentive and the ego gratification incentive under a single heading: the signaling incentive" (Lerner/Tirole (2002), p. 214). Once again, we have the parallels to the mechanisms and incentives in the market of science almost at hand. Following Merton (1973) a scientific researcher seeks for individual reputation among the community of scientists and the rewards that are assigned to priority of discovery (e.g. prizes and eponymy). Besides, by gaining peer recognition and

[16] Cf. Lakhani/Wolf (2005), p. 5.

being cited widely the scientist's performance may serve as a signal for future career concerns and hence future financial opportunities. That is to say, finally, the incentive structure for programmers to contribute to the source code in software development and for researchers to create and publish a scientific work respectively, follow rather similar rules.[17] Economic theorizing on the relevance of performance signaling in OSS-projects reveals that this incentive is stronger, the (a) more visible the performance to the peer group, (b) higher the effect of one's efforts on the performance and (c) more informative the performance about talent.[18] Especially the first aspect might be of particular relevance for assessing the role of open access in science. The visibility of the performance of a researcher then reveals two crucial issues. First, Merton (1973) provides evidence to the fact that academic research exhibits fads. While some fields of research attract large numbers of researchers, others are neglected for years. A fad then creates strong signaling incentives as it provides motives for the production of high-quality works. The reason is that an author can be confident that a large number of readers will investigate their work. Second, the visibility and influence of an academic work depends on the reputation and hence the impact factor of the targeted journal. As a result, the effects on the impact factor and the citation rate are important for the assessment on the role of open access in science.[19]

The second aspect Weber (2004) identifies as a core challenge of the open source software production process is the organization and coordination of the contributions made by the various peers in the software community.[20] In particular, a favorable characteristic in the organization of the open source production process is its modularity.[21] Open source projects are generally characterized by a division of the overall project into small parts, so-called modules. That is, the overall project aim is broken down to single tasks. The individuals can tackle these specific tasks independently from one another by a free access to the source code of the software. An optimal design of the modular production process hence requires limiting the independencies between modules.[22] As a consequence, by working on single, well-defined modules each software developer contributes to the source code of the project. This provides evidence for a software development as an evolutionary process.[23] Accordingly, there is a strong need for standard interfaces to enable a common language between the modules,

[17] Cf. Lerner/Tirole (2005a), p. 117.
[18] Cf. Lerner/Tirole (2002), p. 214.
[19] See discussion.
[20] Cf. Weber (2004), pp. 157 et seq.
[21] Cf. Lerner/Tirole (2005b), p. 62; Weber (2004), pp. 172 et seq.; Maurer/Scotchmer (2006), pp. 25 et seq. A comprehensive analysis of the modularity aspect in open source provides Johnson (2002).
[22] Cf. Weber (2004), p. 172; Glass (2005), p. 95.
[23] Cf. Weber (2004), pp. 76 et seq.

coordinating the efforts of the software engineers. This aspect of organizing innovation in the sense of a modular production process is also valid for the architecture prevalent in scientific research. In fact, the knowledge production process in science is by its nature cumulative. Each article builds on other articles and as such on other modules to advance the knowledge basis in science. Researchers answer to new modules by critique or provide improvements and extensions to the ideas contained in these modules.[24] The intuition is similar to the one in open source software development. By providing new pieces of (source) code a contributor enables others to learn and build upon this new code. The same is true to scientific progress. In science, a new scientific article gives new insights which enable other researchers to answer questions that they have been working on. In addition, by critique and refutation a process of mutual learning is induced. As a consequence, an academic work (a journal article, a book or a comment) can be seen as a piece of code that is provided (freely) to the scientific community and on which other researchers can build, extend or debug.[25] The intuition behind this crucial insight and the consequences for the organizational structure in science can be illustrated by applying a simple example on the functioning of science. In this context, the proof of Fermat's Last Theorem by Wiles (1995) and Taylor/Wiles (1995) abounds as a recent and very famous example in the mathematician discipline. The historical origins of this theorem can be traced back to the 17th century. Pierre de Fermat established this theorem somewhere around 1637.[26] Its basic intuition is easy to grasp, but nevertheless remained unproved for more than 350 years. Fermat's Last Theorem is a general case of Pythagoras' Theorem.[27] In general, Fermat argued that the equation

$$a^n + b^n = c^n \qquad (1)$$

is insolvable for integral numbers a, b, c; with $a, b, c \neq 0$ and an exponent $n > 2$. Fermat himself only provided a proof for the special case $n = 4$. Several attempts to proof this theorem for any n failed.[28] Finally, it was Andrew Wiles to provide the proof in 1995.

[24] The author of this paper as well greatly profits from earlier works (modules) in the economics of copyright and the economics of science. A short look at the references used within this work may already give an idea of what is meant by this insight. As such, each researcher necessarily stands on the shoulders of giants as he borrows from earlier contributions, clearly stressing its cumulative character.

[25] Cf. Willinsky (2005).

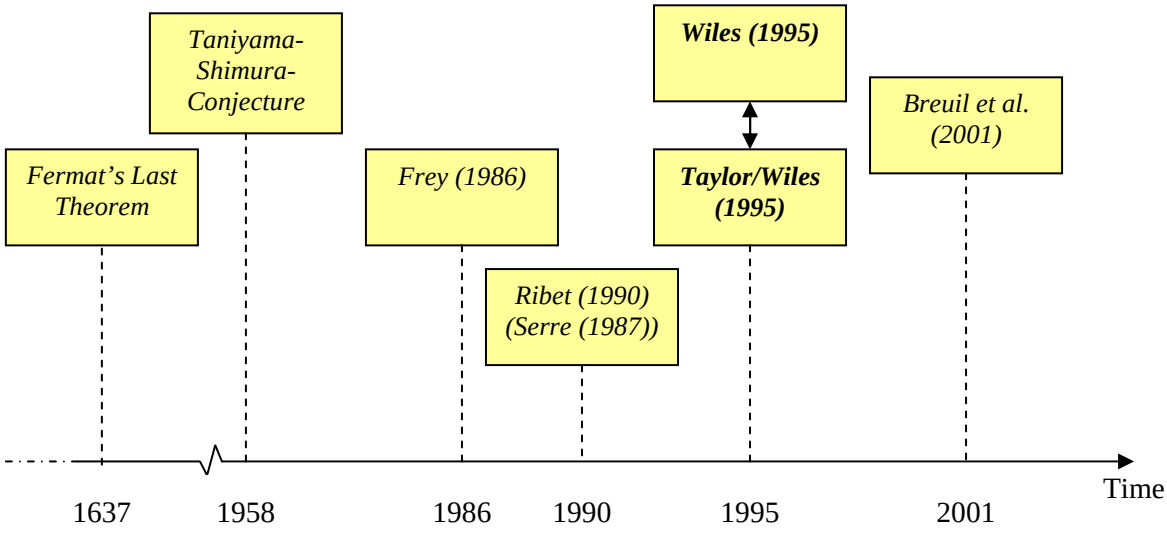
[26] Cf. Kramer (2000), p. 169.

[27] The theorem of Pythagoras says that for a right triangle with the legs a, b and the diagonal c the relationship $a^2 + b^2 = c^2$ must hold. That is, the Theorem of Pythagoras is a special case of equation (1) with $n = 2$. See Kramer (2000), p. 170.

[28] The anecdotes on the last theorem of Fermat report that Fermat left a handwritten commentary in his private edition of Diophant's Arithmetica that he had found a "marvellous" proof, but that there was not enough space to present it underneath his notes. The proof from Fermat, however, was never found (cf. Kramer (2000), p. 169; Singh (1998), p. 55). Several proofs for specific numbers of n were provided by Leonard Euler (n = 3), Leonardo Fibonacci and Euler (n = 4), Peter Gustav Lejeune-Dirichlet and Adrien-Marie Legendre (n = 5) and Gabriel

Nevertheless, it was not Wiles alone to solve the theorem. He was standing on the shoulders of a variety of renowned mathematicians, who – to stay with our previous terminology – provided the modules to the final proof. Figure 1 gives an overview on the crucial modules for the proof of Fermat's theorem.

Figure 1: The Modular Architecture of Science – Lessons from Fermat's Last Theorem



Source: Copyright by the author.

The core module of the final proof is known as the Taniyama-Shimura-Conjecture.[29] Finally, it was the seminal work of Frey (1986) that provided the additional piece of source code that lead to Wiles' proof. Frey's Curve established a connection between elliptic curves and Fermat's Last Theorem, suggesting that the Taniyama-Shimura-Conjecture implies Fermat's Last Theorem. When Ken Ribet (1990) showed that if Frey's Curve was not to exist the Taniyama-Shimura-Conjecture was necessarily true, Andrew Wiles recognized his chance to solve the 350 year old puzzle.[30] He had only to show that the Taniyama-Shimura-Conjecture was true to prove the unsolved puzzle. Borrowing from Weil (1967), Frey (1986) and Ribet (1990) and extending on the works of several others in the fields of elliptic curves and modular forms (e.g. Èvariste Galois (1811-1832)) Andrew Wiles provided his proof within three lectures at the Isaac Newton Institute for Mathematical Sciences from June 21-23,

Lamé (n = 7). In addition, Sophie Germain could show that for all primes less than 100 the theorem was true (Singh (1998), pp. 133 et seq.).

[29] The Taniyama-Shimura-Conjecture establishes a connection between the research fields of elliptic curves and modular forms, and hence builds a bridge between analysis and algebra. Weil (1967) extended the Taniyama-Shimura-Conjecture, showing that for a special case of elliptic curves (so-called L-Series) the conjecture was true. That is why the literature often refers to the Taniyama-Shimura-Weil-Conjecture. See Darmon (2001).

[30] An additional module Ribet (1990) extended on was a work by Jean-Pierre Serre (1987). Serre provided the so-called epsilon conjecture that was needed to finally link the Taniyama-Shimura-Conjecture with Fermat's Last Theorem.

1993.[31] The proof-reading, however, revealed an immanent error in Wiles' proof. Wiles and his former student Richard Taylor finally solved the error. Wiles and Taylor published the final proof of Fermat's Last Theorem in the Annals of Mathematics in 1995. In the end, Breuil et al. (2001) provided the last module to the proof of the modularity theorem, borrowing from many of the new techniques Wiles had established. Consequently, this example clearly stresses the cumulative character of research.[32] Creating barriers to the access to the modules in each sub-discipline in science hence applies breaks to scientific progress. Extending on the rationale of the economics of copyright finally gives evidence to a frequently neglected dilemma of copyright law: The Tragedy of the Anticommons.[33] Accordingly, we would expect that by an open access to academic works this problem could be solved, facilitating a wide spread and citation of research results. As such, this would satisfy both – the incentives and motives apparent in the market of scientific research and the aim to force knowledge spillovers as fast as reasonably possible.[34]

Third, Weber (2004) identifies the complexity of the software development process as a final core challenge in open source software projects. One crucial aspect then to cope with the complexity of OSS projects is its technical design and hence the previously mentioned characteristic of source code modularization. Obviously, by forcing the organization of small programs aiming at single task, the overall project is easier to understand and to debug.[35] This reduces project complexity. In addition, communication among the "hackers" abounds as a determinant for project success. A major prerequisite in this regard is a good documentation, making the process of OSS development transparent and comprehensible to the peer group. That is, the primary incentive for programmers to carefully document code is to facilitate the creation of additional code by others and to allow for a general understanding of the functions or the role of a single piece of code within the overall scheme.[36] Again, this aspect clearly reveals some important parallels to the mechanisms in science. In science, researchers have a strong incentive to force a comprehensible documentation of their research methods, databases and bibliography.[37] Well documented research enables others in the scientific community to run the same experiments (re-analysis) and to extend or debug on the research

[31] The title of Wiles' presentation was „Modular Forms, Elliptic Curves and Galois-Equations"(cf. Singh (1998), pp. 277 et seq.

[32] Of course, this example analyses a particular research field in the discipline of mathematics. Nevertheless, it can be seen as an example of the traditionally modular architecture in science in general.

[33] A comprehensive analysis of this trade-off between static and dynamic efficiency in copyright law provides Heller (1998).

[34] See discussion on this point.

[35] Cf. Weber (2004), pp. 172.

[36] Cf. Weber (2004), pp. 78 et seq.

[37] Cf. Willinsky (2005).

results of their colleagues. In particular, an open access via the internet would facilitate the usage of the very same data sources. That is, by an access to the same data researchers are enabled to fully understand the methods and results documented within a publication and hence to comment or extend on particular methodological aspects. Furthermore, other researchers are enabled to move readily from a citation in the text to the source via hyperlinks.[38] Bibliographical software like EndNote, RefWorks or ProCite provides direct access to the references used by an author. Another aspect regarding the communication among the "hackers" and researchers, respectively, is a framework of discussion. Weber (2004) argues that crucial to the success of an OSS project is that the engaging developers "talk a lot" (Weber (2004), p. 81). In science, this framework for explicit discussion is provided by (international) conferences as well as critique and refutation to publications. An open access regime, however, could even provide an additional instrument for discussion and the organization of the peer-review process: Open Assessment. An open assessment supplements the traditional peer review by a "public" peer review process. As such, other researchers are provided with a platform to directly comment on discussion papers or by rating them.[39]

In conclusion, extending on the parallels between open source in the software sector and open access in science reveals several starting-points to discuss the role of open access in science. It appears to be reasonable to draw attention to the lessons learned from the success of open source. Thus, a further discussion of the identified applications is needed to appraise the chances of an open access regime in scholarly publication. In particular, our previous outline reveals the need to discuss two crucial issues: First, the effect of a shift towards an open access for scholars on the citation rate and the impact factor of journals (motivation). Thus, there is a strong need to discuss the ability of researchers to accumulate reputation and create demand in an open access regime. Second, the crucial issue of a wide dissemination and hence diffusion of new knowledge, comparing an open and a closed access model for scholarly publication.

2.2. Discussion

All of the previous analysis reveals one crucial message for the future of scholarly publishing: A shift in paradigm towards an open access regime seems justified and reasonable in

[38] In this context the author of this paper also went the extra distance to provide a list of the internet references with integrated hyperlinks that allows to move directly to the particular information via the internet.

[39] Siegert/Werner-Schwarz (2009) provide an analysis of a particular open access journal ("New Journal in Economics"), also approaching the issue of open assessment. They conclude a rather positive picture upon an open assessment to research results.

economic terms. In fact, an analogy to the open source movement in software development as well as the experiences made with open access journals emphasize that an open access model may eventually fit better to the norms, incentives and organization structure of scientific research. In particular, two aspects abound that match to the interests of authors. First, an open access to scientific results may lead to a higher citation of works and hence may allow for an added value for authors who are interested in citation counts. Second, an open access forces a wider and immediate diffusion of new knowledge, creating a broader fundament for communication among researchers. Nevertheless, both aspects raise needs for discussion from economic perspective.

The most intriguing aspect of an open access to scientific research via OA journals[40] is its expected impact on the number of citations. In general, economic theorizing on the relationship between the terms and conditions of access to journal content on the one hand and the change in citation counts on the other hand gives reasons to assume an increase in citations subject to a change towards an open access regime. The basic intuition behind this idea of a causal relationship is thereby not difficult to grasp. As in an open access regime there will be no entrance fee for readers accessing a scientific work, i.e. $p_C > p_{NC} = 0$, we would expect more readers to read a work as a consequence of a shift towards open access to scientific research. That is, with prices to fall to zero we would expect readership to increase and hence the probability of getting cited. Consequently, OA journals are more often cited. Furthermore, there will be an additional number of citations that results from a free access to the data sources and the code.[41] Obviously, a shift towards open access would likely benefit the authors as they are interested in maximizing their individual citation counts. An empirical assessment on this effect regarding the number of citations, however, reveals a rather differentiated picture. Lawrence and Giles (2001) provide evidence to a three times higher citation rate on average for open access content.[42] Besides, Eysenbach (2006) applies a longitudinal bibliometric analysis of a cohort of OA and non-OA articles in the context of a particular journal (The Proceedings of the National Academy of Science (PNAS)). He shows that OA articles compared to non-OA articles are more immediately recognized and cited by a factor of two.[43] A very recent survey by Davis (2009) suggests that the citation advantage of

[40] Note that the arguments apply to the "gold road" (Harnad et al. (2004)) of open access publishing only, i.e. OA journals. The reason is that in contrast to self-archiving the road via OA journals ensures the provision of the additional publishing services, helping to distinguish high quality articles from the Akerlof lemons (Akerlof (1970). In particular, Esposito (2007) raises the concern that an open access to everything may worsen the situation by opening the gates to increasing amounts of unfiltered information. See also Bosch (2009), p. 91.
[41] Cf. McCullough (2009), p. 124.
[42] Harnad/Brody (2004) find similar evidence for the citation advantage of OA articles.
[43] Cf. Eysenbach (2006), p. 694.

open access is declining by about 7 percent per year. Taken all journals together there appears to be only a small open-access advantage of 17 percent.[44] In contrast, other empirical investigations relativize the picture upon open access journals, as they provide evidence that there is no such causal relationship between open access and higher citations. In this context, Davis et al. (2008) show that there is in fact a significant impact on the amount of accessed paper downloads. However, their empirical investigation reveals no significant difference in regard to the number of citations when comparing OA and non-OA articles. That is, the picture that can be drawn on the relationship between an open access and a higher citation rate still remains questionable from empirical perspective. Bosch (2009) emphasizes that further assessments are needed, particularly approaching the still prevalent methodological weaknesses of the existing surveys, e.g. the problem of a selection bias.

In addition, several authors stress the concern that OA journals could be restricted in accumulating reputation and creating a reasonable level of demand.[45] Academic journals are typically ranked, while the ranking of a journal is dependent upon the number of readers and citations. The problem then is that the number of citations attainable from a published article necessarily depends on the reputation and hence the position of a journal in the ranking. Rowlands and Nicholas (2005) provide evidence that the reputation of a particular journal abounds as the most relevant aspect in the author's decision making.[46] The reason is just simple economics and follows the immanent mechanisms of the reward system in science. In science, only publications in highly ranked academic journals provide with scholarly esteem. Besides, appointments for professorships also follow a mechanism of short listed journals and numerical weighting schemes. As such, it is not the aspect of a wide and rapid dissemination or an open access that drives an author's decision where to publish – it is rather the journal's reputation that counts. Consequently, it seems rather unlikely that (especially young) researchers have a strong incentive to publish their prestigious research results in rarely known open access journals.[47] The problem for an OA journal then is as follows: In order to build up a certain level of reputation the journal will have assure readers to read the works and authors to submit high quality works. Readers, however, will prefer particularly highly ranked journals to minimize information cost, while authors are forced to publish in highly ranked journals to attract readers.[48] Thus, following Cavaleri et al. (2009) a classical chicken-egg problem emerges. Experiences suggest that it will be very challenging for OA journals to

[44] Cf. Bosch (2009), p. 92.
[45] See for example Cavaleri et al. (2009), pp. 94 et seq. or Björk (2004).
[46] Cf. Rowlands/Nicholas (2005), p. 17.
[47] Cf. Björk (2004), p. 12.
[48] Cf. Cavaleri et al. (2009), p. 94.

climb up in journal rankings. A closer look at the first ranked journals still reveals the predominance of commercial journals.[49] From economics perspective there seems to be evidence for a first mover advantage of already well-established (commercial) journal publishers. Thus, it turns out to be a challenge for newly launched OA journals to enter the group of high prestigious journals and hence to accumulate reputation and to create a certain level of demand.

The second aspect that an open access regime raises is that by disseminating scientific results via the internet free of charge, an immediate and wide spread of new scientific information is reached. In fact, especially the option of uploading pre-prints or conference papers into repositories may speed up communication among scientist.[50] David (2003) argues that scientific progress as a cumulative process of knowledge accumulations depends (in the long-run) decisively on a rapid and widespread disclosure of new findings. That is, by providing an earlier access to academic works via the uploading of article manuscripts scientific progress and discussion is enhanced. The relevance of the aspect of the speed of the publication, however, may differ considerably between different scientific disciplines. In this context, Kling and McKim (2000) give evidence to the fact that subject-specific repositories had existed prior to the birth of the internet in such research areas where speed is of substantial importance.[51] Particularly in the fields of natural science (e.g. physics, computer science, mathematics etc.) speed is a decisive determinant for advancements in the knowledge base.[52] Furthermore, a wider spread may also help to manage competition for scientists between complementary research activities. As such, an open access via the internet will facilitate the visibility of new research results and may hence create a market signal to other researchers in a particular field. Open access could then be viewed as a signaling system to avoid a doublization of activities. Scientists may be able to learn earlier from the advancement of others and extent on new findings. In addition, open access facilitates the replication of research activities by providing with the access to the data sources. Replication enables to re-analyse a certain experiment and hence is crucial for satisfying the scientific principle of verification. Nevertheless, McCullough (2009) raises doubt regarding the better ability of OA journals to cope with the aspect of replication. He shows that high-ranked traditional journals

[49] A recent list, ranking the journals by using the Impact Factor is provided at http://www.econ.vu.nl/econometriclinks/rankings. In economics, the Quarterly Journal of Economics abounds as the most influential journal, followed by Econometrica and the Journal of Political Economy.

[50] Cf. Björk (2004), p. 3; McCullough (2009), p. 118.

[51] An example for such a pioneering repository is the founding of *arXiv.org* by the physicist Paul Ginsparg (cf. Björk (2004), p. 3). See also section 3.1. on the history of the open access movement.

[52] The traditional publishing model in science seems to neglect the importance of a rapid diffusion of knowledge, as the time-gap between submission and publication of a paper is often large.

already make data and code more readily available than OA journals – which appears somehow paradoxical from an economists perspective. The causality of this aspect, however, is still in doubt.

2.3. Implications – The "Open Access"-Dilemma

Finally, the previous discussion draws a somehow bilateral picture on the open access regime. On the one hand side, an open access regime is likely to be beneficial to authors and the advancement of science in general. On the other side, it is the immanent rules of the system of science which create a fundamental barrier to a change.

From economic theory perspective then, these immanent rules in the reward structure of science cause a fundamental coordination failure. Scientists happen to be the prisoners of their own system, creating a scenario of an open access dilemma.[53] While from a social planer's perspective it would be worthwhile to force a change in the paradigm of scholarly publishing (from a closed access model towards an open access model), the immanent incentives provided by the system of science avert from a cooperative equilibrium. The basic intuition behind this fundamental "Open Access"-Dilemma can be illustrated by the matrix shown in figure 2.

Figure 2: The Open Access Dilemma

		Player B	
		Cooperation (Open Access)	Defection (Non Open Access)
Player A	Cooperation (Open Access)	win / win	lose / win
	Defection (Non Open Access)	win / lose	***lose / lose***

Source: Copyright by the Author.

Suppose a two-scientist game with two possible strategies to choose in publishing one's own scientific results. Each scientist can either publish his work in any OA journal or in one of the existing non-OA journals. Now recall the rationale of the previously outlined chicken-egg problem.[54] In science, only publications in highly ranked academic journals provide with scholarly esteem. Besides, appointments for professorships also follow a mechanism of short listed journals and numerical weighting schemes. That is, each scientist seeks to publish in as highly ranked academic journals as possible. As newly launched OA journals will suffer a

[53] The expression of a prisoner's dilemma follows an often cited example used in non-cooperative games (game theory). See Axelrod (1987). The historical origin of the prisoner's dilemma can be traced back to Merrill Flood and Malvin Dresher who belong to the group of pioneers in the research field of game theory in the 1950's.
[54] See also Cavaleri et al. (2009).

competitive disadvantage compared to well-established non-OA journals (e.g. a first mover advantage), OA journals will be restricted in accumulating reputation and hence in creating a certain level of demand.[55] Consequently, scientists striving for individual reputation and seeking for a signaling of their performance in the market will not likely choose to publish their prestigious research results in rarely known open access journals.[56] Following the rationale of figure 9 both players (A and B) will have a strong individual incentive to publish their research results in non-OA journals and hence will not cooperate. The reason for this dominant strategy in defection is to be found in the costs that a player suffers if he is alone to publish open access.[57] That is, while the single cooperative player provides open access to his works (positive externality), others will gain scholarly esteem and receive the appointments at prestigious departments. This dominance of deviant behavior appears to be particularly strong for young scientists who have not yet reached the goals of peer recognition and prizes or eponymy.[58] In the end, the players of our constructed game appear to suffer a lock-in to the weak Nash-equilibrium (lose/lose).[59] Thus, it will have to be discussed how we can overcome this fundamental coordination failure by the application of appropriate policy instruments.

3. Copyright and Open Access: What is to learn?

Our analysis, finally, leaves us with several crucial questions to cope with: What is to learn from all of the above with respect to the roles of copyright and open access in the future of science? What are new ways of scholarly publishing in the information age? What role will copyright play in the future of scholarly publishing?

The roads towards the future of scholarly publishing will decisively depend upon the question whether copyright is removed for works in science, or not. Obviously, a law abolishing copyright in academic works – as Shavell (2010) recommends – would necessarily cause a shift from a closed to an open access model. The reason reverts to the general intuition of copyright. Copyright provides its right holder with an exclusive right, preventing others from

[55] Cf. Cavaleri et al. (2009), p. 94.
[56] Cf. Björk (2004), p. 12.
[57] In this situation figure 9 reveals that he is the one to lose, while the other player wins by publishing in highly ranked non-OA journals and hence by accumulating individual reputation.
[58] Another aspect that could lead to a self-enhancing effect in our prisoner's dilemma is the necessary shift from a "Reader-Pays"- to an "Author-Pays"-Principle. In this context, we would expect authors to prefer a transfer of their copyright to the publishers (traditional model) instead of having to pay a publication fee per article. Nevertheless, we would expect this effect not to dominate as there are reasons to assume universities and other granting entities to bear the costs for the authors.
[59] Note that this prisoner's dilemma can not only be applied to a game among scientists, but as well to a game of jurisdictions deciding on the law setting of a copyright in science. The reason for this dilemma is based on the fact that copyright law is by its very nature a national law. In this context, the open access idea eventually may particularly gain interest in regard to an access of developing countries to scientific knowledge.

copying the work. As in the traditional publishing model the copyright is typically transferred to the publisher, it is the publishing entity to hold this exclusive right, enabling publishers to engage in price discriminating practices. If copyright were now to be removed for works in science, publishers would no longer be able to set (high) subscription prices for the readers of the academic works, but would be forced to impose a submission fee on the authors of the published works. That is, an elimination of copyright would necessarily induce a shift from the traditional "Reader-Pays"- Principle to an "Author-Pays"-Principle. Accordingly, the readers of academic papers would receive an open and free access to all scientific content. The organization of the distribution process would have to revert to the green and golden roads of open access publishing, i.e. an application of self-archiving/repositories ("green road") or OA journals ("golden road"). However, journal publishers with a well-organized reviewing process would still constitute a premise in scholarly publishing to assure a certain (high) level of quality and hence to reduce the information cost for readers. The dissemination of the papers could then be structured as online versions via the internet or as hard format via libraries.[60]

Despite of this first road towards an open access model in scholarly publishing, also a world with copyright may provide different options to facilitate the (already begun) open access movement. In this context, Hoorn and van der Graf (2006) provide evidence to three particular choices with regard to copyright in OA research journals. First, the authors could retain the copyright on their writings. As an example for such an open access model abounds the Electronic Journal of Comparative Law (EJCL).[61] A crucial aspect in the copyright policy of EJCL is that the copyright remains with the author of a contribution. The author is free to publish his article elsewhere as long as a proper reference is made to its publication in EJCL. In contrast, the readers of EJCL articles are free in using the expressed ideas in the journal, while they are prohibited in copying, distributing and re-publishing complete articles or parts of them. However, readers are explicitly encouraged to make copies (electronically or printed) for personal and classroom use.[62] Second, copyright could be shared by an application of a Creative Commons license. Several examples of the CC licensing options abound in the practice of open access. In particular, the journal publishers PLoS and Biomed Central (who

[60] Note that the marginal cost for online distribution is zero, while for the hard format the printing costs will induce a crucial constraint to the price setting. The reason is simply competition. This will finally raise the question whether the hard print version would be able to survive in the absence of a copyright system. See Mueller-Langer/Watt (2010) for a discussion.

[61] The Electronic Journal Comparative Law (EJCL) is a journal for academic works in the fields of comparative private and public law, comparative legal aspects of information technology and the methodology of comparative law. See http://www.ejcl.org.

[62] Cf. http://www.ejcl.org/general/about.html.

are the two leading publishers in OA publishing) apply the so-called Creative Commons Attribution License (CCAL). The CCAL allows authors to retain the ownership of the copyright for their articles, but allows anyone to download, reuse, reprint, modify, distribute, and/or copy articles in the respective journal. However, the author as well as the journal source needs to be cited,[63] while no explicit permission for a use of the content is required – neither by the author nor by the publisher.[64] In the end, this type of CC license ensures a maximum impact of an academic work for his author. In addition, the so-called CC "share alike" license allows to explicitly restrict the reuse of publication. In total, the creator of a work may choose between a set of six different licensing conditions.[65] A third possible choice regarding the copyright in OA journals would be to choose the traditional way of (partly) transferring it to the OA publisher. That is, a possible way towards OA publishing could be that traditional journals convert into OA journals. In practice, there are already several examples where journal publisher have converted partly or completely to the OA publishing model.[66] In this context, for example Springer Open Choice offers their authors the additional option of providing open access to their publications. A prestigious journal that has converted to the OA model is the British Medical Journal (BMJ). The BMJ uses licenses which keep the copyright with the author, while the author has to transfer all commercial exploitation rights to the publisher.[67] That is to say that the author retains all other rights to his article. In particular, the author may post the full article on his own or the employer's website, make (up to 50) copies for personal or professional use, republish the complete article (in any language) in a self-written or self-edited book and reproduce parts (figures, tables and up to 250 words) of it in other works without permission. Consequently, the BMJ allows for a maximum freedom in the (copy)right for authors exclusive the right for commercial exploitation.[68]

In the end, also in a world with copyright there seems to be promising business models to facilitate a shift in the paradigm of scholarly publishing – from the traditional closed access model towards an open access to academic works. In this context, especially the idea of using the Creative Commons licenses to organize the publishing scheme reveals economically

[63] This "citation constraint" just follows the mechanism of the reward system in science, as the citation of articles is the predominant currency within the system of science. That is, this constraint provides a prerequisite for the functional efficiency in the market of science.

[64] Cf. http://www.plos.org/journals/license.php.

[65] See http://creativecommons.org/about/licenses/ for an overview and description of the six different licensing conditions in the Creative Commons licensing scheme.

[66] See http://oad.simmons.edu/oadwiki/Journals_that_converted_from_TA_to_OA (last visited on January 26, 2011) for a list on the traditional journals that already have converted to an open access model. A list regarding the very opposite way from the traditional model to open access is provided by http://oad.simmons.edu/oadwiki/Journals_that_converted_from_OA_to_TA (last visited on January 26, 2011).

[67] See http://group.bmj.com/products/journals/.

[68] Cf. Hoorn/Graaf (2006), pp. 2 et seq.

reasonable starting points. Finally, the future of scholarly publishing will unlikely be a one way street for the dissemination of scholarly works. One can even think of arguments why OA journals and traditional journals complement each other.[69] Nevertheless, our analysis has provided several advantages of the OA model. Besides, there is a strong consensus among scientists that an open access to scientific context is in general reasonable and justified. That is, the future way of scholarly publishing may rather be the one of promoting open access.

4. A Critical Perspective

The qualitative conclusions drawn from the Shavell-model as well as the arguments forwarded in discussing the role of open access in science revert back to one crucial assumption. This assumption is that we suppose the quality and the nature of scientific output to be independent from the financing-principle ("Reader-Pays"- versus "Author-Pays"-Principle) in organizing journal dissemination. Stated differently, the classical model of providing journals to distribute scientific output will not change subject to the question whether the readers (subscription fee) or the authors (submission fee) pay the journals. As a consequence, we assume OA journal publishers to provide the same publishing services to ensure a certain level of quality in journal content and to bundle different articles to convenient packages.

Obviously, if the two publishing models were to result in the same content, an open access regime would allow for a transfer of social surplus to the scientific community and away from the publishing companies – clearly a socially beneficial outcome.[70] However, whether in an open access regime journal content would still be made available in convenient bundles (i.e. journal issues) depends upon the question if OA journal publishers are able to recover the costs of providing these publishing services. If the authors or some granting entity would be willing to recover the publication costs, there is no reason to doubt that the nature and the quality of scientific output will be Pareto-inferior. That is, we would expect the same outcome to result in both worlds – the closed access world and the open access world. In general, there seems to be no difference in the quality and nature of journal content whether the journal is financed by a subscription fee from the readers or by a submissions fee by the authors.

However, some simple considerations may put forward doubts to this belief. The point to make here can be titled market power. One can argue that even if copyright law was to be abolished for all future works in scientific research, the journal publishers will still be able to

[69] In particular, McCabe and Snyder (2006) provide a model which shows that both publishing models (open access model and subscriber based model) can emerge as stable equilibrium models.

[70] Cf. Mueller-Langer/Watt (2010), pp. 47 et seq.

retain some degree of market power and hence to internalize profits.[71] The reason reverts back to the previously outlined prisoner's dilemma that restricts OA journals to accumulate reputation and to create a certain level of demand. That is, even under no copyright there will be options for highly ranked journals to charge author fees which exceed the administrative and production costs of journal publishers. As a result, top-tier journal will still be able to make (substantial) profits due to their reputational capital they have accumulated in the past. In addition, the fact that it is the author who pays for a publication of his work may enable these publishers to even extend their profit margin. This argument follows an analysis by McCabe and Snyder (2005). They argue that if journal publishers charge a fee per publication, this is likely to result in a situation of accepting papers that would otherwise not have been accepted. Publishers have a strong incentive to just accept additional papers in order to internalize the fees paid by the author of a paper. In doing so, however, the quality of journal content would fall.[72] From an economic theory perspective, each publisher would accept additional papers as long as the marginal benefits of doing so exceed its marginal costs. In the end, the analysis by McCabe and Snyder (2005) provides evidence to the concern that the overall quality of OA journals could decrease.

Furthermore, several other aspects have to be taken into account when reflecting the conclusions made. First and foremost, there is not the one economic rationale within the system of science that can be applied to all academic disciplines. In particular, a stringent analysis on the role of open access in science will have to consider the specific characteristics of each discipline in science. Obviously, there will be decisive differences in the perception of open access and its relevance for one's advancement among different disciplines.[73] Besides, further research seems required regarding the financial issues in an open access regime. Who is to pay for the publications? Who will provide OA journals and particularly the publishing services that are needed to prevent from a degradation in quality?

In the end, this paper can only be seen as a first overview on some aspects involved when thinking of the future of scholarly publishing and the chances provided by the technological revolution in the digital age. Further and broader assessments, also focusing on international law perspectives will be required to cope with the complexity of the overall system.

[71] See Mueller-Langer/Watt (2010) on this point.
[72] Cf. McCabe/Snyder (2005), pp. 453 et seq.
[73] In addition, it seems reasonable to distinguish between research by scientists employed by universities and those doing research in a firm with purely profit driven incentives. In this context, IPR is still to play a substantial role.

5. Conclusion

In conclusion, the picture drawn from Shavell's analysis and our more general approach eventually underlines the general intuition and the consensus among scientists when reflecting on the incentive structure in science: While copyright seeks to provide a monetary incentive for the creation of copyrightable works, scientists do science to receive recognition among their peer group and to accumulate individual reputation for career advancement. That is, copyright is not required to encourage scientists to do science, whereas the fact that there is a copyright for academic works seems to even impose a severe threat to the future progress in science. In this context, the experiences made by the predominant serials crisis reveals that the publishers of scientific output have been engaging in price discriminating practices, restricting libraries to subscribe and hence researchers to access new findings. In the end, Sir Isaac Newton was right some 300 years ago by acknowledging the giants he was standing on, putting forward one crucial issue to the research schedule that has not lost its topicality – this is the issue of access. Access in general and particularly in science is meanwhile in need for a more comprehensive analysis and universal approach.

The spread of the internet and the technological development in the information age have induced new options in distributing scientific output, initiating a discussion to rethink the traditional model of scholarly publishing. In particular, the literature emphasizes the role of the open access model in the market of science as a promising alternative model to commercial journals. In this context, the Shavell-model and our discussion give hope to believe that an open access to academic works generally accommodates researchers with a wider citation and hence additional incentives to provide high quality output. That is, the open access model appears to fit better to the norms, incentive structure and organization in science. As far as this is concerned, we may gain additional insights from an analogy to the open source movement in software engineering. The lessons learned from the success of open source software teach a fundamental clash between the general objectives of intellectual property right (IPR) enforcement and the incentives mechanisms in the software industry and science, respectively.[74] In the end, a shift towards an open access regime with OA journals[75] seems reasonable and justified from an economist's perspective.

Nevertheless, consciousness is strongly needed with respect to the instruments to facilitate this shift in the paradigm of scholarly publishing. I doubt that a law abolishing copyright in

[74] Cf. McCullough (2009), p. 124; McCullough/McGeary/Harrison (2006), p. 1097.

[75] Note that there is a strong need that the nature of scholarly publishing with journal publishers providing convenient packages of academic articles and additional publishing services to ensure that a certain level of quality is retained.

academic works – as Shavell (2010) recommends – provides a reasonable solution to overcome the prevailing coordination failure of (young) scientists. Indeed, as Shavell's suggestion comes along with several other potential market failures, a removal of copyright for all future academic works will at the most satisfy for a second best solution. Finally, a mix of different policy instruments may facilitate the open access movement in science. The optimal mix of instruments will be a tough schedule for further economic assessments. Especially the effect of (universal) open access in science on the average quality of academic works is neglected by Shavell. In fact, the answer whether an OA model is socially desirable will only be answered by approaching both dimensions – the effect on the quantity and average quality of academic works.[76]

In addition, the question whether an open access model or the traditional model creates better incentives for scientific research is still in need of a more comprehensive analysis. In particular, the complexity of the system of science asks for a multi-disciplinary approach, encouraging a dialogue between economists and lawyers.[77] Whether an open access regime or the traditional publishing model creates better incentives for scientific research will depend on so many aspects that it will only be answered in time. Balancing the interests of different groups in the publishing context is unlikely to result in a single perfect solution.

In the end, this analysis reveals several starting points to rethink the framework of scholarly publishing and to further discuss the role of open access versus copyright in science. Standing on the shoulders of one another, the future design of the scientific framework will then have to focus more on the incentives of scientists to do science and hence to contribute to the advancement in knowledge production. In addition, the institutional design will forward questions from an international law perspective. Obviously, a promising avenue for further research.

[76] See Watt (2010) on this point.

[77] In this context, recent investigations on the role of IP law in the information age by lawyers may forward discussions in economics. See for example Hilty (2006a, 2006b, 2007).

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