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Conceptual paper

Scholarly work in the Internet age: Co-evolving technologies, institutions and workflows

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ABSTRACT

This study explores how ICTs and the Internet are influencing, and being influenced by, the evolution of institutions, organizations and workflows that play a role in scholarly work. Based on a literature review and a structured analysis of 8 carefully selected web sites, this study explores: (i) the evolving business models of scientific journals; (ii) the new competitive dynamics triggered by open access and article-level metrics; (iii) the traditional and emerging forms of peer review; and (iv) the emerging ICT-enabled changes in research workflows. The findings depict a highly complex and dynamic scenario, in which different scholarly communities, with their respective institutional and organizational environments, are experimenting different ICT-based arrangements and solutions, which are dramatically widening the range of possible activity systems through which scientific knowledge is created, exchanged, evaluated and leveraged.

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Introduction

The self-organizing capabilities of the global scholarly system stem from a peculiar, unique incentive structure. Faculties are responsible to two intertwined, but distinct social entities: their universities and their disciplinary communities. Universities give scholars professional credit through tenure and promotion decisions, usually based on their publications. It is disciplinary colleagues, however, who determine these publications' success, through peer review and citations (Acord & Harley, 2013).

Complex and diverse systems of institutions, i.e. norms and values, have been developed in the different contexts worldwide to govern the tensions due to the complex incentive structure of scholarly work. These institutions rely on specific intermediary organizations that have evolved throughout centuries (Willinsky & Provencal, 2012) as pivotal to the scholarly system.

In the traditional model, that took shape between the nineteenth and the twentieth century, the key intermediary organizations

were university libraries and non-profit publishers (such as university presses and disciplinary associations). The model was quite simple: university presses and disciplinary associations had the responsibility of selecting publication-worthy research; university libraries bought the published work at a price that subsidized the non-profit publishers; and the faculty could use for free the literature made available by libraries, as the foundation for further research (Beverungen, Bohm, & Land, 2012). This model has become much more complex in the last decades, with a myriad of further actors playing many, diverse and often disruptive roles (Wellen, 2013), but the basic logic of the cycle described above is still viable.

What makes this model unique is the fact that, even if it governs a big, exponentially growing, and critical business at the global level, some core phases of the process are “islands of gift economy” protected by highly inertial institutional and organizational environments. These islands of gift economy (Wellen, 2013) include processes such as comment exchange in scholarly conferences, patronage, mentoring, and the core engine of the academic system: peer reviews.

It is not surprising, then, that the theory of the commons (Hess, 2008; Hess & Ostrom, 2007) is growingly mentioned in studies and

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debates on the scholarly system (Fecher, Friesike, & Hebing, 2015; Wellen, 2013). The theory of the commons acknowledges the existence of systems that need collective collaboration to maintain their capability to provide certain communities with valuable resources. Wikipedia is a typical example of knowledge commons. The commons are by definition threatened by social dilemmas (Friesike & Schildhauer, 2015), because the “rational opportunism” of individual actors, if not effectively governed, sooner or later disrupts the system’s capability to provide the actors with the desired resources. For example, should all Wikipedia users behave “rationally”, they would just exploit the others’ work, without contributing to the platform, thus jeopardizing their own possibilities to extract value from the platform in the long term. Effective multi-layered institutions, strong social networks, reputational mechanisms and the community’s self-organizing capabilities are the only antidotes to the so-called “tragedy of the commons” (Dietz, Ostrom, & Stern, 2003).

Similarly, should all scholars worldwide “rationally” refuse, for example, to waste time in peer reviewing, the whole system would collapse. The scholarly environment can be viewed as a complex ecosystem that can provide the community with valuable resources, only if the antidotes listed above protect the system from critical opportunistic drifts. The studies on the *scholarly commons*, or *academic commons*, are still in their infancy (Fecher et al., 2015; Wellen, 2013), but this approach is extremely promising; in our opinion, the commons view is likely to prove crucial to the much-needed scientific understanding (McNutt, 2013) and effective governance of the evolutionary processes that are transforming the scholarly system.

This study explores this emerging issue. More specifically, this study explores how ICTs and the Internet are influencing, and being influenced by, the evolution of institutions, organizations, and workflows that play a role in the scholarly commons.

Indeed, the new digital age emerged in a phase, 1980s–1990s, in which the scholarly system was already destabilized by the exponential growth of the global scholarly community and, consequently, of both global competition and volume of published work (Nentwich, 2003). Some first, naïve predictions described a forthcoming world in which ICTs would completely change the forms and formats of scholarly communication; would cancel out the publication costs, thus making scientific data and articles available for all; and would replace the traditional gatekeeping mechanisms of the academic world with a more democratic and open universe of ideas (Acord & Harley, 2013).

The reality proved much more complex and it contradicts these simplistic predictions. Although the digital format improved access, searchability and navigation, the “classical” form of the scholarly journal is anything but obsolete, and the PDF has become the standard form of journal articles, mimicking the print format (Larivière, Haustein, & Mongeon, 2015). Scholarly publishing has become an oligopolistic market, with most journals in the hand of few commercial players that impose very high prices for both library subscriptions and “gold” open access (Beverungen et al., 2012). Publication outlets proliferate, including the so-called “predatory” journals and conferences (Bohannon, 2013; Mervis, 2013); this exponential proliferation has placed a premium on high-prestige journals, which perpetuate or even exacerbate the traditional gatekeeping mechanisms to protect their reputation and role (Harley, 2013).

This study explores this highly dynamic scenario, by concentrating on four aspects in particular: (i) the evolving business models of scientific journals; (ii) the new competitive dynamics triggered by open access and article-level metrics; (iii) the traditional and emerging forms of peer review; and (iv) the emerging ICT-enabled changes in research workflows.

Based on a literature survey and a structured analysis of 8 websites selected as representative of the emerging change processes, this study shows that the scholarly system is today a dynamic and complex environment, with emerging divergences across disciplines and geographical areas, strong conflicts and tensions, and growing preoccupations for the fragility of the scholarly commons. The analysis confirms that ICTs, far from resulting in mere technical changes, have triggered paramount economic, social and organizational transformations in the scholarly system through a complex interplay between institutions and technologies. These extremely relevant transformations have attracted many ideological debates, declarations, and manifestos, but are severely under-investigated by social sciences (Harley, 2013; McNutt, 2013), and call for a specific engagement of scholars in the fields of organization, innovation and information systems studies.

Method

This study stems from a literature survey based on two important special issues published in 2013.

The first special issue, dedicated to “Scholarly publishing and the Internet” (Jankowski & Jones, 2013) appeared in the journal *New Media and Society*.

The second special issue, entitled “*Communication in Science: Pressures and Predators*” was hosted by *Science* (Stone & Jasny, 2013).

Backward and forward search was conducted (Vom Brocke et al., 2009) based on the articles included in these special issues. The retrieved publications were selected for relevance to the research question; in addition, we decided to focus on recent publications (after 1999). This led to the identification of a basket of 47 relevant publications.

These studies mention several organizations, communities, and initiatives as particularly representative of the role of ICTs in the scholarly system’s evolving scenario. After a careful online research based on the keywords’ combinations that better fit the investigated issues (e.g. scholarly publishing evolution, scholarly publishing AND ICT, etc.), we selected the more representative eight websites that provided information on these organizations, communities, and initiatives (Table 1).

These websites were browsed, and about 250 pages were selected as relevant to this research’s purposes. These pages were downloaded and served as a basis for coding (Bryman & Bell, 2011), along with the 47 selected publications.

These contents were analyzed and coded through grounded theory techniques (Bryman & Bell, 2011). This led to the identification of four key aspects of the evolution of scholarly commons in the Internet age: (i) the evolving business models of scientific journals; (ii) open access and article-level metrics; (iii) traditional and emerging forms of peer review; and (iv) the emerging changes in research workflows. These four issues are synthesized in the following sections.

Scientific journals: the growing power of top commercial publishers

Since the 1950s, national research budgets in the United States expanded at 3–4% per year. This led to a massive increase in the rate of research output, through the specialization of academic subfields, each requiring its own journals. The recognized journals in each subfield acquired the status of “must have,” thus creating inelastic demand that enhanced the market power of the publisher (Wellen, 2013).

This situation attracted many commercial publishers, which gradually complemented and often replaced traditional non-profit publishers, such as academic presses.

Table 1
Web sites analyzed for this study.

URL	Organization/community/initiative	Reason for inclusion in this study
https://101innovations.wordpress.com/	Innovation in Scholarly Communication: Changing Research Workflow	The site presents a very recent and large survey on the adoption of ICT tools in research workflows.
https://www.force11.org/	Force 11: the Future of Research Communications and e-Scholarship	The site provides information on the activities of a global community of librarians, publishers, and researchers advocating ICT-enabled innovation in scholarly work.
https://mellon.org/programs/scholarly-communications/	The Andrew W. Mellon Foundation Programs: Scholarly Communications	The site describes the activities of an important funded program supporting digital scholarship.
https://www.elsevier.com/	Elsevier	The site provides information on the strategies, activities and financial results of a representative global commercial publisher.
http://www.jstor.org/	JSTOR	The site presents the activities of a non-profit organization that provides libraries, publishers, and individuals with web-based services facilitating scholarly work.
http://journals.plos.org/plosone/	PLOS ONE	The site presents the activities of the largest journal in the world, which publishes 85 papers per day based on an innovative web-based business model.
http://f1000research.com/	F1000 Research	The site presents the activities of a highly innovative platform, based on open peer review that takes place after publication.
https://www.altmetric.com/	Altmetrics – who's talking about your research?	The site presents the activities of a start-up company that develops advanced algorithms and software for measuring the impact of individual articles and authors.

Because of this exponential proliferation of publications, many of which distributed by for-profit publishers, there were growing financial problems for university libraries. In 1997, institutional journal subscriptions were 30 times more expensive than in 1970, amounting to an average annual price increase of 13% (Beverungen et al., 2012). The costs of buying, storing and managing printed journals became unsustainable, and the community of librarians and scholars pioneered new projects since the 1980s to promote electronic journals, in the hope that the transition to digital publishing would help address the so-called “serial pricing crisis” (Correia & Teixeira, 2005).

This transition to digital publishing was accompanied by ideological expectations. Many scholars and librarians thought that while in the past the financial investments required for traditional print, storage and distribution justified the role of commercial publishers, the digital revolution would disintermediate the process. This was expected to allow academics to take publications into their own hands, for example through a renaissance of university presses (Beverungen et al., 2012).

In the light of these expectations, what happened, in reality, may look paradoxical. In a very recent article, Larivière et al. (2015) demonstrate that since the advent of the digital era, the top five most prolific commercial publishers (Sage, Reed-Elsevier, Wiley-Blackwell, Springer, and Taylor & Francis) have *increased* their share of the published output. This concentration is due to both the foundation of new journals and the acquisition of existing ones on the part of the big players. Social sciences disciplines (including also business, organization, and management) have the highest level of concentration (about 70% of papers from the top five commercial publishers; it was about 10% in 1973). The main reason is that social sciences did not develop large scientific societies that regroup and publish various journals covering different sister disciplines. These numerous, small and de-centralized scientific societies did not have the means to adapt to the digital era; in many cases, their publishing activities have been acquired by, or outsourced to, big commercial publishers, thus contributing to their market power (Beverungen et al., 2012) and scarce price competition (McGuigan & Russell, 2008).

This concentration is specifically enabled by the digital nature of today's publishing. In fact, the contemporary publishing infrastructure provides a wide range of digitally enabled services such as indexing, retrieval, and reference management, which complement the core business of content provision. In addition, once this infrastructure is established, the marginal costs of selling further subscription, issues, or individual articles are near to zero. Therefore, the major academic publishers have developed multi-year licensing arrangements called “Big Deals.” These deals bundle together high and low impact journals into single packages that are sold in bulk form to university libraries (Beverungen et al., 2012). These strategies create significant entry barriers to independent publishers that do not belong to large groups (Stewart, Procter, Williams, & Poschen, 2012).

The big commercial publishers are fully exploiting their increased power. In the last years, their profits ranged from 30% to 40% (Beverungen et al., 2012; Larivière et al., 2015), while the subscription prices constantly grew until they became unsustainable, especially for small libraries. On the other hand, through these big deals, scholars have been accustomed to having access to an increasingly large proportion of the scientific literature, which makes it very difficult for university libraries today to negotiate out of Big Deals to optimize their collections and meet budget restrictions (Larivière et al., 2015). This situation raised public debate and indignation. As a House of Commons (UK) report from 2004 put it, “public money is used at three stages in the publishing process: to fund the research project; to pay the salaries of academics who carry out peer review for no extra payment; and to fund libraries to purchase scientific publications” (Beverungen et al., 2012). The manifestos against commercial publishers and Big Deal subscriptions were often written and disseminated by librarians. In fact, libraries are being disrupted by the very technologies they pioneered. Publishers and other global service providers such as JSTOR and EBSCO now provide much of the software, technology, research tools, and metadata worldwide, thus replacing most of the traditional functions of libraries themselves (Wellen, 2013).

On the other hand, the big commercial publishers respond to those who blame them for free-riding by claiming that also

digital publishing requests big investments in digital infrastructures, software development, and difficult, costly experimentation with users. Moreover, commercial publishers claim they must also face the risks and threats of competing with global players of cloud computing, such as Google (Hazen, 2015; Stewart et al., 2012).

Eventually, the tensions between the giants of electronic publishing and the academic world exploded with the emergence of the so-called “Academic Spring” in 2012. The Academic Spring witnessed peer-review and subscription boycotts of Elsevier after the company had supported legislative efforts in the United States to ban open access mandates (Wellen, 2013). After these boycotts, commercial publishers started to realize that some form of higher-level collaboration with the scholarly community, to build a more sustainable system, was advisable. Some pioneering publishers, such as Nature and PLOS, started dedicating efforts to propose themselves as innovation intermediaries for the common good. The role of innovation intermediaries implies that publishers should leverage their pivotal role to support the transition of the scholarly community to a more advanced exploitation of all the possibilities offered by the digital revolution (Stewart et al., 2012).

Meanwhile, the financial pressures stemming from Big Deals are being partially relieved, also thanks to library consortia (Hazen, 2015). Beyond all these controversies, some scholars think that these deals are least partly responsible for the positive change, i.e., academic researchers increased the number of articles they read by 87% between 1977 and 2005 (Wellen, 2013). “Moreover, efficiencies related to digitization are evident in the vast productivity differences between the market for journals—which are predominantly digital—and books, which are still mostly printed. In the 25 years ending in 2011, member institutions of the Association of Research Libraries (ARL) paid 402% more for 333% more journals. By comparison, the same libraries paid 90% more for only 10% more monographs [...] scalable distribution systems have supported the massive expansion in the number of small, specialized outlets for scholarship” (p. 4).

Open access, article-level metrics, data sharing and peer review

Open access academic publishing

The Academic Spring of 2012 was a symptom of a wider global movement (Friesike & Schildhauer, 2015) toward Open Access as an alternative to the subscription model in academic publishing.

The Budapest Open Access Initiative (BOAI) is usually cited as a key turning point in the Open Access movement (Correia & Teixeira, 2005). The BOAI identified two main strategies: self-archiving (often identified as “green open access”) and open access journals (often identified as “gold open access”). Both types of open access have steadily developed (Wellen, 2013), not only because the free availability of the full paper increases citation rates, but also because the governments of the leading countries as for research prestige (USA and UK) have imposed open access publication for publicly funded research. Green open access implies that authors archive the pre-print or post-print versions of their articles in freely accessible repositories such as institutional databases, Research Gate or Academia.edu; the process usually respects embargo periods that vary from publisher to publisher. Gold open access, instead, corresponds to a pay-per-publish model.

Another milestone of the Open Access movement was the Finch Report (Wellen, 2013), commissioned by the UK government and presented to the public in 2012. This report significantly contributed to the idea that open access would improve the flow of knowledge not only within, but also beyond the research community while facilitating text-mining and better research discovery

methods. Another reason cited by Open Access advocates is the need to fight artificial scarcity in the publication market. Traditional journals pursue selectivity and exclusion, by attracting more submissions from impact-hungry authors while limiting the final volume of published articles (Wellen, 2013). For these reasons, traditional journals end up being gatekeeping systems that may encourage conservatism and conformism, while discouraging innovative research that challenges disciplinary boundaries or the journal’s scope.

After the new open access policies of the USA and UK governments, even the leading commercial publishers today include open access as a core part of their strategic vision. Almost all of the major academic publishers allow authors to pay an optional Gold Open Access fee—often over \$3000—to enable free online access to articles published in their traditional journals. This situation shows that Open Access has not hindered journals from taking advantage of their role, since the average first-copy costs of journal papers are estimated to range between 20 and 40 US dollars per page, depending on rejection rates (Larivière et al., 2015).

This, of course, raised criticism, since only part of the publications are Open Access, and then the universities have to pay publishers twice: for gold open access, and for subscriptions. Some publishers have agreed to waive Open Access fees for institutions that subscribe to their journals, but the situation is highly dynamic. The strongest opponents of Gold OA, however, worry that the need to allocate publication funds may introduce rationing of funds and controversies about which scholarly contributions and disciplines should be eligible for support. Since STEM (science, technology, engineering, and medicine) fields receive much more grants and are much more time-sensitive, Open Access options are much more attractive and affordable for these disciplines than for social science and humanities (SSH). Indeed, the “SSH community is less concerned about boosting research productivity than it is about avoiding a pattern of publishing reform in which the market would dictate scholarly priorities and resources would be managed in a way that upsets the level playing field between more and less affluent disciplines” (Wellen, 2013).

Another important phenomenon is the emergence of innumerable fully, “native” Open Access journals. Many of these Gold Open Access journals have a bad reputation. Open-access profits are not linked to quality selection, but to volume. Therefore, abuse is frequent, as a Science investigation has found. In 2012, faux papers with blatant scientific flaws were experimentally submitted to 304 open-access journals: more than half accepted the paper (Bohannon, 2013). These results shed light on how ICTs and the Open Access option contribute to the phenomenon of the so-called “predatory journals”: these journals make money by exploiting the need to publish even in low-reputation outlets, especially on the part of scholars from less competitive universities and developing countries.

However, even if many fields (e.g., business and management) do not have highly ranked Open Access journals (Friesike & Schildhauer, 2015), Open Access is far from being a synonym of low quality. Of particular interest are the inter-disciplinary megajournals that have recently been launched, based on particularly innovative Open Access models. Examples include PLOS One, F1000Research, and SAGE Open (Harley, 2013). The average quality of the articles published in these megajournals, measured through the traditional indicators, is diverse. For example, PLOS One has an Impact Factor of 3.234 in 2014. F1000Research, launched in 2012, rapidly escalated to Scimago Q1 in 2014 for the category “Pharmacology, Toxicology, and Pharmaceuticals.” SAGE Open, the only megajournal dedicated to SSH, has a lower ranking; in fact it is now classified in Scimago Q4 for “Social Sciences”, but we must say that this journal published one of the most interesting and accurate

articles we found in our literature survey for this study (i.e., [Wellen, 2013](#)).

The Open Access philosophy and technologies imply and facilitate further innovations that are too recent to be evaluable. These innovations include article-level metrics, data sharing and open, post-publication peer reviewing. Further implications of the new, ICT-enabled models of scholarly communications include innovative marketing and dissemination approaches to increase articles' impact both in the scholarly community and to the larger public ([Beverungen et al., 2012](#)).

Article-level metrics and data-sharing

Article-level metrics are based on the principle "People do not read journals. People read articles" ([Rabesandratana, 2013](#)). Big data and Web 2.0 techniques offer completely new opportunities to assess the impact of the individual article, well beyond simple citations. For example, PLOS article-level metrics include citation data, social media usage, and comments in the press that serve as indicators of quality and impact. This evidence is in line with previous studies about the central role of social media in knowledge sharing and the related necessity to employ effective KPIs to measure their impact (e.g. [Alberghini, Cricelli, & Grimaldi, 2014](#)). These new metrics are expected to disentangle the reputation of articles (and authors) from the reputation of the outlets ([Wellen, 2013](#)). However, since careers are based on publication metrics, the scholarly community is extremely cautious about these innovations. The valuing, fine-tuning and institutional acceptance of article-level metrics are likely to be slow, inertial and controversial processes for years to come ([Stewart et al., 2012](#)).

Data sharing is considered very important by many Open Access activists. In the traditional printed journals, there was not enough space to publish the full data sets scholars based their analyses on. Traditional flagship journals often maintain this concision and impose precise page limits even to their electronic publications. Conversely, Open Access journals have no reason to constrain article length and encourage, or even impose, the publication of full data sets. In a growing number of cases, data sharing is mandatory for grant and public funding beneficiaries, in order to encourage transparency and greater return on investment thanks to data reuse ([Acord & Harley, 2013](#)). However, the existing institutions result in strong inertial forces against data sharing. Data sets, exhibitions, and other 'subsidiary' products, per se, are far less rewarded in tenure and promotion decisions than standard publications. Scholars are then scarcely incentivized to use their time to prepare the data and necessary metadata in standardized formats for deposit and reuse. In addition, scholars may fear that data, once made public, enable criticism for mistakes or imprecisions. Last but not least, scholars may be wishing to keep the data confidential and maintain the option to reuse them for further publications in the future, hindering others from doing the same ([Acord & Harley, 2013](#)). For these reasons, the distance between the rhetoric of open scientific data and the reality is still great, and it is quite hard to make predictions for the future.

Peer review: toward a simplified review process

One of the main reasons why scholars may prefer Open Access journals is their expectation of rapid publication. Open Access publishers soon realized that the main constrain to rapid publication is the traditional blind peer review process ([Stone & Jasny, 2013](#)). Open Access megajournals are in the position to introduce simplified review processes since these journals are interdisciplinary and do not have to evaluate the correspondence of the article's topic with the journal's scope and approach. For these reasons, these journals usually adopt simplified peer review processes. Therefore,

these journals accept articles for publication based on an accelerated peer review process, screening only for accuracy, validity, and scientific soundness rather than novelty or importance. In many cases, the paper is published first and then undergoes open (instead of blind) peer review. This model is considered highly disruptive and faces considerable inertia ([Acord & Harley, 2013](#)); several experimental activity systems have been experimented to address these problems. Perhaps the most successful and interesting model of open peer review is that developed by F1000Research. In this case, the reviewers are rewarded with discounts on later Gold Open Access submissions, whilst papers, although published immediately after submission, are indexed in PubMed only after the successful conclusion of the open review process, thus allowing clear quality filtering.

These innovations have already demonstrated to have several merits. Open access, article-level metrics and open, simplified peer review are a possible integrated solution to the forthcoming information explosion in worldwide scholarly work, due to the growing productivity of scholars from countries that have remained excluded from international publications so far ([Roberts, 1999](#)). Moreover, these ICT-enabled approaches already offer valuable solutions to scholars struggling against time pressures. Last but not least, these outlets allow scholars to publish also interesting "orphan studies," such as those including unexpected negative results, inter-disciplinary or unconventional approaches, that are usually rejected by high-prestige traditional journals ([Shafer, Shafer, Design, & Lane, 2010](#)).

Emerging changes in research workflow

The academic world is in the middle of forceful changes triggered and influenced by ICT. It is becoming growingly clear that different scholarly communities and subfields are creating and adopting different tools in different ways, to meet the specific needs and practices that they delineate collectively ([Acord & Harley, 2013](#)).

Some pioneering studies are investigating how and why different scholars adopt different ICT tools in different combinations to innovate scholarly work (for example ([Acord & Harley, 2013](#); [Harley, 2013](#); [Shehata, Ellis, & Foster, 2015](#))). Getting the whole picture is quite difficult since new tools continuously emerge and evolve through interactions with other tools. An extremely interesting survey has just been conducted by two librarians of the University of Utrecht. This survey provides a wide-range, granular assessment of which are the ICT tools that scholars use in their research workflows. The online questionnaire was filled in by 20,663 researchers worldwide between 2015 and 2016. The results, very well organized and readable, are available online (<https://101innovations.wordpress.com/>). [Table 2](#) synthesizes the survey outcomes that are more relevant to our goals.

Interestingly, the site provides also the aggregated data of the most typical combinations of tools that shape the respondents' workflows. These results confirm that technological innovations only come to fruition if stakeholders adopt and embed them in their settings and practices ([Stewart et al., 2012](#)). In general, scholars seem much more keen to adopt ICT tools enabling literature search, filtering, access, data analysis, and cloud-based collaboration on specific common projects, than ICT tools enabling to share and disseminate one's scholarship.

In addition, there are differences and divergences between disciplinary fields as for technology adoption. For example, in fields with low commercial value and/or growing lag times to publication (e.g., physics/astrophysics, economics, and quantitative social sciences), scholars are more willing to post drafts to personal websites, preprint servers, and working paper repositories (e.g., arXiv).

Table 2
The main results of the “101 Innovation” survey. Re-elaborated from the data presented at: <https://101innovations.wordpress.com/>.

Phase of the research workflow	Sub-phases (examples)	ICT tools (examples)
Preparation	Fund research, define priorities, develop collaboration, etc.	Open Science Framework, PMango, Crowdcrafting, GanttProject, etc.
Discovery	Get alerts, reference management, annotate, etc.	Google Scholar, WOS, Scopus, Mendeley, ResearchGate, etc.
Analysis	Collect data, mine data, share notebooks, elaborate data, etc.	Excel, R, SPSS, NVivo, fsQCA, myExperiment, etc.
Writing	Visualize results, process text, cite, translate, etc.	Word, GoogleDrive, LaTeX, Dropbox, Mendeley, EndNote, Zotero, etc.
Publication	Archive/share data, archive/share presentation, select target journals, etc.	ResearchGate, SherpaRomeo, SJR, SlideShare, etc.
Outreach	Valorization, dissemination, social networking, etc.	Twitter, Wikipedia, Academia.edu, Mendeley, Wordpress, etc.
Assessment	Comment publication, measure impact, researcher evaluation, etc.	Publons, WOS, JCR, Scopus, ORCID, ResearcherID, etc.

Instead, working papers are unheard of in highly competitive fields like chemistry or molecular biology that are characterized by large grant funding, commercial potential, a quick time to publication. Pre-publication is also avoided by many scholars in the humanities or qualitative social sciences, who are wary of sharing ‘unfinished’ drafts before completing their long, careful, interpretive argument (Harley, 2013).

While new digital technologies have made scholarly communication much faster, faculty also accuse the so-called “digital soup” of enabling a proliferation of annoying online junk. Scholars tend to be growingly overworked and look for more filters, not fewer, in determining what to read. Most scholars turn to the familiar filters of peer review, perceived selectivity, high-prestige flagship journals, and personal networks to filter what they pay attention to (Acord & Harley, 2013; Harley, 2013). All the researches on this topic confirm that social, organizational and institutional factors strongly influence scholars’ decisions on technology adoption (Harley, 2013).

Conclusions

The academic system today co-evolves with ICTs and is becoming growingly complex and dynamic. Since the academic system’s role and sustainability depend on the protection and development of the scholarly commons, this system is fragile to several possible threats. However, these threats and the possible solutions are quite under-investigated from a scientific point of view. This study contributes to the debate about the assessment of the impact of current changes in the scholarly system, highlighting both the opportunities and threats brought by the ICTs’ innovations to the scholarly publishing system. On one hand it underlines that, even if the development of such innovations could have benefited smaller and de-centralized players, the traditional big players are grown bigger in the last years employing a strategy of concentration in order to increase their importance in the publishing market and protect themselves against the risks of digitalization and the related increase of open access players. On the other hand, ICTs’ innovations have paved the way to opportunities that potentially may result in disruptive changes in the academic publishing field. The first opportunity addressed by our study is open access and its ambiguous application in the academic publishing field, in fact, the same concept is declined in the development of highly ranked open access megajournals, such as PLOS One, and in the practice of Golden Open Access applied by traditional big editors.

The article-level metrics is another huge changing factor enabled by ICT’s innovation, in fact tracking the paper citations, its social media diffusion and comments, permits to disentangle the reputation of the article from the reputation of the journal in which it is published, increasing the publishing opportunities in a broader range of journals, not necessarily in highly ranked ones.

This study also copes with the issue of employing digital channels to share scientific datasets and made them open access too, in particular, it highlights the more frequent issues about this point, such as researchers concerns about made them available to the public and the scarce incentives in doing that.

What emerges from our analysis suggest that also the traditional peer review process will be affected by ICTs’ innovation in particular in terms of simplification of the process and development of incentives to reviewers.

Lastly, we addressed the changes brought by ICTs’ innovations to researchers’ practices and workflows underlying, also in this case, the ambivalent role of digital innovations. On one hand they provide researchers with new and valuable tools for research activities, but on the other hand, they have encouraged the diffusion of low-quality research contents, pushing researchers to “take shelter” in traditional highly ranked journals to filter the quality of this over-abundance of academic contents.

Despite our study gives to the reader a broad vision of the issues linked to ICTs’ innovations in academic publishing, it is affected by some limitations, in particular, even if the selected web sources are relevant and representative, the sources’ number is quite limited, furthermore in-depth interviews with relevant actors, involved in the scientific publishing field, would support our study with additional empirical evidence. Besides future research should address in more depth and detail each issue, emerged from our analysis, because each of them is worthy of a specific literature review and empirical data collection and analysis.

While manifestos and ideological conflicts proliferate, there is a scarcity of scientifically sound assessments on the actual impact of the ongoing changes. As authoritatively called for by the Editor-in-Chief of Science in the 2013 Special Issue (McNutt, 2013), it is the time that scientists apply scientific thinking to assess the impacts of the different and intertwined institutional, organizational and business models that are dynamically emerging in the scholarly system.

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