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A Study of Three Alternative Open Access Publishing Models

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1 INTRODUCTION

1.1 Background

Since the 1990s, the widespread adoption of the Internet and the World Wide Web has made possible cost-efficient instant dissemination of the scholarly literature in digital format. Between 1995 and 2005, scholarly journal publishing experienced a near-complete move from the print to digital format when the HTML and PDF formats became available and widely adopted as digital document standards. Alongside this digitalisation of the scholarly journal publishing system, some publishers started to make free digital versions of their journals available in parallel with the printed version requiring a subscription (Laakso et al., 2011).

Even before the massive use of computers and the Internet, researchers from high-energy physics had started to disseminate their work through personal emails and subsequent email lists in the 1980s, which led to the establishment of the arXiv preprint database in 1992 (Ginsparg, 2009). This implies that scientists from some disciplines are actually early adopters of digital technologies to change their ways of communicating research. The rise of open access (OA) initially occurred in the late 1990s when some individual scholars founded OA journals using a bottom-up approach, making journals accessible via the Internet to readers without any charges. In 2002, the announcement of the Budapest Open Access Initiative (BOAI) became a significant milestone in the history of the OA movement, which helped to formalize the term “open access” by proposing one of the most widely used definitions of OA:

> “By “open access” to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose [...]” (BOAI, 2002).

The early development of OA, as noted by Schöpfel (2015), could be summarized as a grassroots movement, as a community-driven project. But today individual scientists’ initiatives are no longer the main driving force, instead OA growth is facilitated by the interests of other relevant stakeholders such as universities, research funders and publishers. The current movement includes top-down pressure, particularly with respect to policy interventions into OA from governments and funders as well as universities.

As the OA movement progressed, two main routes for achieving OA emerged. One is provided by the journal publishers offering OA content directly, also known as the "Gold" route. Another route is by authors self-archiving copies of their articles in web repositories outside the publisher's platforms, also called the "Green" OA route. The focus of this thesis is on gold OA. To offer gold OA, scholarly publishers have adopted different approaches. Most of the major commercial publishers have typically experimented with the gold OA model by introducing hybrid OA options for their existing subscription journals (Laakso et al., 2016). In hybrid OA authors pay an optional one-time fee to make their individual articles OA upon publication. Following the fast growth and business success of the first major OA journal publishers - the Public Library of Science (PLoS) and BioMedCentral, existing commercial publishers have also started to establish their own pure OA journals and a growing number of new publishers focusing on OA publishing specifically have also emerged. The financing of these OA journals is no longer based on subscription revenues, but on other methods of covering costs of operating the journals. While most publishers of OA journals do not ask authors for payment (Crawford 2019), article processing charges (APCs) paid by authors have in some fields become the dominant funding model for OA journals. A side-effect of this APC-based business model is that it has also spawned a great number of dubious companies, which charge for publishing, but whose journals fail to meet established ethical practices and standards of scholarly publishing. Such publishers have been termed "predatory" publishers, and have recently received a lot of negative media attention (Hern & Duncan, 2018; McLoughlin, 2018; Kolata, 2019; Kwon, 2019).

The discussion around the opportunities and threats of OA publishing has been taking place for more than 20 years, however, OA is now more widely accepted as a possible future for scholarly communications. This is being reflected in changes in researcher behaviour, publisher options, funder- and institutional policies. There is a growing trend in the proportion of articles becoming OA (Gargouri et al., 2012; Archambault et al., 2013; Piwowar et al., 2018). There has also been an increase in the number of gold OA journals. The evidence of this trend has been reported in previous studies measuring gold OA journal and publication volumes. (Björk et al., 2010; Gargouri et al., 2012; Archambault et al., 2013; Chen, 2014; Laakso & Björk, 2016; Björk, 2017; Crawford, 2019). However, in particular studies estimating the share of "Gold OA", have usually been based on journal lists from the Web of Science (WoS) and Scopus ,which tend to have weak coverage of OA journals not published in English (Mongeon & Paul-Hus, 2016).

Getting comprehensive data on OA publishing has been a persistent challenge since the concept was introduced, the situation has been improving but there are still many trade-offs to consider when designing studies on OA publishing. Although the Directory of Open Access Journals (DOAJ) is considered a more comprehensive list of OA journals compared to the OA journals included in WoS and Scopus, the index has recently tightened inclusion criteria. Hence there are many OA journals not included in the DOAJ, either because they don't meet the criteria or because the publishers have not bothered to apply or are even unaware of the index. "Gold OA" is often assumed to be synonymous with the APC business model, however, in 2018, data from the DOAJ indicates that approximately 70% of its indexed 12, 180 OA journals are free to publish in, which implies that the APC model seems not to play as dominating a role as it has been thought to be in terms of the number of journals. The more common model used by the majority of OA journals is in fact based on other funding from a range of different sources. Nonetheless, when further looking at the number of published OA articles, it was found that APC-based OA journals contributed the highest share of about 60% in 2018 (Crawford, 2019). In light of this, APC remains a mainstream model used by major publishers of OA journals.

Of these non-fee journals, many have smaller publication volumes and are regional by nature (Tennant et al., 2019). A large number of journals have converted from the traditional subscription model, especially those published by universities and scholarly societies. In addition to them, early independent scholar-led OA journals, also referred to as 'indie' journals in this thesis, are one of the groups operating primarily on a volunteer basis and have shown differing evolutionary paths across time. OA journals publishing in languages other than English are another important group of journals, which are usually free for the authors to publish in and stand out for their unique mission of serving the local academics. 'Predatory' OA journals are a peculiar phenomenon facilitated by the APC model. They generate profits for the publisher and publish articles generally without rigorous peer review practices and proper editorial oversight (Cukier et al., 2020). So far, little is known about the overall status of these groups of OA journals, hence, understanding them offers a varied perspective on the landscape of gold OA and contributes towards building a more holistic picture of the development of OA.

1.2 Purpose of the thesis

The purpose of this thesis is to examine the situation of gold OA journals that have implemented three different operating models. The main aim is to provide a fuller

understanding of gold OA by focusing on such OA journals and analysing their historical development, current status and future avenues on the basis of article, journal, and publisher level empirical data as communicated in the following three research questions:

RQ (1): How sustainable has the 'indie' journal model been for journals which adopted the model early?

RQ (2): To what extent has the 'predatory' OA publishing market developed between the years 2010 and 2014 in terms of journal and article volumes, distribution over scientific disciplines, country of publishers and authors, APC levels as well as publishing speeds?

RQ (3): What are the key characteristics of Chinese-language OA journals, what are their publishers' major motivations in becoming OA, what are the perceived challenges in their operations and what are their attitudes towards internationalization?

The thesis is composed of three articles, each of which focuses on studying a specific group of OA journals to answer research questions specific to that group. Taken together the separate studies contribute towards the main goal of this thesis. The three articles are presented in chronological order primarily by the time period for which data was collected, rather than in the order they were carried out. The following describes the research purposes of each article and their individual contributions towards the overall aim of the thesis.

Article 1: Björk, B.-C., **Shen, C.**, & Laakso, M. (2016). A longitudinal study of independent scholar-published open access journals. *PeerJ*, *4*, e1990. doi: 10.7717/peerj.1990

The purpose of the first study was to take a quantitative measurement of OA journals founded by independent scholars prior to 2002, referred to in the study as 'indie' OA journals, and further carry out a qualitative case study to explore how such journals can ensure long-term sustainability in their operations. The past empirical evidence concerning the development of these 'indie' journals is scarce in formal OA studies. This study involved first aggregating a master list of such journals, and collecting further longitudinal data from their websites. This bibliometric analysis focuses on the situation of publishers of 'indie' journals in terms of their active journal and publication volumes from the year 1995 to 2014, the distribution of subject fields, and the age distribution for

ceased journals. Moreover, the study presents five cases that provide insights into various sustainability aspects relevant for 'indie' OA journals.

Article 2: Shen, C., & Björk, B.-C. (2015). 'Predatory' open access: a longitudinal study of article volumes and market characteristics. *BMC Medicine*, *13*(230), 1-15. doi: 10.1186/s12916-015-0469-2

The purpose of the second study was to measure the longitudinal development of alleged 'predatory' OA publishers in terms of journal and publication volumes between the year 2010 and 2014. At the time of the study news about this phenomenon were dominated by reporting of warning examples, Beall's list and experiments with fake papers, and robust empirical research had not yet been reported. In addition to the measurement for the number of 'predatory' journals and articles, the article also explores other key factors such as distributions of articles across different scientific disciplines, country of publishers and authors, APC levels and publishing speed.

Article 3: Shen, C. (2017). Open access scholarly journal publishing in Chinese. *Publications*, *5*(4), 1-17. doi: 10.3390/publications504002

The purpose of the third study was to explore the characteristics of non-English language OA journals, specifically focusing on Chinese-language OA journals as an example. Previous OA measurement studies have largely adopted the major bibliographic databases such as Web of Science and Scopus as their data sources, which emphasize scholarly journal published in English in their coverage, therefore little is known about the situation of non-English language OA journals. This article takes the Chinese-language OA journals as an example to provide an insight into the development of such journals for their numbers, distributions of type of publishers, subject fields and journal ages, key motivation to become OA, and major barriers in their operations. Of particular note is that the Chinese-language OA publishing has certain national characteristics considering economic status and policy orientation of scholarly publishing, however, by understanding its situation it is possible to offer a unique perspective on OA publishing for non-English language journals.

Figure 1 presents a visual summary of the research purpose of each article and how they are placed together to reach the ultimate objective of enhancing a more comprehensive understanding of gold OA.

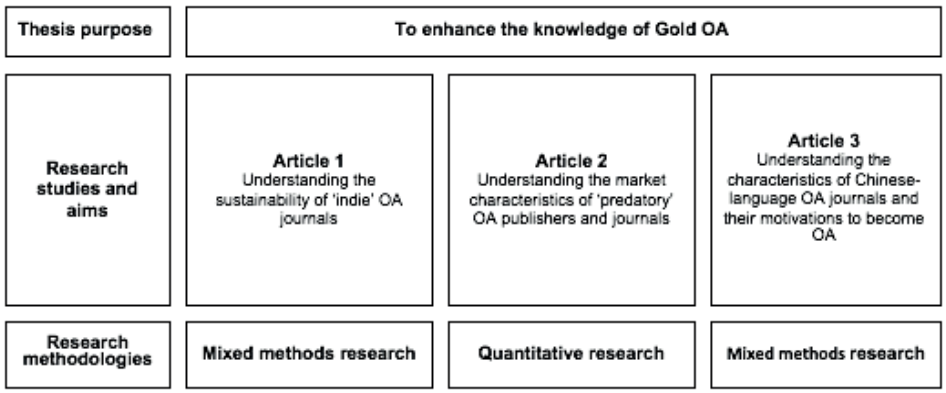

Figure 1 **Research aims and methodologies of the three included articles**

1.3 Structure of the thesis

This thesis consists of seven chapters. Following this introductory chapter, chapter two looks into the broader context of scholarly journal publishing by reviewing its history, key stakeholders, business models, the present situation in terms of the number of publishers, journals and articles, languages of scholarly publishing and some of the major challenges being faced. Chapter three summarises important aspects of OA publishing that includes definition, primary approaches towards reaching OA, and the current global share of OA. Chapter four describes the enablers of OA from technological, financial, policy and philosophical perspectives. The chapter also reviews a variety of business models relevant to OA as well as discusses the scientific quality in the context of OA journals, emphasizing the problem of 'predatory' publishing. Chapter five presents the research philosophies that underpin the three included articles and the methodological approaches adopted in this thesis, describing each study design and comparing the data collection and data analysis methods used. Chapter six provides summaries of the three articles included in this thesis. Finally, chapter seven discusses the main findings of this thesis, its contributions to both research and practice, and its limitations.

2 SCHOLARLY JOURNAL PUBLISHING

2.1 Introduction

Scholarly journal publishing is part of the broader and more general context of scholarly communication. This section describes the system of scholarly communication and particularly focuses on introducing scholarly journals and the different roles they play in scholarly communication.

Over the centuries, scholarly communication has evolved from a principally print-based system to an electronic and web-based one enabled by the emergence of the computer, Internet and the World Wide Web. Scholarly communication is commonly equated with the practice of scholarly publishing, namely the publication of scholarly articles in journals or similar formats (e.g., Sosteric, 1998; Odlyzko, 1999; Graham, 2000; Rowland et al., 2004). In fact, it is far beyond this narrow set of activities and encompasses a wide variety of informal and formal communication channels that scholars in all fields use to disseminate information, such as face-to-face discussions, conferences, letters or personal communication (Borgman, 1990). Recently social media (Twitter, Facebook, ResearchGate etc.) have become an important channel.

Within this broader system of scholarly communication, scholarly journal publishing has remained as the primary means of disseminating research results between academics across the globe. The history of journals can be traced back to the seventeenth century with the publication of the first French scholarly journal, *Journal des Scavans* in 1665, which was followed by the English journal *Philosophical Transactions of the Royal Society* founded by Henry Oldenburg (Osburn, 1984).

Relative to other means of communications, the scholarly journal article has several advantages. For example, its publication has a much shorter publication process and lower printing costs than the publication of the scientific book. Scholarly journals are also more accessible since they are more likely to be obtained via the library subscriptions systematically and consistently, while access to books is commonly a purchase choice for individual academic researchers or their departments (Ware & Mabe, 2015). In addition to this, the important status of scholarly journals is also due to the development of research evaluation based on journal-level metrics such as Journal Impact Factors. A researcher's reputation, further research funding and career advancement opportunities depend on the quality of the journals in which his articles are published. The importance of journals has been further consolidated by the evolution

of the peer review system which has become an increasingly mainstream and important process of quality control (Ferreira et al., 2016). Because of these advantages, the peer reviewed scholarly journal is an established and preferred form of communication in science.

The development of scholarly journals should respond to the changing needs of the scientific community across time. For scientists, the need for information is always an integral part of their scientific work. They want to get access to the latest high quality scientific results as a foundation for their own research. In this context, quality control and accessibility are key factors. From an author perspective equally important needs are to establish the ownership of research results and spread these results to the widest possible group of scientific peers, which enables the authors to obtain recognition, reputation and future funding possibilities. Modern scientists are also often faced by information overload enabled by various technological developments. Today's flood of information has led to an increased need for scientists to overcome their time constraints and have an effective control of what the most important and interesting research results within their disciplinary areas are. Therefore, in order to understand how scholarly journals have addressed these needs it is useful to look at the roles they are playing in serving them. Roosendaal and Geurts (1997) have identified four core functions of scholarly journals: registration, certification, awareness and archiving.

Registration

The journal is a channel for registering scientific discovery, by recording the time when manuscripts gets submitted and published, so that the authors can be credited publicly for their new discoveries.

Certification

The certification, also referred to as peer review, is seen as a core function of journals. When authors submit their research work to the journal, the journal editors send the manuscript to external experts in the same specialities who examine the quality in terms of its rigour, validity and significance. Recently changes to the peer review system have also been proposed in attempts to decouple peer review from journal publishing. For instance in post-publication peer review the review occurs after initial publication and some manuscripts are promoted to status of fully peer reviewed.

Awareness

The journals replaced letter communication among scientists to become a method that is practical and efficient in disseminating the findings of scientific research and making them available to the broadest audience possible.

Archival

For scientists, to publish an article in a scholarly journal is a means of archiving their scientific work permanently. This is achieved by journal publishers who find a long term preservation solution either in their own systems or through third-party organisations such as national libraries. University archives and disciplinary repositories also allow scientists to access the past issues of published contents for future reference and citation.

Until now, these four have been the central functions of a scholarly journal, but an additional function has become increasingly important. Filtration helps managing limited reading time in the face of the information explosion posed by the continuous growth in the number of scholarly journals and research outputs (Johnson et al., 2018). Journals commonly specialize in a particular discipline and report up-to-date scientific progress to a particular community of researchers in that area. The importance of research work published in journals is determined by the reputations of journals, often, the impact factor is used as an indicator to rate journals. This hierarchy makes it possible for researchers to keep up with the research of highest potential relevance to their own work.

2.2 Key stakeholders

Key stakeholders in the journal article publishing process include researchers, publishers, journal editors, university libraries, abstracting & indexing services, the general public and scientific funding institutions. This section attempts to describe the key stakeholders and the roles that they play in the context of scholarly publishing.

Researchers

Researchers affiliated with universities and research institutes are the main creators of scholarly content. They distribute such information in many ways, informally communicating with their colleagues, giving presentations at conferences and so on, but among these different modes of communication, publishing articles in peer-reviewed journals are especially preferred, partly because of the prevailing culture of “publish or

perish" in academia. Researchers are typically also the primary end-users of journal contents, and use articles they read as an input to the creation of more knowledge and research findings. Researchers also play important roles as journal editors and peer reviewers.

Publishers

A scholarly publisher is a publishing house specializing in scholarly books or journals or both. The size of scholarly publishers can vary from one journal to a couple of thousand. Most scholarly publishers were initially learned societies which operate on a non-profit basis and set up scholarly journals to reflect their members' wide interests. Later on commercial academic publishers emerged and gradually took over a large share of the publishing market. Scholarly publishing has become a highly profitable business. The five largest publishers are all commercial publishing houses, which have high profit margins, for example, 36 percent made by Elsevier in 2010 (Buranyi, 2017). Apart from these two publisher categories, Solomon (2013) in his study also mentions four other types of publishers including university publishers, independent scholar-led publishers, government agency publishers and publishers affiliated to other organisations.

Journal editors and editorial boards

Journal editors play a critical role in the scholarly communication process. They are commonly highly regarded university scholars specialized and experienced in the field of the journal, and appointed by the publisher. One of the major responsibilities of the journal editors is to monitor and ensure the quality of the received manuscripts through a proper peer review process and make the final decisions concerning the acceptance of manuscripts for publication. Editorial board members are chosen by the journal editors for their expertise in the field. One of the roles of an editorial board is to work together with the journal editors in the development of the journal. In recent years there have been cases of pressure from editorial boards towards the journal publishers to convert journals to OA (Laakso et al., 2016). An illustrative example from the Information Science field was the collective resignation of the editorial board of the Journal of Informetrics (JOI) as a protest against Elsevier's refusal to participate in the Initiative for Open Citations (I4OC) (Waltman et al., 2020).

University libraries

The main tasks of university libraries is to facilitate the acquisition, organization and distribution of scientific information for their researchers and students. Traditionally, libraries purchase or subscribe to a wide range of contents such as textbooks and journals, archive printed copies and add them to the existing physical collections. Following the move to electronic publishing today's libraries focus more on acquiring, collecting and delivering electronic information by means of various licenses for online access to the publisher's journal portfolios, reference tools, e-books and so on, while maintaining limited print-based resources and services.

Abstracting & indexing (A&I) services

Abstracting & indexing services are sometimes in the academic setting referred to as "secondary" publishers. They provide tools for researchers to rapidly locate pertinent and relevant information in sources such as books, journals and so on through indexes and abstracts and thus help researchers to manage the information overload. There are two types of A&I services: general and specialized. General A&I services such as Google Scholar, WoS and Scopus cover all sciences, while specialized ones focus on a specific topic or just one discipline, for example, PubMed and ChemAbstracts in the fields of medicine and chemistry, respectively. In addition to those A&I services which operate on a commercial basis, libraries also provide similar functions to facilitate information retrieval for their library users.

The general public

Outside academia, the general public is also a potential group who might be interested in reading journal articles. Unlike academic researchers who usually have access to literature bought by their institutions lay persons quite often lack affordable access, although they also provide funds to support the research in the universities through tax payments. Such access barriers have therefore turned out to be one of the driving forces behind OA publishing that aims to make science freely accessible to anyone.

Scientific funding institutions

Publishing scholarly journals takes time and resources. Scientific funding institutions are such organisations that indirectly support scholarly publishing by funding individual researchers or research projects through grants, salaries and other forms of funding. In

addition to governments which in different forms directly fund universities and research institutions there are public and private organisations which provide research grants, examples include the National Institute of Health (NIH) in USA and the private charity Wellcome Trust in the UK. Many of these have become vocal supporters of OA, since they see it as important that the research they fund gets the widest possible dissemination and hence impact.

2.3 Business models

This section focuses on introducing different traditional business models for subscription-based scholarly journals. Other new types of business models enabled by digitalization and the rise of OA will be presented in the Section 4.5.

The single journal subscription model

In this model, either individuals or institutions pay subscription charges periodically to the journal in order to have access to its published contents. Before the Internet the subscriber received a copy of each printed paper issue by mail. Nowadays the access can also be print & electronic combined or electronic only. Publishers, in particular society ones, tend to offer much lower personal subscription prices than institutional ones (King & Albertorio, 2008).

Licensing and Big deals

Licensing electronic access to large bundles of journals has gained increasing prevalence since the late 1990s. The leading publishers sell such "big deals" to university libraries, library consortia and even national consortia. The benefit for subscribers is obtained from the heavily discounted price of a bundled package compared to the sum of subscribing to all the same individual journal titles. Hence they can offer access for their researchers and students to a much larger number of journals than previously. The drawback is that these bundled packages (Science Direct, Springer Link etc.) consume a larger portion of the limited library acquisition budgets thus reducing their flexibility to subscribe to journals from other publishers. Publishers also perceive that with such arrangements their previously less subscribed titles could be given more exposure, thus possibly increasing the amount of usage. And in particular in dealing with consortia and multi-year contracts they can negotiate individual deals based on the customers' ability to pay, rather than use list prices for big deals. The big deals, which can also include access to past years' archives, also puts subscribing libraries in a strong lock-in situation.

Pay per view (PPV)

In pay per view (PPV) end-users request an individual article from a publisher and after completing an online payment process the original article can be downloaded immediately. The PPV model has not yet established itself as a mainstream model for most institutions due to its cost unpredictability and high pricing levels set for individual articles. A particular problem is that while the big electronic licenses to thousands of titles are usually paid from the general university library budgets, the costs of PPV (including the administrative work) usually fall on departments or even research projects of the academics who request the articles.

2.4 Publishers, journals and article numbers

Number of Journals

Estimates of the global number of scholarly publishers and journals can be obtained using existing bibliographic databases. A search in Ulrichsweb (Ulrich's Web Directory, the most comprehensive serials index) was conducted using the search criteria academic/scholarly, refereed/peer-reviewed, active and primary edition. As of November 2019, a total of 46,813 English and non-English-language journal titles were found. The number of peer reviewed journals that are published annually has seen a steady growth by an average of about 3.5% over the past three centuries (Johnson et al., 2018).

Number of Publishers

Counting the total number of publishers in Ulrichsweb is much more complicated. Based on the same search criteria, a total of 100 publishers with multiple journals can be found publishing 39,285 journals. Every publisher has a large portfolio of journals ranging from 79 to 3101. The remaining 7,528 journals are likely journals published by organisations (for instance scholarly societies, university departments) which publish only a single journal each. In this case, a total of 7,628 publishers could be identified. However, it warrants mentioning that Ulrichsweb is likely to underrepresent the population of publishers with a relatively smaller number of journals, as data has indicated. Another figure based on Crossref data reported there were about 10,000 academic publishers in the world (Johnson et al., 2018).

Publishers differ vastly in size, commercial/non-profit status, geographic location and economic situation. A study conducted by Morris (2007) analysed Ulrichsweb data from

2007 and noticed that only 2% of publishers publish more than 100 journals, while the majority of other publishers (80.5%) publish less than 10 journals. Among 23,277 journals, more than 50% were non-profit or associated with non-profit organisations, based on searching for the any of the words 'society' 'association', 'institute' or 'institution' and 'university' in English and other languages in the publisher field. In further examining the journals from the five largest publishers representing nearly 25% of the total journals, only less than 14% are commercially published society journals, which imply that small publishers are largely non-profits or in association with such organisations. The top five major English-language publishers (Springer, Elsevier, Taylor & Francis, Wiley-Blackwell, Sage) dominate the scientific publishing market in terms of numbers of journal titles (Johnson et al., 2018). Larivière et al. (2015) demonstrated that the above five major publishers contributed more than 50% of all WoS indexed papers in 2013. Their consolidation of the market has also helped sustain their high profit margins. From a geographic perspective, over half of the journals are published by publishers based in the USA and the UK.

Articles

Ulrichsweb does not directly index individual journal articles, in contrast to Scopus and WoS. The most recent per-year estimate is from Johnson et al. (2018) which suggest that as of August 2018 there were about 3 million articles published a year by 33,100 active scholarly peer-reviewed English-language journals indexed in Ulrichsweb. Lower bounds for the number of articles published per year can instead be found using the WoS and Scopus indexes. Scopus, which indexes more journals than WoS, shows 2,508,632 articles in 2018.

Johnson et al. (2018) found 73 million journal articles over all years out of 97 million DOIs published from about 60,000 journals based on the CrossRef database. Another study by Khabsa et al. (2014) analysed the documents from Google Scholar and Microsoft Academic Search and estimated that at least 114 million English-language scholarly documents were accessible on the web. These also include conference papers, dissertations and master theses, books, technical reports and working papers. Historically, the growth rate of the number of scholarly publications (all document types) has been approximately 3% annually from 1980 to 2012 (Bornmann et al., 2015).

2.5 Languages of scholarly publishing

In the past decades, English has become established as the global language of scholarly publishing (Research trends, 2008). The vast majority of journals indexed in the leading bibliographic databases such as Scopus and WoS are published in English. The situation becomes even further exacerbated when today's widespread research assessment exercises evaluate the performance of researchers based on the journals that they publish in and often require that the journals are included in these international indexes. Hence researchers are under pressure to publish their work in English, further contributing to a rapid growth and development of English-language scholarly journals. While English has become the established language for international scholarly communication, researchers still publish in other languages than English. Historically, many journals from the social sciences, and the arts and humanities are published in languages other than English largely because researchers from these fields traditionally deal with local topics and publishing their results in native languages is important for other local scholars to read and use.

It is also true that in non-English speaking countries such as China, scholarly journals publishing in local languages remain in the majority while most are less visible from the rest of the world for instance due to non-inclusion in the indexes as well as in the bigger electronic journal licenses that major publishers offer (Johnson et al., 2018). This situation triggers the need to understand the situation of scholarly journals published in other languages aside from English, particularly in relation to these new changes to scholarly communication. As of November 2019, 10,854 out of 46,813 (23.2%) Ulrichsweb indexed active peer reviewed scholarly journals were publishing their articles in languages other than English. However, in general, most of the bibliographic databases, even UlrichsWeb, Scopus and WoS have more extensive coverage of English-language journals than other languages so that non-English-language journals are largely underrepresented (Mongeon & Paul-Hus, 2016). So far there is a lack of comprehensive studies that provide an overall estimate of the size of this problem, however, some studies report on country-specific situations from a variety of sources and measure the total number of journals published in the languages of the countries in question.

For example, Shin (2012) studied 1,437 journals listed by the National Research Foundation of Korea (NRF) and found almost all published in Korean. Of 7,248 journals published in France, Greece, Italy, Spain and Turkey (source Ulrichsweb), more than

75% were published in other languages than English (Anglada & Abadal, 2010). In a study of 437 Nordic OA journals the share published in the local languages varied across disciplines (Björk, 2019). The natural science and medical journals published mainly in English, while journals from other subject areas published either in the local languages or both. Ilva (2018) looked at scholarly publishing in Finland and found that there are currently over 100 domestic peer-reviewed scholarly journals, most of which are small and published in the Finnish and Swedish languages.

2.6 The scholarly publishing crisis

Since the 1980s, the subscription prices of scholarly journals have dramatically increased, much faster than the rise in the Consumer Price Index and the inflation rate (McGuigan, 2004; king & Alvarado-Albertorio, 2008; Weingart & Taubert, 2017). Nevertheless, the overall growth in library expenditure of the universities is slower over the same period (Johnson et al., 2018). These price increases and the pressure on library budgets to gain access to the needed materials has made libraries coin the term "serials crisis". OA publishing has been proposed as one solution to this problem, based on a belief that OA publishing would lower publisher's costs. The real costs of scholarly publishing are, however, difficult to estimate. Several reports have indicated that the costs of publishing vary widely across journals from hundreds of dollars per paper to more than ten thousand dollars. For example, the editor-in-chief of Nature gives his estimates of publishing a paper in Nature at $30,000–40,000 in 2013, while a paper published by Ubiquity Press only costs an average of $300 (Noorden, 2013). The variance in per-paper prices is on the one hand affected by the profit margins of different publishers, on the other, the rejection rate and power relation between publishers and academic libraries (Morris, 2005; Noorden, 2013; Larivière et al., 2015).

A study found that the five biggest commercial publishers accounted for more than half of today's journal papers: Elsevier, Taylor & Francis, Wiley-Blackwell, Springer and Sage (Larivière, et al., 2015). In 2013 the Science, Technology & Medicine division of Elsevier reaped a high profit margin of nearly 40%. The situation has raised an increasing concern among the scientific community over the oligopolistic and dysfunctional structures of the scholarly publishing industry and if this publishing model serves the interests of researchers and universities. Buranyi (2017) commented in The Guardian that "It is an industry like no other, with profit margins to rival Google". Macdonald (2015) in another report from Sciencealert questioned the established business models of these large commercial publishers and noted; "it is based on taking advantage of scientists to create

content for them for free, and then selling it to back to them once it's published" and "publishers don't even pay for quality control - which is done by other scientists for free in the form of peer review". Therefore, a central question many scientists occasionally ask is why these publishers charge large fees for access and what is the value that they add to the published paper and to the entire research community, especially when their publishing and dissemination costs are likely much reduced since the arrival of the Internet and the development of IT.

The publishers of expensive journals attribute their high prices to the selectivity, reflected in the number of articles that they reject. A high-prestige journal is unique and scarce, and there is no substitute. Researchers desire to publish in these journals due to the prestige that follows, which bring them further funding and career advancement opportunities based on requirements in the current research evaluation system. For example, Chinese universities constantly emphasize the importance of researchers publishing in journals indexed in SCI (Science Citation Index) which include typically the most consistently high impact journal titles in many scientific disciplines (Clarivate Analytics, 2019). Because of the prestige, the publishers of these journals have absolute bargaining power on the prices that they want to charge to their buyers, which basically are university libraries. Generally, these publishers sell more journals than libraries specifically need, bundled with their less attractive titles at an undisclosed price. Such big multi-journal licenses consume a large amount of library budgets and make it difficult for them to purchase other needed resources. Over the past years, researchers and universities have complained about the situation and begun to protest against the monopolized large publishing houses (Howard, 2010; Globe, 2012; Sample, 2012). But unfortunately, most of the papers published by high-impact journals are still locked behind paywalls and controlled by just a few powerful commercial publishers.

2.7 Summary

Recent years have seen dramatic changes in how the results of scholarly studies are published and disseminated. While new publishing venues emerge, a large share of scholarly communication continues to be journal article based, particularly in the area of Science, Technology and Medicine (STM). With the advancement of technology, the traditional paper-based publishing world has entered a new era of digital scholarly publishing, where most of the journals provide web access to their readers. However, some aspects of the old paper-based model remain the same (Saarti & Tuominen, 2017). The traditional model of peer review still plays a major role in controlling the quality of

the published research and journal-level bibliometric methods such as journal impact factors are still widely adopted.

Moreover, technology has not completely transformed the scholarly publishing industry. Libraries still struggle with the escalating subscription costs charged by the publishers. Even though publisher competition is likely to be intensified by more new arrivals, the current state is that several large commercial publishers still have an oligopolistic position in scholarly publishing (Larivière et al., 2015). An ideal state of science communication, as Saarti and Tuominen (2017) stated, should "aim at complete OA to subject all research to the systematic critique of the whole scientific community". But the development of OA has not progressed as rapidly as predicted. In practice, most scientific information is still published behind a paywall.

3 OPEN ACCESS

3.1 Introduction

The first articulated public definition of open access (OA) can be traced back to the Budapest Open Access Initiative (BOAI) in 2002.

"By 'open access' to this literature (peer-reviewed research and unreviewed preprints), we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited." (BOAI, 2002)

A year later, the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities (2003) and the Bethesda Statement on Open Access Publishing (2003) announced their definitions of OA successively. As the definitions used in these three statements are very similar, they have collectively been referred to as the BBB definition. Compared with a long version of definition from the BBB, Peter Suber (2012) proposed a much shorter version but which shared the essence of two most important OA components: "the removal of price barriers" and "the removal of permission barriers". In his definition,

"open access literature is digital, online, free of charge, and free of most copyright and licensing restrictions".

OA started as a grassroots movement, as a community-driven project (Schöpfel, 2015). It was initially driven by scientists who started using Internet technology to share their work more rapidly and for free in the late 80s and early 1990s, not by professional publishers. OA in fact started in the same sort of environment as the Open Source programming movement. Several journals were launched by the scholarly community using a bottom-up approach and were made accessible via the Internet to the readers without any charges. But today individual scientists are no longer the main driving force, instead OA is developed more due to demand from other relevant stakeholders like universities, research funders and publishers.

3.2 Primary approaches to OA

There are several different approaches to make scholarly articles freely accessible online to the readers. Johnson et al. (2018) considered the different approaches to OA in terms of what is made open, when it is made open and where it is made open. “What is made open” refers to the version of the manuscripts or the article itself that is going to be made OA. “When it is made open” concerns the timing when the content can be available to the public. This section focuses on the different locations “where” articles can be made open. Publishers’ journal platforms and repositories are two primary web locations to publish and deposit open content, but certainly other options do exist like personal websites, email lists, blogs and so on. In 2002, the BOAI initiative first proposed two main strategies for OA publishing: OA journals and self-archiving. Ten years later, the same group of scientists met again and renewed their terminology given that changes had occurred to the OA world in the past decade. Thus a distinction was made between OA through journals (also called the “Gold OA”) and OA through repositories (also called “Green OA”) (BOAI, 2012).

3.3 Gold OA

OA delivered directly by the journal publisher is called “Gold OA”, sometimes also referred to as “publisher-provided OA”. However, the terminology of “Gold OA” has been used in different ways in various OA studies. For example, Laakso et al. (2011) divided gold OA into three major categories: Direct OA, Delayed OA and Hybrid OA based on the scale of journal content availability to measure the development of OA journals. However, some might argue that these three subtypes of gold OA were not mutually exclusive and they actually relate to each other when it comes to the aspects such as the economic models they employed. As was also pointed out by Piwowar et al. (2018), it remained a challenge to have an authoritative definition of OA as the term itself was “somewhat fluid”, not to mention the classification of OA, which has led to a wide variety of different definition of OA subtypes. However, it is worth mentioning that gold OA is not synonymous with the APC-based business model. Gold OA journals often do not require payment. In this thesis, “Gold OA” refers to journals where all articles are made freely available online for readers without any delay (e.g. *BMC Medicine*, *PeerJ*, *PLoS One*) based on the definition from a more recent OA study (Piwowar et al., 2018). It is clear that all of the three studies included in this thesis concerned scholarly journals that make all their articles OA immediately upon their publication, which without question falls with the category of gold OA.

As of November 2019, there are a total of 13,930 such journals listed in the Directory of Open Access Journals (DOAJ), the major index for this type of OA journals. Over the past decade, several studies have reported the longitudinal development of gold OA journals and their published OA articles (Laakso et al., 2011; Laakso & Björk, 2012; Piwowar et al., 2018), however it should be noted that the classification of gold OA may be different across these studies.

Moreover, Crawford (2018) provided a more in-depth analysis on the situation of gold OA publishing market from the year 2013 to 2018 based on data from the DOAJ. During this period the number of journals increased from 7,609 to 9,217, and the number of articles from 373,039 to 619,469. Further analysing the journal and article level data in 2018, the study found that 51 % of the journals are from university and college publishers, followed by such OA publishers (20.4%), which publish only OA journals. The segment of OA journals that charge authors for publishing (so-called APCs) has grown faster and become more common (Laakso & Björk, 2012). However, according to Crawford's study, 69 % of OA journals, particularly journals published by universities, do not charge APCs. A small group of large publishers, including Elsevier, Springer, BioMed Central and Public Library of Science (PLoS) account for 43 % of all OA articles, and are estimated to obtain 84 % of potential APC revenues.

The development of digital technologies has resulted in dramatic shifts in how scholarly publishing is financed. A number of new types of business models have been proposed to support the OA distribution of scholarly journals. It is important to remember that there is a broad range of publisher types that include independent scholar-led publishers, society publishers of all sizes with single or multiple journal titles, commercial and non-profit publishers. No single model can actually work for all players but they co-exist and are used in different ways by different types of the publishers. The following is a brief introduction to different OA business models. More elaboration will be made in Section 4.5.

Author-pays model

The author-pays model is the most commonly used by OA publishers. It works like this: the authors use grants, institutional or personal funds to pay a publication fee after the manuscripts are accepted. Page charges have also historically been used by subscription journals to supplement subscription income, in particular by society journals (Tenopir & King, 2000).

Subsidised OA model

Not all of OA publishers charge a fee. Some publishers finance themselves by endowments, grants or institutional/governmental funding. This is particularly common among university and society publishers. Many independent scholar-led publishers operate on a community/voluntary basis.

There are a number of subtypes of OA discussed in the OA literature. The following lists some of them.

Delayed OA refers to a category of journals in which the most recent articles are only accessible to paying subscribers, but after an embargo period articles are made free for online reading to all (e.g. *Government Information Quarterly*, *Global Economics and Management Review*). A study identified 492 delayed OA journals publishing a total of 111,312 articles in 2011 (Laakso & Björk, 2013). In 78 % of the journals articles were made OA within 12 months and in 85 % within 24 months from publication.

Hybrid OA is when the author can pay an optional fee to make an individual article OA immediately on publication in a subscription-based journal (e.g. *Electronic Markets, Frontiers of Computer Science*). In recent years many major publishers have offered this OA option for the majority of their journals. Björk (2017) estimated that the total volume of hybrid OA journals grew significantly from about 2,000 in 2009 to almost 10,000 in 2016, publishing a total of 45,000 OA articles.

Bronze OA is a newly proposed category describing a group of OA articles that are available to read on the publisher's website either immediately or after an embargo but without a clear and formal license information. Piwowar et al. (2018) found that among a sample of 100,000 articles from the CrossRef database, bronze OA accounted for the largest share of OA articles, the results of which call for more future research to study this particular subtype of OA.

In addition to the gold and hybrid OA categories, free access to articles are by many publishers offered for a limited period after publication for promotional purpose, after which they restrict the access to only paying subscribers. Other journals make their primary research articles freely available, but require a subscription when an author wants to access their value-added contents such as editorials and review articles. As there is currently no comprehensive index of such types of OA journals, they have been

overlooked in most previous OA studies. Quite possibly such articles make up a sizeable proportion of the bronze OA category.

3.4 Green OA

While OA journals remain the primary channel among researchers for increasing the availability of their articles, researchers today have the possibility to independently disseminate certain versions of their manuscripts on other web-based services. These include institutional repositories (IRs), subject repositories (SRs) such as arXiv and PubMed Central, and academic social networking sites (ASNs) such as ResearchGate and Academia. edu.

According to the terminology of the Sherpa/RoMEO database (Kieńć, 2015), a "green" scholarly journal represents a journal which publishes pay-walled articles while allowing authors to archive manuscript (in some cases even the publisher's) versions of their articles in OA repositories (SHERPA, n.d.). According to the categorization from Björk et al. (2014)'s study, there are two distinct versions of green OA copies: Preprint and Postprint. Preprint is a term used to define a version of manuscript that is either a working paper or a manuscript submitted to the journal but before peer review. Postprint means the manuscript that is accepted by the journal after peer review but without the copyediting and layout. In addition, it also sometimes refers to the final published journal article (which sometimes is called the Version-of-record). Due to this confusing use of terminology (for instance in the agreements with authors) the term personal version is currently commonly used instead of postprint. Most journal publishers usually restrict the authors right to self-archive to either preprints or more commonly personal versions, and they usually require embargo periods before allowing that.

In a nutshell, the term "Green OA" refers to indirect free access to an article or an earlier version of the manuscript that is available on any location outside of the publisher's journal platform on the Internet (Harnad et al., 2004). In the early days of the Internet, an author's personal webpage or the website of their department was more often used to archive green OA copies. After the wide-spread emergence of curated OA repositories, these became better alternatives for the authors due to the fact that they can ensure the permanent storage of the content and improve its visibility (Björk et al., 2014). There is also evidence that in the past few years, ASNs have become a major contributor to free full-text access to journal articles (Van Noorden, 2014, Laakso et al., 2017, Thelwall et al., 2017). The four most popular locations for archiving green OA copies are currently

institutional repositories, subject repositories, ASNs and personal/departmental websites of the authors. A study by Archambault et al. (2014) analysed the availability of 514,000 articles published between 2011 and 2013 and reported that around half of them could be retrieved freely on the web through a number of different channels: OA journals (12.1%), repositories (5.9%) and other unknown mechanisms (30.9%).

Repositories

An OA repository can be either affiliated with a research institution or linked to a particular subject area or discipline, i.e. Institutional or Subject Repository. For many years, there have been discussions about the low degree of self-archiving by researchers of manuscript copies of their articles into IRs (Swan & Brown, 2005; Jantz & Wilson, 2008; Xia, 2008; Xia & Sun, 2013; Yang & Li, 2015; Laakso et al., 2017; Lovett et al., 2017). Various solutions have been proposed to solve the problem, of which one strategy in particular could be effective, that is, the adoption of an OA mandate and policy at the institutional level. Such mandates require or request researchers to archive their research articles openly in the repository, within the legal bounds of their publishing agreements.

As of March 2019, 732 universities and research institutions as well as 142 funders and research organisations have adopted OA mandates (ROARMAP, n.d.). However, although some mandates have been in place for years, their resultant compliance rate differs widely. Some mandates have resulted in deposit rates as high as over 80%, while other IRs accompanied by mandates have no higher compliance than those IRs without mandates (Vincent-Lamarre et al., 2016; Larivière & Sugimoto, 2018). Mandates issued by funders tend to be more powerful, as they can stop research funding for non-compliance by researchers.

Preprint servers

Among other choices, preprint servers might also be used by researchers to disseminate their work prior to the final publication. The idea of preprints is to rapidly publish the submitted version of manuscripts before peer review with no access barriers. The first preprint server, arXiv, appeared in 1991 and has become an established means of scholarly communication in the field of physics, computer science and mathematics. As of May 2019, 1.5 million articles were hosted in arXiv (arXiv.org, 2019). Posting preprints openly on the web has also been popular in economics. The more recent scientific

publishing platform F1000 Research, built upon the idea of preprint servers, publishes research papers from life scientists in preprint form and introduces an innovative type of open peer-review process for the submitted manuscripts (F1000Research, 2019).

Academic social networking sites (ASNs)

ASNs are digital platforms on which academic researchers can upload their articles, abstracts, and links to published articles. In addition, ASNs incorporate some elements typical for social networks customized to meet specific needs of researchers (Meishar-Tal & Pieterse, 2017). ResearchGate and Academia. edu, are two most popular ASNs, both founded in 2008. As of 2017, the leading ASN ResearchGate has more than 15 million registered members across 193 countries and provides access to over 100 million publications (ResearchGate Fact Sheet, n.d.). The greatest problem with ASNs as green OA media is the lack of good control over the version of manuscripts that authors are allowed to upload. In many cases, publications provided by authors on ASNs are final publisher versions, often violating the author or license agreements signed with their publishers (Laakso et al., 2017; Lovett et al., 2017).

There is an ongoing debate on whether ASNs are competing with or complementary to digital repositories, particularly IRs. Several studies have identified that the use of ASNs for "Green OA" is greater than IRs, but the overall uptake of OA remains low (Borrego, 2017; Lovett et al., 2017; Laakso et al., 2017). In general, both ASNs and repositories are widely used as an online hosting space for researchers' articles. Repository depositing is more of a requirement mandated by some funders and universities. More than that, they offer different valuable service to researchers. ASNs are useful to connect researchers with others in the same field and to keep updated with new publications from the researchers they tend to follow, although these features of social networking are under-used at present (Jorden, 2019). IRs, can on the other hand better provide a long-term solution to preserve the OA version of articles. From this perspective, IRs and ASNs complement each other in their strengths, but when it comes to the content, they have in fact been competing, especially when ASNs have little control of the versions of uploaded documents and attract a large number of researchers who prefer to share the final published versions of their articles.

3.5 The uptake of OA

Over the last decade, there have been a number of empirical studies that measure the uptake of OA at different levels. An early study by Björk et al. (2010) found that for

articles published in 2008, 8.5% were made freely available on the publisher's website (categorized as gold OA articles), and that in addition 11.9% green copies were found in repositories and websites. In total, the estimated average OA availability across all disciplines in 2009 was 20.4%.

Gargouri et al. (2012) analysed 107,052 articles from the WoS database published between 2005 and 2010 in 14 different subject fields. They estimated that the share of OA in 2011 was about 24%, of which 21% was green OA and 2.4% was gold OA. The percentage of green OA was higher than gold OA for all disciplines except biomedicine, a discipline in which researchers have a more established practice of publishing in gold OA journals. The overall proportion of OA had grown spontaneously over the years but at a very slow rate of about 1% increase annually counted as a total of all articles published.

In 2013, Archambault et al. studied 320, 000 Scopus-indexed articles published during 2004 to 2011, from 22 different scientific disciplines. They reported that a total of 44% of the papers from 2011 were made OA somewhere on the web. Among them, 11.5% of articles were published in gold OA journals without an embargo period, and the share of green and hybrid OA articles altogether was 32.5%. The diverging results of this study compared to the previous measure by Gargouri et al. (2012) is largely because of different methodological approaches, especially the differences in the sources of data.

Piwowar et al. (2018) used oaDOI, an open online tool to find OA copies, to collect a sample of 100,000 journal articles from a population of 66 million with a Crossref DOI. The findings show that at least 28% of the articles were estimated to be OA. Over the last years, there is a growing trend of OA proportion, with a highest percentage of 45% in the most recent year analysed (2015). One remarkable discovery of this study was that the most common OA subtype is "Bronze", which is a little discussed category. Such articles could for instance be articles or whole issues that subscription journals make freely available for promotional purposes.

While these OA studies used different measurement methods that make their results not directly comparable, the provided figures do give a reasonable depiction of the growth of OA prevalence over time.

4 ENABLERS OF OPEN ACCESS

The development of OA publishing is driven by a combination of factors:

- The Internet and the World Wide Web makes it technically simpler and cheaper for publishers to distribute electronic collections and change the way people access scholarly publications.
- The oligopolistic structure of the journal publishing industry enables big publishers to keep raising subscription prices year by year, which puts research libraries under lots of cost pressure. Libraries have seen OA as a possible solution to this problem.
- On the policy level, funders, institutions and other stakeholders are increasingly mandating their funded papers to be made OA.
- Science itself is developed due to the open exchange of ideas among researchers and fast dissemination of new knowledge and therefore "openness" can benefit the scientific progress.
- Free access to knowledge is also viewed as a fundamental civic right that everyone can defend and advocate for more equality of access.

4.1 Technology

From 1995, there has been a near-complete move from print to digital format in journal publishing (Acerra, 2012). However, this transformation did not happen overnight. Before 2000, although electronic journals played an increasing role, the usage of traditional print journals still dominated among researchers (Tenopir et al., 2000). It was not until technical issues of the document compatibility and delivery mechanisms were solved by the release of the HTML (the standard markup language for creating webpages and web applications) and the PDF (the standard file format to present documents), and become standards for the digital version of journal articles, that the electronic publishing of journals has been common (Laakso, 2014). A survey on scholarly publishing practice in 2008 estimated that 96 % of journals from science, technology and medicine subjects, and 86 % of titles from arts, humanities and social science subjects were available in digital form (Gray, 2011).

Today electronic copies of journal articles can be distributed to a worldwide audience at almost zero marginal cost as printing and shipping physical copies is no longer necessary. This technological development raised possibilities for new innovative business models. One outcome is the notion of OA to content, and further than that, content made available using open standards for reuse (i.e. Creative Commons). The following developments in the technology have promoted the progress of OA in general.

Open journal system (OJS)

Open journal systems (OJS) is a journal management and publishing system developed by the Public Knowledge Project (PKP) as an open source software platform (Public Knowledge Project, n.d.). OJS provides a full-package technical solution to every stage of the journal publishing workflow, including submissions, peer review, the editorial process, online publishing and indexing. OJS in particular makes electronic publishing possible for smaller publishers with limited resource and budgets, for example, independent scholar-led publishers. It has also made it easy to convert existing society and university published journals to online OA journals with extremely low operating costs. OJS has been argued to be "a third path, dedicated to maximizing access to research and scholarship, as an alternative to traditional scholarly society and commercial publishing routes" (Edgar & Willinsky, 2010). In 2014, a total of 8,286 OJS supported journals were identified, having published 2.8 million articles (Kevin, 2015). In addition to being used and adapted by small publishers themselves OJS is often used by national and regional OA journal portals that also provide hosting of the system and contents.

National or regional portals for OA journals

There are a number of important journal portals in different countries or regions of the world for hosting OA journals. There is usually no charge for included OA journals because the majority of such portals are publicly funded. Many small and older journals published by scholarly societies and universities commonly choose to publish their electronic OA versions of articles on these portals because they offer a highly cost-effective publishing infrastructure for these journals to convert to OA model. Moreover, by using this type of service, the journals can gain the additional advantage of improving their visibility by being indexed in more bibliographic databases. Based on DOAJ data from 2016, Björk (2017) identified 21 OA portals, publishing a total of over 6,000 OA journals. One of the most notable findings from this study was that these portals are commonly used by journals from Latin America and Asia. Scientific Electronic Library Online (SciELO) is one of the most successful regional OA portals, which as of October 2019 served more than 1,700 journals from Latin American and the Caribbean region as well as Portugal and Spain, having published a total of 861,797 OA articles. The establishment and integration of SciELO Citation Index into the WoS in 2014 has further signalled the increased presence of this portal in the world. (Packer, 2014). Among

national OA portals, J-stage is one of the most well-known example for indexing and promoting Japan's scholarly journals.

4.2 Serials and access crisis

Despite the technical possibilities offered by the Internet to lower the marginal costs of distributing journal articles almost to zero and the new low-cost publication models which have been made possible, the "serials crisis" discussed earlier in Section 2.6 remains an issue at the heart of today's journal publishing system. Publishers have shifted from selling copies of scholarly literature to libraries to selling the rights of electronic access to entire collections of their academic journal titles (a type of agreement called a "big deal"). Initially the "big deal" model seemed attractive to most libraries since they were able to get access to a hugely increased number of journals at a combined price only slightly higher than the sum of the individual subscriptions they had paid earlier to the publisher in question.

However, the direct consequence of this change is the increased control of the existing largest commercial publishers. The economists Edlin and Rubinfeld (2004) studied the anticompetitive effects of big deal bundling and concluded that "the big deal locks in libraries and leaves few dollars in budgets to purchase journals from entrants to the journal industry. In this way, it creates a strategic barrier to entry. Viewed from a long run perspective, erecting a strategic barrier to entry by bundling can be seen as a device that allows publishers to either maintain or increase their existing market power". As a result, academic libraries have very weak bargaining power and are forced to buy into the deal for the important titles their patrons want even if it includes many unwanted items. Due to this power structure of the market, the leading journal publishers have been able to persistently increase the price of access to their journals.

In many cases, the rate of increase in the libraries' costs for electronic access continues to be greater than the increase in their budgets. Under such circumstances, libraries face increasingly financial difficulties to afford the price hikes imposed by these large publishers. At the same time, access has increasingly also become a problem for researchers from developing countries as some of their libraries cannot bear the high price. This further aggravates the divide between the Global North and the Global South in research.

Because of these developments, the university library community has looked for ways in which it could influence the system of scholarly communication positively for the benefit

of authors and readers. Many librarians have become major advocators of OA and helped establish a number of OA organisations, such as the Scholarly Publishing and Academic Resources Coalition (SPARC). SHERPA is another well-known organisation in UK led by the universities to facilitate the development of OA institutional repositories (SHERPA, n.d.). “OpenDOAR” and “ROMEO” are two influential OA projects by SHERPA to support the global research community. The former has established a comprehensive and authoritative list of institutional and subject-based repositories and the latter provides a database of publisher copyrights and policies concerning authors’ self-archiving rights.

4.3 OA mandates

What is more, the growing number of OA mandates from funders, institutions, and even national and international governments also play a particularly significant role that helps further propel the OA movement forward. As of May 2019, the Registry of Open Access Repository Mandates and Policies (ROARMAP, n.d.) listed in total 142 research funders of different countries that have formulated their own OA mandates.

The effect of the OA mandate from the U.S. National Institutes of Health (NIH) has been particularly important and has been reflected in the cumulative number of OA articles archived in the PMC, growing much faster than the number of non-OA articles from 2004 to 2014 (Tennant, et al., 2016).

In 2008, the Faculty of Arts and Science at Harvard University adopted the first OA mandate at the institutional level. So far, 764 research institutions and universities, according to the ROARMAP data, have adopted OA mandates (ROARMAP, n.d.).

The European Commission (EC) has also included the broadening of access to publicly-funded scientific research and the optimization of research impact, as a priority in its R & D strategy. From the start of the Horizon 2020 programme (2014-2020), the EC specified that project participants must comply with an OA mandate for all of their peer-reviewed scientific publications resulting from projects funded via the programme (European Commission, 2017). The EC’s push for OA has also shaped policy in member nations. For example, in response to the EC’s recommendation, the Swedish government is working hard to developing its nation-wide OA mandate that requests all of its publicly funded research to be OA from 2025 (OpenAIRE, n.d.). In Finland, Federation of Finnish Learned Societies (2020) has also issued a declaration for open science and research (2020-2025), in which a part of the vision and mission is to promote openness as a

fundamental value throughout the research community and its activities. The country's largest research funder, the Academy of Finland, has already required that research from their funded research and associated data are published in OA channels (AKA, n.d.). A number of Finnish universities have also implemented OA mandates of their own, for example, University of Helsinki and Aalto University mandate their affiliated researchers to self-archive their published scientific articles in the university's repository (ROARMAP, n.d.).

Outside Europe, the Finch report, which recommended OA to all the country's publicly funded scientific research (Finch, 2013), represented a major step towards a national OA policy in the UK. The report was followed by a new OA policy requiring that all the publications funded by the UK Research Councils should be made OA.

Many institutional mandates have low compliance rates, which has been discussed in the previous section 3.4. Anderson (2014), describes institutional mandates as "a mixed bag. Some are powerful, many are not, and a great many of them are not even real". While mandates issued by funders tend to be more strictly enforced, an analysis of 12 selected funding agencies still found that the compliance rate varied also greatly by funders (Larivière & Sugimoto, 2018). The reason why the rates of compliance differ across funders can be viewed as a combination of several factors: incentives for researchers, opt-out mechanisms, copyright protections, deposit guidelines, infrastructures and other associated requirements.

4.4 Philosophy and ideology

The move towards OA is often connected to the philosophical concept of "openness", which in a general sense refers to "the degree to which a thing or action is freely accessible" (Moore, 2017). The research process is considered to have an open nature in itself, which is manifested by the long tradition of researchers sharing their work with scientific peers through publications (Long, 2001). Advances in science have benefitted from the "the open exchange of ideas" and "wide and rapid dissemination of new knowledge" among scientists (Borgman, 2007).

Open-source software is one manifestation of the "openness" philosophy. The idea is to make the human readable source code of software accessible to anybody and free to use, modify and improve (Opensource.com, n.d.). In many respects, OA has been influenced by the principles of "open source". Particularly, OA publishing uses the same sort of permissive licenses as in open source licensing principles, in place of traditional

copyright. To date, the most prevalent license for OA distribution is Creative Commons (CC) licenses, with CC-BY as the most accommodating licenses to satisfy the needs of maximum dissemination and use of licensed materials (Creative Common, n.d.).

Aside from the OA's connection with "openness", Moore (2017) proposes that the development of OA is also derived from the ideology of free access. More specifically, OA should remove the price barriers to access. As Willinsky (2006) argued, "Access to knowledge is a human right that is closely associated with the ability to defend, as well as to advocate for, other rights". Therefore, the desire to achieve more equitable access to research and level the playing field between developed and developing countries is an important driver for OA (Tennant et al., 2016).

4.5 OA business models

While publishers of OA journals receive no income from readers, it still costs money for the publishers to produce these publications. This section will present a brief summary of major business models associated with the financing of OA journal publishing.

Publication fees

The OA business model has frequently been considered equivalent to the author-pays model, where authors themselves or a third-party pay the publication fees upon the acceptance of the article in return for that article being made available OA for publication. Such fees are known as article processing charges (APCs). Commonly, it is not the authors who directly use their own money to cover the payments of APCs, but use other funding sources including their institutions or external research grants. Nevertheless, the availability of funding for such payments is strongly influenced by the author's research discipline and the country of origin (Solomon & Björk, 2012a). Authors from the biomedical and physical sciences are more common to receive grants in which APCs can be embedded, as are authors from higher income countries.

The APC market is diversifying in terms of pricing. A study in 2012 showed that the price of APCs across 1,370 DOAJ-listed full OA journals varied considerably, from 8 to 3,900 USD, depending on the scientific discipline, type of publisher, prestige of the journal and country of publication (Solomon & Björk, 2012b). The average APC calculated over 1,370 journals and 100,697 articles published in 2010 was 906 and 904 USD respectively. Of all the disciplines, journals from biomedicine had the highest APCs. Commercial publishers charged higher APCs on average, compared with society, university or scholar

led publishers. The study also suggested that APCs for journals with high impact factors was higher. Both commercial and society publishers offered discounts and waivers on APCs to authors from the developing countries.

Traditional subscription publishers also offer a "hybrid OA" alternative. In this arrangement, authors can pay an APC to make a particular article OA in an otherwise subscription-based journal. Previous studies of the APC market found that hybrid OA charges were consistently more expensive than those for full OA journals (Solomon & Björk, 2012b; Björk & Solomon, 2014; Pinfield et al., 2015; Solomon & Björk, 2016). Björk and Solomon (2014) estimated an average APC of 2,727 USD for hybrid journals based on the APC list prices of the six biggest publishers. One particular problem concerning hybrid OA is "double dipping", where publishers are accused of charging both APCs and subscriptions for the same article. Despite some publishers providing offsetting arrangements and a few even providing details of their pricing models to address this concern, the real impact of these schemes remains unclear (Pinfield et al., 2015).

Membership fees

Some scholarly society and professional association journals are traditionally subsidized by membership fees, and in some cases a free copy has been part of member benefits. Moreover, nowadays some publishers also provide memberships arrangements to institutions, based on which they give discounts on APCs for authors from these institutions to publish OA articles. Also the payment processes for APCs is simplified reducing the administrative work and costs of the institutions, either by paying later (e.g. central invoicing) or prepayment ways.

The megajournal PeerJ has been experimenting with a one-time membership fee ($399-499), where members can publish from one to five articles per year depending on the level of membership. If the articles have multiple authors, the model requires that every author must register for membership (PeerJ, n.d.). The advantage of the model is that the price per article for each researcher is much cheaper than the APCs of comparable OA journals. A drawback is however that a lot of authors only publish once in the journal. It's also difficult to deal with such a scheme if the costs are to be paid from institutional APC funds or included in the allowed costs of externally funded projects.

Read-and-Publish agreements

"Read-and-publish" agreements, sometimes also referred to as "transformative agreements", is an emerging type of business models as an alternative to the traditional subscription agreements. The principle of this model is to bundle the "Big Deal" license with prepaid publication fees, through which not only the institutions are given the access to the publisher's subscription content but also the corresponding authors from the same institutions can publish OA articles in hybrid journals without the need to pay individual APCs. Over the past years, five largest publishers as well as other small ones have signed one or more similar type of agreements (Hinchliffe, 2019). For example, Elsevier recently agreed to its first "read-and-publish' deal with a Norwegian consortium of universities and research institutions for two years (McKenzie, 2019). This model is supported and pursued by an increasing number of institutions and library consortia in the world with the belief that it will reduce their subscription costs and facilitate the growth of OA publications. In 2019, some have even cancelled the big deal contracts with big publishers to push for a "read and publish" licences or similar agreements. Examples include the University of California.

Advertising

Many print journals have sold advertising for years as a source of income. There are a variety of mechanisms for generating advertising revenue for OA journals, either through a traditional way of directly dealing with prospective advertisers on a certain product or by joining an online advertising network such as Google AdSense or Amazon Associates. A survey conducted by Frantsvåg (2010) found that advertising was not widely spread among OA journals, however, larger journals and publishers tend to employ advertising in their income models more often than smaller counterparts.

Printed subscription fees offsetting the costs

This is a traditional model used by the subscription-based scholarly journals, as has been described in the previous section 2.3. In this scenario, the revenues from printed subscriptions are used to support the online publishing of an OA version of the articles for the journals.

Subsidies

Some OA journals are financially subsidized by governments, scholarly societies, universities or their departments and other various organizations. The subsidies can be in whole or part, directly or indirectly, one-time payment or continued funding, from one or more sources. This form of business model is particularly important for many society and university OA journals which are often free to publish in, however, there is still a potential risk of financial unsustainability attached to this model.

Volunteer effort

As noted, some OA journals are operated entirely on volunteer efforts, where dedicated editors contribute their time and unpaid work to produce the journals. Such journals, charge neither readers nor authors. Often such journals nowadays use the free OJS platform.

Other business models

There are a number of other possibilities for financing the publication of OA journals. The Open Access Directory has compiled a list of business models and revenue sources for OA journals that include the above mentioned approaches and other forms such as auctions, crowdfunding, e-commence and endowments (OAD, n.d.).

4.6 Quality of OA journals

The question of the quality of OA journals has for a long time been a hotly debated issue. Opponents of OA continue to assert that OA journals publish articles that do not meet the requirements for scientific quality normally expected from peer-reviewed scholarly journals. Peer review is a core mechanism for scholarly journals to assure the quality of their published research, which has two distinct functions: check scientific soundness and validity of the work and evaluate its importance and novelty to science (Wicherts, 2016). It is true that enabled by the electronic publishing of the articles, journal publishers have also experimented with new methods of review, for example open peer review, in which the pre-publication editorial records of the submitted manuscript are posted on the web and sometimes invites readers to comment after publication.

The particular approach of peer review employed by so-called mega-journals can be seen as another example. Since there is no space limit for electronic journals, OA publishers that publish no parallel paper version can publish as many articles as they want per year

following the number of submissions that are of acceptable quality. Taking advantage of this scalability, mega-journals have emerged. Such journals have a big publishing volume, a broad coverage of subject areas, and accept articles for publication only based on whether they are scientifically sound (Björk, 2018). The best known example of these is *PLoS One* which had published more than 215,000 OA articles as of May 2019. Following the pioneering success of *PLoS One*, Nature publishing group launched a mega journal *Scientific Reports* which since 2015 has surpassed *PLoS One* in terms of the published article volumes (Björk, 2018). One might argue that the peer review criteria used by mega journals, which don't consider the anticipated scholarly significance should lower the average quality, but essentially they let the readers determine the impact and illustrate it through article-level metrics including the viewership, download rates, social sharing and citations in a real time manner.

The rise of 'predatory' OA publishers and journals suggests that some OA journals have relatively substandard or even non-existent peer review in order to maximize revenues by accepting virtually all submitted papers. Nevertheless, as Suber (2013) commented in his blog article, "OA journals can be first-rate: the quality of a scholarly journal is a function of its authors, editors, and referees, not its business model or access policy". Early evidence can be traced back to 2004, when McVeigh (2004) found that according to the Journal Citation Reports "there was at least one OA title in each scientific field that ranked at or near the top of its field" in terms of its citation impact. Furthermore, Wicherts (2016) pointed out the fact that there are controversies surrounding the quality of peer review in both subscription journals and OA journals. Traditional peer review has also been subject to several criticisms such as unreliability and inconsistency, long delay and high expense (Hellauer, 2017).

Over the past decade, a few studies have attempted to determine the quality of OA journals as compared to traditional subscription journals (McVeigh, 2004; Miguel et al., 2011). Björk and Solomon (2012) made a comparison between two groups using WoS or Scopus data in terms of the average number of citations to the articles in a journal as a measure for the quality. The main results indicated that OA journals indexed in WoS and Scopus are close to the same level of scientific impact and quality as subscription journals, in particular in the biomedical fields and for APC funded OA journals. In light of this, the discussion around the quality of scientific publishing should not concentrate only on OA journals, but needs also to consider the quality of subscription journals for comparison.

‘Predatory’ OA publishing

‘Predatory’ OA refers to the situation where start-up OA publishers abuse the APC-based publishing model to make money from authors without providing a proper peer review or any other associated editorial and publishing services. The term “predatory publishers” was first coined by Jeffrey Beall. Starting in 2010, he created a list of “potential, possible or probable predatory” publishers and individual journals based on his self-defined criteria. Beall’s list vanished suddenly from the internet with no explanation in January 2017. But there were controversies surrounding the list’s accuracy and reliability, mainly due to a lack of transparency in Beall’s criteria and his application of these. Criticisms aside, the existence of the list and the media attention it achieved helped raise awareness of the problems and dangers of ‘predatory’ publishers.

Today, ‘predatory’ publishing is a real, and widely discussed problem. One side-effect has been to damage the reputation of OA journals in general, and claims have even been made on the negative effects on global science communication (Leeming, 2017; Richtig et al., 2018; Stuart, 2018). However, there are differing opinions on the scale of this problem. Eve and Priego (2017) examined the harm of ‘predatory’ publishing practices to a variety of stakeholder groups. They concluded that there was little harm, highlighting the fact that “established publishers have a strong motivation to hype claims of predation as damaging to the scholarly and scientific endeavour. Eve and Priego noted that, “in fact, the systems of scholarly peer review are themselves already acknowledged as deeply flawed”. Olijhoek and Tennant (2018) in their blog article also supported the view that the problem of ‘predatory’ publishing was overstated, and they argued that “it was in fact, only a minor nuisance caused by scientists who do not follow simple rules on where to publish”. Moreover, it is important to note that so far only a couple of studies have tried to analyze the real impact of articles published in ‘predatory’ journals with regards to their citation counts (Björk et al., 2020). If these articles are actually rarely cited, it means that they are basically little read and used by the scientists in their research, which further implies that the danger of ‘predatory’ publishing’s impact to the entire scientific community tends to be exaggerated.

Blacklists and whitelists

In order to help authors avoid submitting to ‘predatory’ publishers, both blacklists and whitelists can be useful. Blacklists index journals or publishers that allegedly are questionable, the best known example being Beall’s list. After its sudden closure, the

Cabell's journal information service started publishing a similar 'predatory' journal blacklist. The drawback of Cabell's is that it is only available to subscribers.

Whitelists index journals that are legitimate, vetted and verified as meeting certain standards. The leading one for OA journals is DOAJ, which as of November 2019 included 13,930 OA journals meeting a number of quality criteria. In addition, both WoS and Scopus include increasing numbers of OA journals meeting even more strict quality criteria, compared to DOAJ. In August 2019 the SCIMAGO database shows 4,430 OA journals in Scopus, of which 2,906 are also indexed by WoS.

However, both blacklists and whitelists as a solution to the problem of 'predatory' publishing has been a debated topic. Criticisms of blacklists include their poor methodology and lack of transparency (McCann et al., 2018; Memon, 2018; Memon, 2019). In principle whitelists would seem to be a better solution. Rick Anderson in *The Scientist* points out that "we don't need to identify and call out the scammers; we just need to identify and certify legitimate publishers" (Vence, 2017). But also whitelists have included a number of 'predatory' journals. Nevertheless, it seems that there is a commonly held belief that neither blacklists nor whitelists will ever be complete or accurate and thus we cannot solely rely on these listings. It is also important that researchers themselves evaluate journals critically before submitting to them.

4.7 Summary

Open access, as a phenomenon, has in the past years received increased attention from the scientific community, publishers, research funders, governments and even the general public. The OA movement started from the grassroots, initially driven by the interests of individual scientists, however over time, it seems to have become a more mainstream form of scholarly publishing and both commercial, society and university publishers have started OA journals and converted existing journals to OA. The timeline of OA development includes important milestones such as the Budapest Open Access Initiative (2001), the NIH's OA mandate (2008), the EU's FP7 and Horizon 2020 funding programs (2007-2013, 2014-2020) and the UK's Finch Report (2012). At the time of writing of the summary part of this thesis, a broad debate has been ignited by the launch of Plan S (n.d.). This plan is a funder-led initiative for universal OA to research papers, requiring that from 2021 scientific publications resulting from research funded by public grants must be published in compliant OA journals or platforms. As of today, there is broad consensus about the ideological justification for OA, towards an ultimate

goal of creating an equitable and sustainable scientific communication system. There is more emphasis on the practical issues of how to implement OA among various stakeholders and across different regions.

5 METHODOLOGY

This section outlines the research methodology adopted for the present thesis. It first presents the research philosophy that underpins the three studies included in this thesis. After that, it discusses general methodological considerations issuing from previous relevant research and then describes the study design for each individual article and makes justifications for the methodological choices made. Then it provides an overview of the issues involved in the quantitative data collection process and describes the main data sources used in the three articles.

5.1 Research philosophy

Scientific research philosophy is at the core of any research endeavour, reflecting a system of researcher's thought, which involves the choice of methodology, research strategy, data collection methods, processing and analysis (Saunders et al., 2009). No single research methodology is intrinsically better than the others and many researchers advocate using a combination of research methods (Kaplan and Duchon, 1988; Bryman and Burgess, 1999; Creswell, 2003). One´s philosophical stance can be stated explicitly, or it can be derived from the choices made as part of a study. Five major philosophies that can be distinguished from each other in terms of their ontological, epistemological and axiological assumptions: positivism, critical realism, interpretivism, postmodernism and pragmatism. The philosophical stance should be determined in relation to the purpose of the research at hand (e.g. Saunders et al., 2009). This thesis adheres mainly to the positivism and critical realism stances. These two philosophies will be briefly presented next, together with a discussion of how they relate to the research questions of the thesis.

Positivism

Positivism is founded on the belief that the social reality is external, can be observed and measured from an objective viewpoint, independently of the researcher's set of values. Based on observable and measurable realities, regularities and generalisations can be produced, further than that, predictions can be made. The traditional approach in positivism has been successfully applied within the natural sciences, and today it is also widespread as the basis for research in the social sciences. This thesis has been conducted within the subject of Information Systems Science, a discipline with a strong focus on empirical studies often with an emphasis on practical relevance. The topic of business models and their sustainability fits well into exiting research traditions in information

systems science. Since the subject topic of this thesis deals with the interaction between technology and people along with their usage of information, it also falls into the field of Information Science. By nature, this field is highly interdisciplinary and influenced by the evolution of technologies (Prebor, 2010). Budd (1995) recognized that most research in Information Science conforms to the positivist paradigm. The studies in the thesis build to a high degree upon bibliometrics and web observation data, which facilitate objective observability and possibilities for other researchers to directly build upon the data or extend the studies with replicable methods.

Critical realism

Critical realism is often seen as a middle ground philosophy between positivism on the one hand and interpretivism on the other. Critical realism subscribes to the view that reality is external and independent but cannot be observed directly from our perceptions and knowledge of the reality. An important characteristic of critical realism is that it has a sophisticated and multi-layered ontology (Saunders et al., 2009). It emphasizes that what we know as the reality is those aspects that can be constructed from our experience and perspectives. The real reality, however, has multiple layers encompassing the structure and mechanisms that influence what we observe and can be experienced. Only if people understand these underlying structure and mechanisms, as defined by McEvoy and Richards (2006), through "a combination of empirical investigation and theory construction", can the reality be fully apprehended. The ultimate goal of research using the critical realism perspective is not to predict or to interpret but to provide a further understanding and explanation of these mechanisms and structures.

In this thesis, the research questions were outlined in Section 1.2. A mostly positivist philosophy was deemed most suitable for exploring RQ (2). i.e. to measure the growth of 'predatory' OA journals and articles through quantifiable journal and article level data. With regards to RQ (1) and RQ (3), blending in elements from critical realism was considered as the most appropriate philosophical perspective. The nature of these research questions assume that answers cannot be found using a single methodology, but require an integrated approach involving both quantitative and qualitative methods that require contextualisation both to each other and to the external environment. So the central reasoning for adopting critical realism is that it enabled the adoption of mixed methods to provide a deeper level of explanation and understanding of the phenomena involved, in comparison to positivism and interpretivism (McEvoy and Richards, 2006; Mingers et al., 2013). In this research, quantitative methods helped to identify and

quantify samples of journals based on specific criteria, and qualitative methods allowed to explain the underlying causes such as the major motivation behind Chinese publishers' choice of OA, which is less likely to be captured by standardised quantitative measures. Moreover, triangulation of quantitative and qualitative data in both studies was used to provide a more multidimensional understanding of circumstances surrounding gold OA journals.

5.2 The study design

OA is often discussed in the broader context of scholarly communication, which is one of the fields of study in library and information science (LIS). LIS is defined by Togia and Malliari (2017) as "a field emanated from professional practice and closely linked to practical problems". Research on LIS strives to address important information issues, such as: "information retrieval, information quality and authenticity, policy for access and preservation". As a field of practice, not only scholars from the relevant LIS subjects but also librarians as well as a number of other information practitioners have engaged in discussions about this field and its nature. LIS research has developed for more than 50 years since 1960s and is now a mature area of research. By nature, LIS is a multidisciplinary field incorporating a wide range of research designs and methods from social, behavioural and management science as well as computer science.

A number of studies have systematically reviewed research methods used in LIS (Koufogiannakis et al., 2004; Hildreth & Aytac, 2007; Hider & Pymm, 2008). The results of these studies showed that the most common research strategy is quantitative descriptive studies based on surveys and questionnaires. Descriptive statistics is the most frequently used method of data analysis. Recent studies from Chu (2015) as well as Togia and Malliari (2017) have suggested that today a wider variety of research methods have been used in LIS research, for example, qualitative research approaches seem to gain more importance. The open web is also opening up new interesting avenues for quantitative studies, for instance involving social media. It's important to highlight that the choice of research methodology should depend on the purpose of the study, the data sources available and the studied topic in particular. It warrants mentioning that the thesis topic of studying publishing business models in the Internet era falls quite naturally into the broader e-business or e-commerce domain.

Among various topics of LIS research, OA is still a relatively young area of research. The advancement of OA studies has progressed through various forms of formal and informal

communication. In addition to many opinion pieces and case reports rigorous empirical research has been important in order to construct the evidence base supporting the debates about OA (Pinfield, 2015). Particularly important have been studies measuring the development of OA uptake using quantitative approaches (Hedlund et al., 2004; Björk, et al., 2010; Laakso et al., 2011; Laakso & Björk, 2013; Björk et al., 2014; Björk, 2015; Wakeling et al., 2016; Björk, 2018, etc.). OA has been discussed by various stakeholders involved in scholarly publishing, including scholarly publishers, academic authors and editors, research funders, policymakers, governments, research institutions and learned societies and empirical prevalence have been important resources for that.

Bibliometrics is a specific methodological approach developed in LIS research to study documents and patterns of publication (Togia and Malliari, 2017). Anyi et al. (2009) in the article discussing such methods have pointed out that "a variety of bibliometric measures can be used to understand the characteristics or portrait of a journal which in turn may reflect the characteristics of the literature and communication behaviour in the fields they represent". Bibliometric measures include analysing article volumes (number of articles published by issue and year), author characteristics (gender, profession, location, etc.), author's productivity (authorship distribution by different subject areas, etc.), co-authorship pattern, content analysis (subject areas of articles, types of research methodology used, analysis of indexation and abstraction information, etc.) and citation analysis as well as characteristics of the editorial board.

One main aim of this thesis is to strengthen the evidence base on "Gold" OA concerning journals and publishers outside the mainstream. The thesis consists of studies looking at three categories of such publishers. Article 1 is dedicated to provide a longitudinal study on the group of 'indie' OA journals as articulated in RQ (1): How sustainable has the 'indie' journal model been for journals which adopted the model early?

Given the focus of this study, a straightforward bibliometric analysis of the development of publishing volumes over time of such "indie" journals was carried out. This is motivated by the fact that many 'indie' journals have major sustainability problems since they depend on voluntary work of one or a small number of enthusiasts. Considering that the total number of targeted 'indie' OA journals founded before the year 2000 is not too big, the full population was studied rather than a sample.

However, quantitative research has disadvantages of only providing a numerical measurement of a phenomenon rather than an in-depth exploration. Therefore, a case

study approach was used in the following step since that methodology provides an opportunity for the researcher to gain a deeper holistic view of the research problem, and may facilitate describing, understanding and explaining a research problem or situation (Tellis, 1997a; Tellis, 1997b; Baxter & Jack, 2008; Baškarada, 2014). Five cases were selected through convenience sampling aiming to present different evolutionary paths of 'indie' OA journals, and further qualitative data was collected from either published interviews, editorials or other available web documentation. Surveys of larger groups of journal editors could in principle have been employed to offer richer and more in-depth answers to this question. This was however not practical due to the fact that it would have taken a lot of effort and time to reach the founders of these 'indie' OA journals, which were established more than 20 years ago.

Article 2 examines the key market characteristics of 'predatory' OA publishers and journals from the longitudinal perspective as proposed in RQ (2): To what extent has the 'predatory' OA publishing market developed between the years 2010 and 2014 in terms of journal and article volumes, distribution over scientific disciplines, country of publishers and authors, APC levels as well as publishing speeds? Given the focus of RQ (2), a quantitative method was adopted.

The two major methodological issues were:

1) From which sources could information about 'predatory' journals existing at the time of the study be obtained.
2) Given that the total number of journals is in the order of 10,000 some sort of sampling method had to be used, since the research would involve manual counting of article numbers from individual journal sites.

The only realistic method to obtain journal names at the time of the study was to use Beall's list of 'predatory' publishers and single 'predatory' journals. This list which was published and updated by the librarian Jeffrey Beall helped raise global awareness of the problems of predatory publishers, but was also the subject of fierce criticism, due to lack of transparency in his inclusion decisions. In 2017 Beall eventually closed the list, with little explanations provided.

As for the second issue the major choice was between either straightforward sampling over all the approximately 10,000 journals or some sort of stratified sampling. In this case stratified sampling was chosen in order to produce accurate generalizations about the total number of active 'predatory' journals and their publication volumes across the

years. In general, provided that the choice of strata is accurate with homogeneity within strata and heterogeneity between strata, the stratified sampling produces samples with a greater level of representation and further provides estimates that are more precise than simple random sampling (Daniel, 2012; Lim & Ting, 2012). Because meaningful differences and similarities were observed after four strata (100+, 10-99, 2-9 and single-journal publishers) were formed, this sampling strategy was preferred over other sampling methods. A total of 613 journals published by 290 randomly picked publishers from different strata were included in the study through two stages of sampling.

In order to reduce the sampling errors, the study also made sure that the quantities of sampled data were sufficient for conducting a reliable statistical analysis. Using the sample of journals descriptive statistics were produced to analyse journal and article level characteristics. However, the final results remain limited due to the methodological complexity, hence, this study only provides a rough estimate with regards to the magnitude of the 'predatory' publishing problem. Also it is important to point out that this study is limited in providing only a quantitative perspective in contrast to articles 1 and 3. It would be almost impossible to contact journals and editors which in no ways will acknowledge they are 'predatory' and answer any related questions.

The focus of article 3 is to study the situation of non-English language OA journals. Chinese-language OA journals were chosen as a case, due to the author being a native Chinese speaker, which is a prerequisite for conducting the study. The aim was on one hand to provide a snapshot of Chinese-language OA journals, on the other to further generate deeper insights into several central aspects of such publishing as communicated in RQ (3): What are the key characteristics of Chinese-language OA journals, what are their publishers' major motivations in becoming OA, what are the perceived challenges in their operations and what are their attitudes towards internationalization? Taking into account this focus, a mixed methods research methodology that involved both quantitative and qualitative research was suitable as this integration provides a better understanding of the situation of Chinese-language OA publishing than either method used alone. This choice of methods was also influenced by the design of the first study, in which a mixed method approach was proven to be effective in providing a more in-depth understanding of the questions under study.

Firstly, this study adopted a quantitative methodology where bibliometric analysis was chosen as the most suitable method, in order to study the overall situation of Chinese-language OA journals in the year 2016.

In order to answer the second part of RQ (3) regarding motivations, challenges, etc., a qualitative research methodology was utilized. Interviews were selected as the method because it is a particularly efficient means of collecting data when the research design involves an analysis of people's motivations and opinions (Keats, 2000).

In-depth interviews were conducted with eight members of the Chinese journal publishing community. All of them were senior persons involved in the operations of particular journals. They represented different disciplines and types of publishers, as well as knowledge levels concerning OA issues. Eight interviews were considered sufficient for this study as long as "the data is enough to explore and document a range of themes" (Travers, 2001). This decision was also made due to the limited travel resources available for face-to-face interviews, since online interviews were not feasible with some potential interviewees. While other research approaches such as surveys or focus groups involving a larger number of participants could be considered, they were not chosen. This was also because of the limited time and resource available to the author.

5.3 The data collection process

A particular challenge to all researchers trying to develop an evidence base concerning the development of gold OA, is the lack of comprehensive data sources that provide metadata at both the journal and article level for different time periods. The use of leading bibliographic databases such as WoS, Scopus and DOAJ has limitations since they fail to include many OA journals, in particular journals that fall into the categories studied in this thesis. One option would be the aggregation of bibliographic data from several databases, however, it takes a lot of effort and time to sort out the overlaps in order to compile a master list. Moreover, until now none of the general bibliographic databases provide reliable data covering average peer review time, publishing fees, journal founding year, etc. There is thus a need to collect additional data for the OA journals studied directly from the publishers' sites. The three studies included in this thesis thus required varying degrees of manual work by visiting the actual journal websites during the process of data collection.

Below the main available external data sources used or discussed in this thesis are briefly presented. They are classified into two main categories: bibliometric indexes and indexes focused on OA journals.

BIBLIOMETRIC INDEXES

Web of Science (WoS)

Web of Science (WoS), formerly ISI Web of Knowledge, is now owned by Clarivate Analytics. It provides a comprehensive indexing service containing citations and abstracts of the most important and influential research literature spanning all scientific disciplines. New journals are after application included only after a rigorous evaluation process, with a low acceptance rate. The journal selection is made principally on the basis of quality and impact. The access to the bibliometric data from WoS requires a subscription.

Through inclusion in WoS journals after a couple of years receive Journal Impact factors, which are very important quality criteria used in academia in many countries, both at the national and university levels.

Scopus

Scopus is the largest multidisciplinary database of citations and abstracts for peer-reviewed research literature, and is owned by Elsevier. Many features of Scopus are similar to WoS, but inclusion in Scopus has usually been more easy also for relatively new journals. In addition to delivering primarily article level data, Scopus also provides author profiles covering basic bibliographic data such as affiliations, subject areas and number of outputs as well as citation based data like the total number of citations to an author's work.

UlrichsWeb

UlrichsWeb is the most comprehensive bibliographic database in terms of its title coverage, and is owned by ProQuest. In addition to scientific journals it also includes other types of serials. As of November 2019 the service indexes 46,813 active peer reviewed academic and scholarly journals. The database includes basic bibliographic data at the journal level such as ISSN, publisher, country, language, publishing and peer review status as well as subject fields. Compared to Scopus and WoS, the selection criteria of UlrichsWeb are by far the most lenient as long as journals meet the basic definitions of a serial.

INDEXES FOCUSED ON OA JOURNALS

The Directory of Open Access Journals (DOAJ)

Founded in 2003, the DOAJ is an index of scholarly peer-reviewed OA journals covering all scientific fields. At the time of writing this thesis, the DOAJ indexes 13,930 journals and more than 4 million articles. In contrast to the commercial WoS and Scopus, the DOAJ has been an effort of the academic community itself and has to a large extent relied on voluntary efforts by academics. DOAJ has established itself as the core index for OA journals, however a concern over the coverage of DOAJ is raised in a recent study indicating that the DOAJ only covers around 33% of a total of 37,755 fully OA journals identified as of January 2019 (Bruns et al., 2019). The most plausible explanation to this situation is that the missing journals either fail to comply with the inclusion criteria of the DOAJ or their publishers do not submit applications to DOAJ. DOAJ has in fact in recent years tightened its inclusion criteria in an effort to weed out journals from 'predatory' publishers. For part of the journals DOAJ also nowadays indexes articles.

Directory of Open Access Scholarly Resources (ROAD)

The Directory of Open Access Scholarly Resources (ROAD) was founded in 2014 by the ISSN International Centre in order to index bibliographic records of OA scholarly journals included in ISSN's general indexes. As of November 2019, there are 36,565 journals in ROAD. However, the inclusion criteria of ROAD are relative permissive as long as the journals get their ISSN numbers and can be identified as being OA. Currently, ROAD only provides journal-level metadata mainly about country of journals, languages, publishing status, frequency, and subject area.

Beall's list

This list was already discussed earlier. Beall's list was an openly accessible list of 'predatory' OA publishers and journals that was started in 2012 by Jeffrey Beall at the time when he was a librarian at the University of Colorado and the list was maintained until its sudden closure in 2017. As of September 2014 when the second study was carried out, it included 614 so called 'predatory' publishers and 416 standalone journals. After the emergence of this list, there was constant controversy surrounding it. A major reason was the unclear basis on which Beall concluded that a publisher was predatory, although he had a long list of self-defined criteria for identifying such journals. But undoubtedly,

this list has aroused a hot discussion among the academic community regarding the quality of OA journals.

China Open Access Journals (COAJ) index

The China Open Access Journals (COAJ) index was established by the Chinese Academy of Science. The aim was to aggregate a list of Chinese OA journals and showcase the work of these journals. As of August 2019, there are 800 indexed journals, of which 60 journals provide contents immediately to the COAJ database at the time of publication. Therefore, COAJ lists data about both journals and articles if available. The selection criteria for journals to be included in COAJ merely require the basic information of journals.

Early OA journal lists of Wells (1999), Crawford (2002), Hedlund et al. (2004)

Three previous studies from Wells (1999), Crawford (2002) and Hedlund et al. (2004) deal with different aspects of early OA journals. In the earliest study of Wells (1999), she identified 387 scholarly journals from several e-journal lists and analysed the key characteristics of this market including distributions of publishers and subject fields as well as the status of journals. Crawford (2002) used an e-journal list of the Association of Research Libraries to form a group of 104 pioneering journals and aimed to explore the longitudinal development for the journals from the year 1995 to 2001. Hedlund et al. (2004) utilized the data from one earlier study (Gustafsson, 2002) which identified 317 OA journals to characterize the journal market.

Since most of the journals in these three studies were founded in the late 1990s before the emergence of professional OA publishers, the majority of the journals could be classified as ‘indie’ journals. On the basis of the data from these studies, a master list of 264 journals was compiled and after removing the journals that do not fulfil the selection criteria for being ‘indie’ ended up in a population of 250 ‘indie’ OA journals. To gather the data about article volumes published by journals per year, the individual journal websites were further visited manually.

The summary of these main data sources used in the thesis is listed in the following Table 1.

Table 1 Summary of individual data source used in the thesis

Main data sources	Coverage	Number of journals	Number of articles	Year
Web of Science (WoS)	peer reviewed research literature	16,830	2,110,524	2018
Scopus	peer-reviewed research literature	24,702	2,508,632	2018
UlrichsWeb	peer-reviewed scientific journals	46,813		2019
Directory of Open Access Scholarly Resources (ROAD)	OA journals at the journal-level	36,565		2019
Directory of Open Access Journals (DOAJ)	OA journals at both the journal and article-level	13,930		2019
Beall's list	a list of 'predatory' OA publishers and journals	11,873[1]		2014
China Open Access Journals (COAJ) index	China's OA journals at the journal and article level if available	800		2019
Wells (1999)	a list of independent, scholar-published journals founded prior to 2002	387		1999
Crawford (2002)		104		2002
Hedlund et al. (2004)		317		2004

5.4 Summary

The development of both "Gold" OA and "Green" OA have been measured using different methodological approaches and data sources, both across time and geographical regions. This thesis addresses questions related to the development of certain subtypes of gold OA journals, going outside the mainstream publishing models, which are well covered in the leading bibliographic indexes. This thesis hence firstly adopts a quantitative methodology to provide both the longitudinal and snapshot studies measuring three specific OA groups that includes 'indie', 'predatory' and Chinese-language scholarly journals. Besides that, two of the articles (1&3) also employed qualitative methodology to gain a deeper understanding of their studied journal group. This chapter also included a discussion of data collection issues which arose in the studies. In addition to using available journal lists as a basis, all three studies required additional manual data collection from individual journal sites for instance for studying OA publication volumes.

[1] The number of journals is calculated from a total of 996 publishers included in Beall's list as of 2014.

6 ARTICLE SUMMARIES

This section summarises the three articles that are included in this thesis, focusing on presenting the purpose, research methods and main results of the studies. The full-text of these articles are available as Appendix 1.

6.1 Article 1: A longitudinal study of independent scholar-published open access journals

This study was carried out together with Bo-Christer Björk and Mikael Laakso.

The aim of this study was to provide a longitudinal measurement of early OA journals founded prior to 2002 by scholars or groups of scholars independently from a professional publisher, scientific society or university. The journal and article volumes of such "indie" journals was studied over the time period from 1995 to 2014. Furthermore, five such journals were analysed in closer detail in order to explore different scenarios for the long-term survival and operation of such journals. A mixed methods study was chosen as the design for this research to enable an in-depth exploration of the sustainability of the 'indie' OA journal publishing model over the past decades. The quantitative data was built upon three previous OA studies of relevant topics, resulting in a list of 250 'indie' journals. The qualitative data was then collected from published case studies giving context to the quantitative results. Finally, the two parts were synthesized to provide a more comprehensive understanding of the circumstances surrounding this type of OA journals.

The results showed that nearly half of the journals had remained active until 2014, most of which still adopted the OA publishing model. The total number of articles published by them indicated continuous growth from 862 in 1995 to 4,954 in 2014. The results revealed that the majority of ceased journals did so between 6 and 9 years after their launch. Compared with commercial OA journals, 'indie' journals remained small in terms of their median number of articles published per year, which as of 2014 was 18 articles. The case studies of five selected 'indie' journals presented five different trajectories on how journals of this type function, which potentially informs other pioneer 'indie' journals on alternative sustainability options. The quantitative data found that 8% of the surviving journals collected APCs to support their operation. This study was published in the PeerJ journal, an OA journal with a good scholarly reputation and a reasonable APC. Although the journal's scope covers all sciences it had before this already published a number of articles dealing with OA topics.

6.2 Article 2: 'Predatory' open access: a longitudinal study of article volumes and market characteristics

This study was carried out together with Bo-Christer Björk.

The aim of this study was to measure the longitudinal development of 'predatory' OA publishing in terms of total article volumes published between 2010 and 2014, and other key characteristics including average APC, publisher's country and authorship distribution as well as publication delay. This was the first comprehensive quantitative study that provided empirical evidence of the 'predatory' OA market, which used to be discussed mostly anecdotally through news stories reporting scandals concerning the lacking rigorous peer review practices of such journals. Since there was a lack of alternative sources for 'predatory' journal and publisher data and manual data collection was not viable, Jeffrey Beall's blacklist was utilized as the primary data source. Although there have been many controversies concerning Beall's list, it is believed that his criteria have covered a wide range of direct and indirect indicators of 'predatory' publishers and journals. The study was designed around stratified multistage sampling primarily because the total volumes of articles and journals published by 'predatory' publishers varies heavily across publishers. To stratify the sampling of publishers on the basis of their sizes is helpful in order to observe and compare the similarities and differences between publishers of various size groups. Data for 613 journals was sampled from a total of 966 publishers spread across four strata (100+ journal publishers, 10-99 journal publishers, 2-9 journal publishers and single journal publishers). Article level data was collected manually by visiting each individual journal's website.

The number of 'predatory' journals and their publication volumes were found to have consistently increased between 2010 and 2014. In 2014, the study estimated 420,000 articles to have been published by 8,000 active journals, compared with 53,000 articles from 1,800 journals in 2010. The results suggested that in 2014 the 'predatory' OA market rivalled that of OA journals indexed in DOAJ concerning the total number of articles. The regional distributions of 'predatory' publishers and authors who published in them are highly concentrated in Asian and African countries, among which India as an individual country ranked highest in frequency. The results suggest a clear variance across the four different strata in terms of the average number of articles per journal and APC amount. The average APC charged by 'predatory' publishers was calculated to be 178 US dollar per article, which is notably lower than that of OA journals included in the DOAJ. The results of this study imply that 'predatory' publishing, from a production

standpoint, might not be a comprehensively global problem but concentrated in particular to a few developing countries.

This study filled the gap of reliable estimates of the overall situation of 'predatory' publishers and journals from a quantitative perspective. By utilizing Beall's list and manually collecting historical data from every sampled journal's website, this study was able to provide the first rough estimate on the size of the 'predatory' OA market and to explore key journal and publisher level characteristics. BMC Medicine, the flagship journal among over 200 BioMedCentral OA titles, was chosen as the publishing outlet in order to reach the widest possible audience. The metrics at the article level so far have justified this choice, since the article has been accessed almost 50,000 times and had 230 Scopus and 478 Google Scholar citations by April 1st 2020.

6.3 Article 3: Open access scholarly journal publishing in Chinese

The aim of the study was to examine the current state of OA publishers and journals published in Chinese in terms of journal publication volume, distribution of subject fields and types of publishers, as well as start year. The study also further explored the key facilitating motivations of Chinese-language publishers to become OA and perceived barriers. This study adopted a similar mixed methods approach as Article 1, involving both quantitative and qualitative research methods. For the quantitative part, journal metadata was extracted from COAJ, an index of China's OA journals, followed by a descriptive bibliometric analysis to identify the major characteristics of Chinese-language OA publishing. In the qualitative part, semi-structured interviews were utilized to collect the views and experiences of the editorial staff working for Chinese-language OA journals. The interviews aimed to provide a more comprehensive interpretation of the quantitative measurements and generate a deeper understanding of OA publishing in Chinese. Although the number of interview participants was relatively small, they offered a variety concerning types of publishers, and experiences obtained from editorial positions.

The results indicated that journals published in the Chinese language were dominating the landscape of OA journals published in the country, with a 91% share. However, considering the total number of China's scholarly journals, the share of OA journals remained low. Moreover, Chinese OA journals were found to have limited visibility towards the international audience due to rarely being indexed by DOAJ, WoS or Scopus. Most of the journals were in the STEM fields and published by universities and scholarly

societies. One interesting finding was that 80% of the journals were established before the Internet emerged, which implied that the majority of Chinese-language OA journals had converted from the traditional subscription-based model. The results also showed that publishers of these journals were motivated to convert to OA for the potential of increased academic impact in terms of impact factor and other citation-based metrics. However, the journals were often found to be troubled by the lack of high-quality paper submissions mainly because the present national and institutional research assessment system was strongly skewed to WoS and Ei Compendrex-indexed journals mostly published in English and often based in the UK and the USA. To internationalize these journals, the lack of a long-term sustainable financial model was a major barrier. The findings suggest that there is a demand for a non-profit government-run OA publishing platform (like SciELO in Latin America) to assist Chinese-language OA journals in professional publishing and promotion.

Many earlier OA studies have to some degree included OA journals in China, however, this study offered the first focused study on an important subset of OA journals in the country – Chinese-language OA journals, and further than that, the study also contributes a qualitative analysis to complement the quantitative results so that a more comprehensive understanding of publishing in this area could be provided. The study was submitted to the OA journal Publications, since the topical fit is perfect.

It is worth mentioning that all three articles were published within four months of initial submission, including peer review and substantial revisions. This is exceptionally fast compared to many leading information science journals, which topic-wise would have been the alternatives among subscription journals.

7 CONCLUSIONS

7.1 Main results & discussions

RQ (1): How sustainable has the 'indie' journal model been for journals which adopted the model early?

The first research question was addressed through a mix of bibliometrics and case studies (article 1). The main results from the bibliometric part showed that the mortality rate of these 'indie' journals was low for the first 2-5 years, but a peak formed in the age bracket of 6 to 9 years, and dropped again significantly after that. This suggested that those 'indie' journals that had survived beyond the 6 to 9 year bracket had already gained reputation and reached stability. As of 2014, more than half of the 250 'indie' journals remained operating. Most of them were observed not to rely on APC funding, suggesting that these journals had found alternative ways to maintain operations. On average the yearly publication volumes of the surviving journals were rather small, with a median of 18 articles in 2014. 'Indie' journals in the social sciences and humanities collectively published the largest relative share of articles between the years 2010 and 2014. This finding provides evidence for the notion that scholar-led social sciences and humanities publishers played an active role in the history of the OA movement, as was also recently argued by Moore (2019).

Case studies of five 'indie' journals further explored the dynamics of this publishing model for early OA journals. By demonstrating five different development trajectories, the results provided insights into the options that such journals could use to ensure the continuity and longevity of operations. 'Indie' journals such as the *Electronic Journal of Information Technology in Construction* were found to be able to survive with minimal resources including the use of free IT platforms to host and publish journals as well as volunteer work for management and editing duties. However, the major concern would be how much volunteer editors can allocate time for unpaid editorial work for the journals. Two other case journals also indicated the possibility of successfully running an 'indie' journal provided that some kinds of external support, whether financial or technical, is available from libraries, institutions or governments. For example, both *First Monday* and *Information Research* are currently sponsored by universities. *Journal of Medical Education Online* represents another alternative scenario where the journal converted into an APC-financed model and is currently published by a major commercial publisher. A total of around 8% of the surviving 'indie' journals were found to be charging APCs. Potential challenges perceived for 'indie' journals included

maintaining a good inflow of submissions, a lack of long-term financial viability as well as handling editor changes.

The quantitative and qualitative results together contributed to a practical understanding of 'indie' OA journals with a particular focus on their long-term sustainability. Apart from this research, more work would be definitely needed to better understand this group of OA journals, for example, it would also be important to explore how similar journals founded after 2002 ensure their survival in the long run. Furthermore, such a study would be of practical use for small scholar-led journals informing them on sustainable means for managing their journals.

RQ (2): To what extent has the 'predatory' OA publishing market developed between the years 2010 and 2014 in terms of journal and article volumes, distribution over scientific disciplines, country of publishers and authors, APC levels as well as publishing speeds?

The second research question was addressed through bibliometric research methods, as reported in article 2. The main results indicated a rapidly growing trend of 'predatory' OA journal and article volumes from the year 2010 to 2014, based on a sample of journals generated using data from Jeffrey Beall's list, but there was a distinct variance in the growth rate across different strata and also a wide spectrum of APC levels. Publishers in the stratum with more than 100 journals in their portfolios published the largest number of 'predatory' articles, with pricing of an average of around 800 USD per article. Publishers in the stratum with 10-99 journals charged only 104 USD per article on average. Journals belonging to this lower-priced stratum started to dominate the market after 2012 in terms of annually published article volumes, in comparison to the journals of publishers with more than 100 journals. This could indicate that authors had a preference to publish in lower priced 'predatory' journals, leading to a faster volume increase in the 10-99 journal stratum.

Another important finding was that authorship was highly concentrated to Asia and Africa, with India the most prominent contributor. An earlier study by Solomon and Björk (2012a) found that 39% of authors from developing countries paid APCs out of their own pocket, which could explain the authors' preference for less expensive 'predatory' journals. India's high presence in the 'predatory' OA market was also reflected in the number of 'predatory' publishers located there (27% of all). As have been discussed in earlier Section 4.6, there are currently two opposite views with regards to the scale of this problem. Due to the present lack of empirical studies looking into the

real scientific impact of articles published in 'predatory' journals, it is too early to conclude how much harm such articles may have caused to scientific research. But clearly the existence of 'predatory' OA publishing severely taints the reputation of OA in general. In terms of the distributions across authors and publishers, the results of the study tended to suggest that the problem of 'predatory' publishing was mainly limited to a few developing countries, where 'international publication' is a prerequisite for academic appointment, more funding, or promotion. Furthermore, the size (in terms of turnover) of this market was still estimated to be relatively small, only 0.7% compared to the overall revenues from the global subscription journal market in 2014.

The results were useful for generating an overall picture of the 'predatory' OA market from a longitudinal perspective. In addition to measures of journal numbers, the results included an estimate of article numbers. Methodologically the study used a complex multistage sampling strategy to tackle the large population and make the generalizations possible, taking into account the major difference in publication volumes across journals. By doing this, the article contributes to a deeper understanding of this OA submarket both at the journal and article level. In future research, this study could be used as a baseline measurement for the 'predatory' OA market in 2014. Country-specific studies on the same issue would be useful as this problem was more concentrated to specific areas.

The results should also be of interest to various stakeholders involved with scholarly journal publishing, especially researchers, universities, research institutions and funders. Researchers could use it as a guideline to understand some of the characteristics of 'predatory' OA publishers and journals. Using results from this study, universities, research institutions and funders could consider possible measures to cope with this problem at various levels either through policy-making or by providing guidelines and information resources. Based on the citation data this article has been widely discussed in the field of information science. Beyond that, the results have also reached scientists from a much wider spectrum of areas, for example, medical researchers, health professionals as well as doctors. Upon its publication, the paper was reported in news items by Science Magazine and Times Higher Education (Johannon, 2015; Matthews, 2015). In a recent study, Financial Times ranks it in the fourth position on a list of a hundred research papers from business schools with the biggest social impact (Jack, 2020).

RQ (3): What are the key characteristics of Chinese-language OA journals, what are their publishers' major motivations in becoming OA, what are the perceived challenges in their operations and what are their attitudes towards internationalization?

This research question was addressed through a mix of bibliometrics and interviews (article 3). The design of the study was partly guided and informed by lessons and experiences learned from the first study. The main results show the absolute dominance of Chinese-language journals in China's OA landscape. The study also indicated that more than 60% of the Chinese-language OA journals were published by universities and scholarly societies and nearly 80% of the journals were long-established journals that had emerged before the digital age and converted to OA. These two important characteristics could partly be attributed to the specific situation in China where scholarly journal publishing is highly regulated by the government and where the role of journals in fulfilling the needs of local academics for publishing outlets is important.

Expectations of increased research impact through the open accessibility of the articles was a major motivator for the studied Chinese-language scholarly journals. There is a belief that such an increase in impact would lead to increased likelihood of getting governmental subsidies to support the development and continued operation of the journals. The journals were found struggling with soliciting a sufficient number of high quality papers and perceived this as the major obstacle to continued successful publishing. This issue was found to be a widespread problem for journals publishing in Chinese because of the increased tendency of authors to submit their manuscripts to international English-language outlets. Due to this trend, by 2011 67 % of all Chinese-authored scholarly articles were published in foreign journals (Wu & Wang 2013). The problem is likely to continue if the existing national research assessment systems continue to strongly favour papers in WoS and EI indexed journals, which are usually published in English-language international journals.

One possible solution would be internationalization of Chinese-language journals and increasing their visibility via inclusion in DOAJ, Scopus and other relevant international indexes. Nevertheless, financial instability made the Chinese OA publishers participating in the study hesitant to take further steps forward even though they showed some interest in this regard. A prominent finding from the publisher interviews was that Chinese-language OA journals were required to consider how to develop sustainable means for addressing their financial issues, and this issue warranted a wide discussion from all the stakeholders involved in China's scholarly journal publishing. The most important

recommendation for solving this problem was to establish a non-profit OA portal run by the Chinese government to support the publishing of local OA journals and to promote their electronic OA versions, similar to the popular Latin American SciELO portal. This would, on the individual journal level, significantly facilitate the setting up and running of OA journals as well as decrease the costs.

Article 3 contributed with a more comprehensive understanding of OA journals published in Chinese by not only presenting key journal bibliometrics but also by offering additional insights into the views of Chinese-language OA publishers on key aspects related to their publishing operations. The results of this study are difficult to generalize to the entire non-English OA publishing world, however, the situation in China might to some degree be similar to other countries where universities and scholarly societies dominate scholarly journal publishing and where journals rely to a large extent on external subsidy funding (for instance, countries in Latin America). Thus, this study presents one possible direction to study the OA situation within a particular country using a mixed methods approach. In addition, the recommendations made in article 3 present possible future directions for the local Chinese-language OA journals and provide useful practical advice to the government. Moreover, article 3 should of interest to those who are coming from outside China and wanting to learn more about the situation of OA in China.

7.2 Thesis limitations

A major limitation of the study is the reliance on secondary sources for identifying the journals of interest in the three focal areas. Due to limitations in these indexes and journal lists not all journals belonging to the three specific OA journal groups under study are necessarily covered in the three studies.

The first study identified the 'indie' OA journals from the combination of three earlier studies which focused on OA journals that had been founded or converted prior to 2002. Similarly, the third study used the COAJ index to aggregate a master list of OA journals published in Chinese language. COAJ has a good coverage of Chinese OA journals, but such indexes and portals are usually not comprehensive in covering all journals that would qualify, as the market keeps evolving over time. Beyond that, the study does not extend the analysis of Chinese-language OA journals to the article level. The main obstacle was the huge workload that would be involved in visiting 595 journal websites to count the total number of articles for every journal.

The use of Beall's blacklist as the source for identifying 'predatory' journals in the second study is a limitation. This blacklist has been criticized for not being transparent and for being based on only a single individual's subjective evaluation of publishers and journals. Because of this major controversy, it is likely that some publishers and journals which shouldn't be characterized as 'predatory' were still included in the blacklist. Similarly, it is highly probable that many journals that would qualify were not found, in this rapidly evolving market. It is in practice almost impossible to assemble and maintain a comprehensive list that is capable of capturing all possible and potential 'predatory' OA publishers and journals. Therefore, estimations of the market size based on Beall's list is limited by the likelihood of the list overestimating or underestimating the real extent of this problem. Nevertheless using his list was the most practical measure to address the proposed research problem at the time of the study, taking into account the limited time and resources of the research project. Beall's list has recently been succeeded by a similar blacklist from a commercial company, Cabell's, but that list still suffers from some limitations.

The second study is also limited by the type of sampling used in the study, which is more complex than normal stratified sampling not to mention straightforward random sampling from a comprehensive journal set. Because of the two stages of sampling, it is difficult to generalize to the full journal publishing landscape without to some levels sacrificing the measurement accuracy of the results. To overcome this, an observation of the full population of 'predatory' publishers and journals would be needed but doing that manually is not realistic considering that the population included 966 publishers and 11,873 journals. An automated web crawling software could have reduced the work to some degree, but to crawl the data from more than eleven thousand journal websites with different layouts and features adds much complexity to developing such software. An additional challenge is also generated by the fact that many 'predatory' journals have ceased publishing and their journal websites had been closed at the time of data collection. Hence, the article-level information is not searchable from their website, but getting that data requires additional steps in order to retrieve the volume count.

Although the final results were limited by reporting only a rough estimate of the 'predatory' OA publishing market, it did provide useful insights into the size of this phenomenon and served as a good starting point for attracting more efforts and resources from different stakeholders to resolve this problem. The reporting of this study in a high-impact OA journal (article 2) generated a lot of media attention and has

contributed to later research by others, as well as debates about the topic as evidenced by the number of citations that this article has received after its publication.

In addition to the above mentioned limitations of the quantitative results of all three studies, the qualitative results reported in articles 1 and 3 cannot be widely generalized due to the small number of qualitative cases and interviews.

7.3 Concluding remarks

This thesis extends the perspective on the landscape of gold OA by looking at three groups of OA journals, which previously had been the subject of few empirical studies, with the ultimate goal of generating a fuller understanding of gold OA publishing. 'Indie' journals, known for the volunteer model for OA publishing, are on average relatively small in terms of their article output per year. Similarly, most of the OA journals published in Chinese are low volume and usually do not charge the authors. They are mainly published by universities and scholarly societies and have converted from the traditional subscription model. This is also common in other countries where public subsidies are used to fund scholarly publishing such as the Nordic countries (Björk, 2019). In most cases, OA journals of these types have problems to scale up largely because they overly rely on external funding and thus rapid growth could possibly lead to financial instability.

By 2018, about 70% of the 12,180 gold OA journals indexed in DOAJ were free for authors to publish in. Publishers affiliated with universities, colleges or institutes were the largest group behind these journals, as a study by Crawford (2019) indicates. His DOAJ-based numbers however underrepresent the OA journals published in local languages, which is notably the case of Chinese-language OA journals. Therefore, the overall picture has highlighted the importance of studying the circumstances of these types of OA journals which are not based on APC-funding.

The 'indie' OA journals could in some respects be seen to fall into this category, as they also have strong links to the universities of their founding scholars. Firstly the universities have allowed the editors to dedicate a lot of their salaried work time to the journal operations, and secondly the journals have been running on university websites at no cost.

While APCs currently represent an increasingly common revenue source especially for major OA publishers, it is clear that this model has not yet addressed the key question

related to the sustainability of the OA model for smaller non-commercial publishers and this could be argued to be a part of the reasons behind the challenge posed by the full transition to OA. Today's realised scenario of OA publishing differs from earlier predictions, where the OA model financed by APCs was believed to reduce overall publishing costs (Poynder, 2012; Green, 2019). However, the costs associated with APCs for OA journals is constantly rising (Universities UK, 2017). From this perspective, there is an urgent need in the near future to continue looking at the development of OA journals based on other publishing models, like the types of journals studied in two of the articles included in this thesis and to explore how to develop alternative sustainable OA publishing models that are suitable to be adapted to different local environments. This is not just a potential research area for OA researchers, but also an important topic for all stakeholders involved in scientific communication and journal publishing. In combination with appropriate sustainable publishing models, it also calls for more studies on the development of governance models that work for different OA journals to ensure the sustained publishing of OA articles, more importantly, to serve the real needs of the academic community.

Furthermore, the lacking awareness of different OA publishing models among scholars continues to cause confusion. This can for instance lead to equating OA journals with only journals where the authors have to pay for publishing, or to difficulties in distinguishing between 'predatory' publishers and legitimate newly-founded OA journals. While the rise of 'predatory' OA publishers has increased suspicion towards the use of APCs in "Gold" OA, the results of the second study indicated that it tends to mainly be a regional problem given the skewed distributions of 'predatory' publishers and authors towards a few developing countries. In order to inhibit the growth in the number of 'predatory' OA publishers, collaborative efforts are needed from various involved stakeholders. The scenario of OA publishing established in Latin America might provide one direction for other regions of the world, where regional portals like SciELO play a key role in hosting and publishing legitimate local OA journals, and also providing the integrated governance infrastructure that can strengthen the credibility of the included journals towards international indexing services.

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APPENDIX 1 ARTICLES

Article 1: Björk, B-C., **Shen, C.**, & Laakso, M. (2016). A longitudinal study of independent scholar-published open access journals. *PeerJ*, *4*, e1990. doi:10.7717/peerj.1990

Article 2: Shen, C., & Björk, B-C. (2015). 'Predatory' open access: a longitudinal study of article volumes and market characteristics. *BMC Medicine*, *13*(230), 1-15. doi:10.1186/s12916-015-0469-2

Article 3: Shen, C. (2017). Open access scholarly journal publishing in Chinese. *Publications*, *5*(4), 1-17. doi:10.3390/publications5040022

PeerJ

A longitudinal study of independent scholar-published open access journals

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ABSTRACT

Open Access (OA) is nowadays increasingly being used as a business model for the publishing of scholarly peer reviewed journals, both by specialized OA publishing companies and major, predominantly subscription-based publishers. However, in the early days of the web OA journals were mainly founded by independent academics, who were dissatisfied with the predominant print and subscription paradigm and wanted to test the opportunities offered by the new medium. There is still an on-going debate about how OA journals should be operated, and the volunteer model used by many such 'indie' journals has been proposed as a viable alternative to the model adopted by big professional publishers where publishing activities are funded by authors paying expensive article processing charges (APCs). Our longitudinal quantitative study of 250 'indie' OA journals founded prior to 2002, showed that 51% of these journals were still in operation in 2014 and that the median number of articles published per year had risen from 11 to 18 among the survivors. Of these surviving journals, only 8% had started collecting APCs. A more detailed qualitative case study of five such journals provided insights into how such journals have tried to ensure the continuity and longevity of operations.

Subjects Science Policy
Keywords Open access, Scientific publishing

INTRODUCTION

Background

Individual scientists or groups of scientists were the first to take advantage of the Internet and the web for dramatically re-engineering the publishing of scholarly peer reviewed journals in creating Open Access (OA) journals. Commercial publishers or scientific societies, who have dominated traditional subscription-based publishing of academic journals, have followed much later. In the mid 1990s, electronic-only publishing in conjunction with the OA model seemed ideologically right and suddenly the threshold for starting a journal had dramatically lowered. All that was needed was some server space at the university of one of the editors, someone who mastered a bit of web programming and an enthusiastic group of academics to spread the word via email and academic conferences.

Most of the OA journals founded in the 1990s were of this variety, later many established subscription journals (particularly society ones) have made their digital versions freely available immediately or with a delay. This has been particularly noticeable in countries where cheap or free national or regional electronic portals have become available, like Scielo, Redalyc, and J-stage. Since around 2003 the OA market has become increasingly

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Additional Information and Declarations can be found on page 14

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OPEN ACCESS

dominated by professionally published journals, which finance themselves by charging authors so-called article processing charges, APCs. At first such journals were being launched by open access publishers like BioMedCentral and PLOS, but in the last couple of years the major commercial and society publishers have increasingly started new OA journals and have also converted some subscription journals to APC-financed models.

Over the years a debate has been raging about the sustainable expenditure for publishing scholarly journals, an issue of particular importance if all journals were to convert to OA (in particular financed by APCs). At one end of the spectrum are the major commercial publishers who claim expenses of around 3,000–5,000 USD per published article (*Morris, 2005*). At the other extreme are scholars engaged in the OA movement (i.e., *Odlyzko, 1997*), who propose that journals can be operated on very low budgets and can be "gratis" at both ends, given that academics can perform almost all needed functions as part of their academic duties anyway, without extra monetary compensation. Much of the publisher-led discussion has been focused on the expenses of IT infrastructure, and copy editing, which are visible parts of the work done in publishing. Less emphasis has been on the tasks involved in coordinating and motivating the network of editors, editorial board members, reviewers, submitting editors etc. which are an essential part of running a journal.

Often the enthusiasm of the founders and their personal network can carry a volunteer-based journal for a few years. But at that same time this type of journal, which lack the support of employed staff and a professional publishing organization, are threatened by many dangers. The editor may change affiliation or retire, or the support of the university hosting the journal might be withdrawn. Authors may stop sending in good manuscripts and it may become more and more difficult to find motivated reviewers. Not being included in the Web of Science, and the impact factor that follows, may in the long run limit the number of submissions severely. On the positive side of the balance the emergence of open source software for publishing (i.e., Open Journals System) and cheap or free hosting services like Latin American Scielo have facilitated the technical parts of publishing.

Now that 15–25 years have passed since the first wave of independent, scholar-published journals were founded, there should be enough concrete evidence to answer questions relating to their sustainability. Much of the data is available freely on the web and it is possible to study which of the early journals have succeeded, which have ceased publishing and which have converted to APC-funding or have been taken over by professional publishers.

Earlier studies

A number of previous studies, both snapshots and some with longitudinal elements, have shed light on different aspects of such type of journals, which for short we will call "indie" journals.

Hitchcock, Carr & Hall (1996) studied electronic English language STM journals available in September 1995. 44 of the 83 relevant journals that they found first appeared in 1995. The share of OA journals varied strongly depending on the type of publisher, with 27% for commercial publishers, 52% for scientific societies and 96% for others (mainly university departments).

Harter & Kim (1997) identified 131 electronic journals, which were active in 1996, of which 77 were judged to be peer reviewed journals (of these 39 had published articles in 1993 or before). Since their study was based on e-journal lists compiled in the US, the study had a strong bias to English-language journals. The hard sciences, social sciences and humanities had about equal shares, with the most popular topics being education, literature, mathematics and library and information science. A total of 69% of the journals had only an electronic version while the rest were published in parallel in print. A total of 88% of the journals were OA.

The MSc thesis of *Wells (1999)* was the first to explicitly focus on scholarly or peer reviewed journals, which were free to read (the term Open Access came into use only around 2002). She was able to identify 387 such journals. Probably due to the journal lists she had used as a starting point, over half the journals were published in the US. Overall the vast majority of journals (around 90%) had started publishing in 1994–1998. Her statistics about the organization/person responsible for publishing the journal was interesting: 56% academic, 14% learned society, 13% commercial and 17% other types. For the electronic only journals, 37% were in the social sciences, 20% in life sciences, 19% in arts and humanities, 14% in the physical sciences and 9% in engineering. The overall mortality rate of journals (where the website could not be found or which had not published articles in 1998–1999) was 25%. The highest mortality rates were observed in journals within social science (43%) and humanities (21%).

The first study to look more explicitly at the fate of early OA journals was *Crawford (2002)*. He grouped 104 journals that had been listed in the Association of Research Libraries' (ARLs') Directory of Electronic Journals, Newsletters and Academic Discussion Lists for 1995 depending on their publication output between 1993 and 2000. He found that 27% were publishing substantial amounts of articles, 20% still published small but steady flows of articles, and that 19% seemed "to have fallen prey to the arc of enthusiasm: after a few good years, the journals had died or become comatose." For the rest of the journals their websites were confusing or could not be found.

Our own research group studied OA journals in 2002–2003, using in particular *Wells (1999)* study as a major input. In the first phase of the study (*Gustafsson, 2002*) 317 OA scholarly journals were identified. *Gustafsson (2002)* also studied the status of the journals identified as active in 1998 by *Wells (1999)* and found that 50% were still active in 2002. In the follow-up study (*Hedlund, Gustafson & Björk, 2004*) the editors of all the 317 journals (for which an email address was found) were sent a web survey, for which the response rate was 20%, hence 60 editors answered more detailed questions about their journals. The range of the number of articles published by these 60 journals in 2002 was 3-111, with an average of 20 and a median of 17. The average rate of acceptance for submissions was 50% and 6 out of 60 journals were indexed by the Web of Science. The cost structure of publishing the journals was asked in the form of the time allocation for general tasks such as management and IT-infrastructure (250 h per year) and for the processing of the average article, which was 22 h.

In their conclusions *Hedlund, Gustafson & Björk (2004)* ask the question "The key question for OA publishing is whether it can be scaled up from a single journal publishing

model with relatively few articles published per year to a comprehensive major journal with of the order of 50–100 articles annually.'' They further note: ''The continuation of the journal relies very heavily on the personal involvement of the editor and is as such a risk to the model. Employing staff to handle, for example, management, layout and copyediting tasks, is a cost-increasing factor that also is a threat to the model.'' Both questions are still highly relevant today.

Since the above studies were carried out, the most significant development affecting the publishing of independent scholar-published journals, has been that free or extremely cheap IT-platforms for publishing journals have become available. In particular the Open source software Open Journals Systems has rapidly become very popular as the basic platform both for publishing articles and for managing the peer review process. OJS is currently used by more than 8,200 journals (*PKP, 2016*). *Edgar & Willinsky (2010)* surveyed 3,000 journals using OJS in 2009 and obtained answers from 998 journal editors. The vast majority of the journals charged neither publication fees nor fees for access, and 83% were OA. Academic departments (51%) and scholarly societies (32%) dominated the picture. The geographic spread included South America with 28%, Asia with 13% and Africa 7%. Topically the STM sciences had 40%, social sciences 30% and humanities 11%. The average number of articles published was 31 per year with 74% publishing 0–30 articles, and 9% 60 or more. The study also contains interesting data about the workload done, revenues etc.

Since 2009, the OA journal scene has changed considerably with the increased presence of APC funded commercial publishers. The publishers who are members of the Open Access Scholarly Publishers Association (OASPA) published around 140,000 articles in 2014 (*Redhead, 2015*). Increasingly leading commercial and society publishers are starting new full OA journals or converting existing subscription journals to OA funded by APCs. Unfortunately, academics are also swamped with requests to submit to so-called predatory OA journals with deficient or non-existent peer review practices (*Shen & Björk, 2015*). Much of the debate about Gold OA concerns APC journals and the majority of OA journals which are free to publish in create much less debate, perhaps because many of them are published in languages other than English and in countries outside the US/UK.

Offering qualitative insight into the current challenges of small independent scholar-led journals, *Morrison (2016)* recently interviewed 15 individuals currently involved in producing such journals. Though most believed that the journals would be able to survive in the increasingly competitive OA landscape, many also expressed concerns about their abilities to thrive with existing reliance on external subsidy funding and the level of technical support currently available to them.

The question remains, how sustainable has the independent scholar-published OA journal model been for journals who adopted the model early? The major advantage of these journals some 20 years ago as well as today is that they are rarely based on APC-funding which might be an obstacle for some potential authors without means or mechanisms to fund them.

METHODS

So far a lot of the discussions (for instance in e-mail discussion lists) about the viability of the 'indie' model has been rather speculative and based on the reporting of anecdotal success stories. Now that over 20 years have passed since the first proper wave of journals founded based on an OA publishing model, there is sufficient longitudinal data available to evaluate the sustainability of the OA model for these early independent OA journals.

The study consists of a quantitative and a qualitative part. The quantitative part builds upon OA journal listings from early OA studies of *Wells (1999)*, *Crawford (2002)*, and *Hedlund, Gustafson & Björk (2004)*. The list of journals from these studies were aggregated into a master list of 264 journals, after which non-independent (e.g., commercially-published, society-published) and journals which had converted from print to OA were removed from the sample (14 in total), resulting in a population of 250 'indie' journals in our study. Each of the journal websites were visited during the second half of 2015 in order to record longitudinal published article volumes, focusing on collecting data about peer-reviewed articles and leaving out editorials and other non-core contents. Some of the earlier studies had already collected and published article volumes and in such cases that data was used and extended. Where available Scopus or DOAJ was used to collect bibliometric information for journals, however, for most the collection was handled manually. It is a cohort type of study, concentrating on journals founded as OA journals prior to 2002 and which we knew were active in that cut-off year. Due to the limited number of journals included in the population sampling was not needed, the whole population was observed.

In the qualitative part the development of five successful 'indie' journals over the past twenty years are described as a multiple case study. The focus is on how the work has been organized and on possible changes in strategies during this time.

RESULTS AND DISCUSSION

Quantitative results

In all of the reporting below, 'indie' OA journals which were no longer active and for which no information could be found on the Internet due to completely vanished presence were excluded. When counting the number of OA articles published every year, only articles from journals which have remained with the OA publishing model throughout their lifetime were taken into consideration. Due to a very low number of both 'indie' journals and OA articles in them between 1987 and 1994, the results for journal volumes and article outputs are presented from the year 1995 onwards. For the average OA article per journal, we provided the medians instead of the means due to a highly skewed distribution in the original data, where a couple of very high-volume journals raise the arithmetic mean disproportionately.

Number of active 'indie' journals over time

Descriptive statistics for the total population of 250 'indie' OA journal founded before 2002 are shown in Table 1. 23 of the journals in the population were categorized as disappeared journals because we could not find their complete information for previous years, they had vanished without a trace and nor was a record of them available from the Internet

Table 1 Descriptive statistics for the journals included in the study.

Population: 250 'indie' journals		
Number of active journals	Journals that become subscription journals	12
	Journals that remain with the OA model	115
Number of ceased journals	100	
Number of disappeared journals	23	

Archive. As such they can be considered ceased but there is no way of determining when they stopped publishing so they are treated separately in the results. The rate of still active journals of the 250 journals that we studied was 50.8%, meaning that approximately half of them were still publishing.

Among the still active journals, the majority have remained with the OA publishing model, however a small number of journals (9%) have converted to the subscription-based model. Most of these had been taken over by large commercial publishers using the traditional subscription-based publishing model, on average 12 years after they had been launched. The share of 250 'indie' journals that are currently included in DOAJ and Scopus, are 39.6% and 40.5% respectively. The reason why Scopus has a slightly higher inclusion rate than DOAJ is likely due to the fact that DOAJ has had a policy of removing non-active journals, while Scopus retains historical records of journals regardless of their status. The results also support the fact that nearly half of 'indie' journals have gained good reputation already, since their inclusion in these major indexes and is consistent with the result that about half of the journals were still active as at 2014.

The development over time of active 'indie' OA journals before and after 2002 is shown in Figs. 1A and 1B. A journal was counted as 'active' in a particular year if it was still publishing articles in that year. Before 2002 the number of active journals grew very rapidly from a total of 76 journals in 1995 to 207 journals in 2002. The year 2002 was the cut-off year to be included in the studied cohort, meaning that no new journals were added to the data set after this point in time. After 2002, the number of journals in the cohort decreased steadily to the 127 that stayed active in 2014.

The share of surviving journals currently charging APCs was also observed, with a result that nearly 8% among them did so. Clearly this is a viable option for keeping a journal running, provided that the submission levels do not drop significantly after this. It is also an option which is better suited for journals in the hard sciences, in particular health and biomedicine journals, due to the fact that APC-funded OA journals are more common with funding mechanisms more widely established and available to researchers.

Annual median number of articles per journal

Figures 2A and 2B describe the annual median number of articles published by the 'indie' journals. The number was relatively stable at around 10 articles in the period 1995–2002. This may be the result of many of the journals just having started their existence at that time, with understandably few articles in the first few issues. After 2002, the median for active journals increased steadily from 11 in 2003 to 18 in 2014. Again, this is probably a result of the fact that the surviving journals had already established a good reputation and increased submission numbers during the period, i.e., the stronger getting stronger.

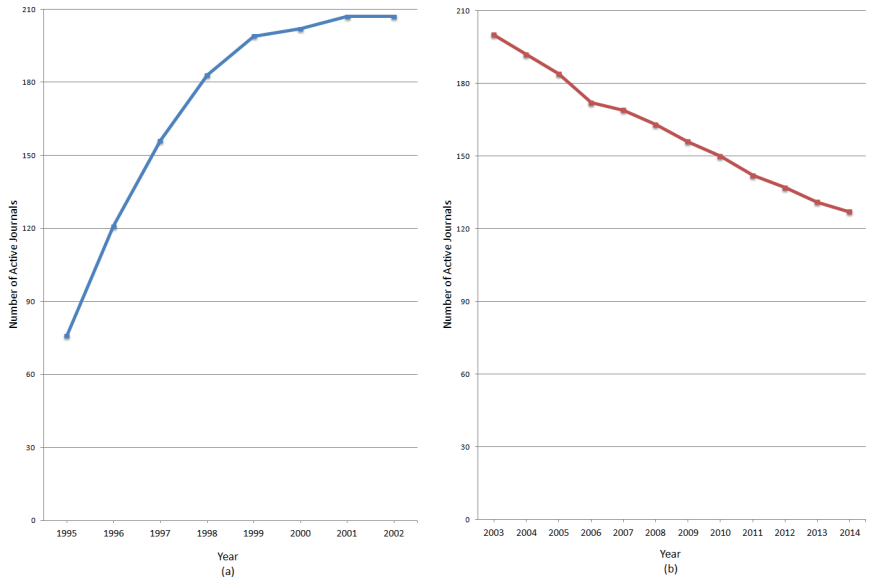

Figure 1 The number of active 'indie' journals from the cohort of journals founded prior to 2002. (A) Results between 1995 and 2002; (B) Results after no new journals were added from 2003 till 2014.

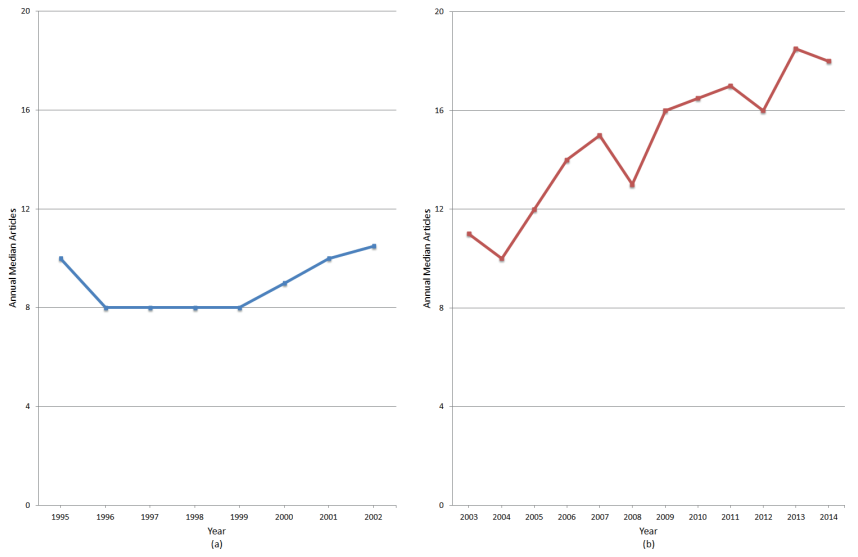

Figure 2 Annual median number of articles published by 'indie' journals from the cohort of journals founded prior to 2002. (A) Results between 1995 and 2002; (B) Results after no new journals were added from 2003 till 2014.

Table 2 Main results datasheet.

Year	Annual median articles per journal	Total number of articles	Number of active journals	Number of ceased journals
1995	10	862	76	1
1996	8	1,305	121	2
1997	8	1,819	156	3
1998	8	2,243	183	1
1999	8	2,593	199	2
2000	9	3,095	202	4
2001	10	3,135	207	1
2002	11	3,563	207	5
2003	11	3,715	200	7
2004	10	3,497	192	8
2005	12	4,241	184	8
2006	14	4,090	172	12
2007	15	4,394	169	3
2008	13	4,760	163	6
2009	16	4,681	156	7
2010	17	5,083	150	6
2011	17	5,290	142	8
2012	16	4,934	137	5
2013	19	5,298	131	6
2014	18	4,954	127	4

The detailed results are included in Table 2 together with other main results for total article volumes. There is a continuous growth in the number of articles published by active journals over the past decades from 862 articles in 1995 to 4,954 articles in 2014, despite the fact that no new journals were added after 2002 (when 3,563 articles were published). The growth between 2003 and 2014 is explained by the growth of the per journal publishing figures. These findings suggest that at least half of the 'indie' journals are quite sustainable, at least at their current publishing level.

Age distribution for ceased journals

Figure 3 illustrates at what age ceased 'indie' journals stopped publishing. Most journals survived the first 2–5 years period, whereas the mortality rate rose in the critical 6–9 years period. After that, the number of journals ceasing dropped sharply, indicating that the surviving journals had found stability.

Subject fields

Figure 4 describes the distribution of total OA articles published across different subject fields. During the four time periods we studied, the article volumes have shown a fast growth in most disciplines except for chemistry, physics and astronomy as well as business and economics. The largest share of articles was in the social sciences with nearly 8,000 articles published in the most recent four years, followed by mathematics with almost 6,000 articles. The discipline of earth science and biomedicine ranked third (4,123 articles) and fourth (3,383 articles).

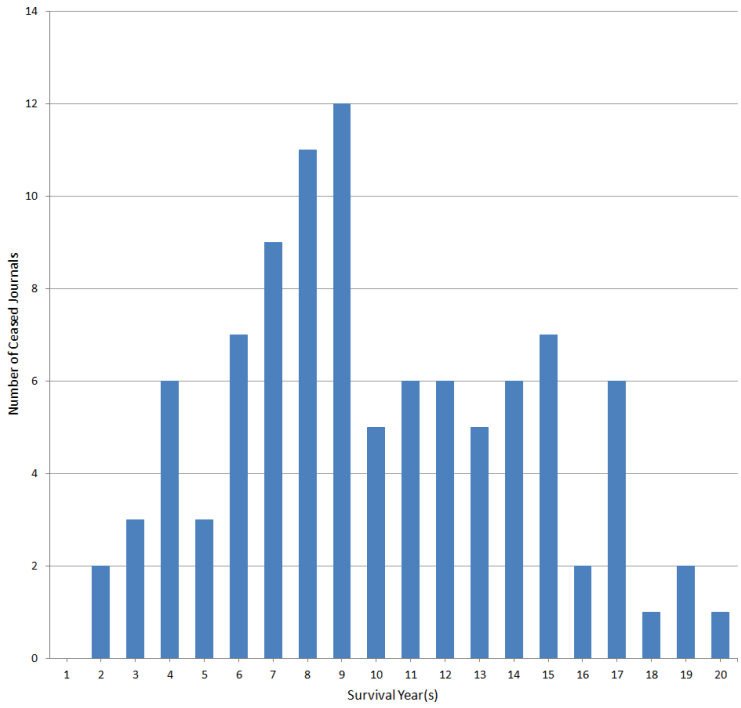

Figure 3 **Age distribution for ceased journals.**

Five cases

In the following five case journals, all founded around 1995 are presented. All journals are still surviving and they were picked as a convenience sample, representing slightly differing evolutionary paths. Two of the journals are nowadays charging APCs and one of these has been turned over to a professional OA publishing company. For some of the discussed journals there are published case studies and descriptions available. One of the authors of this article was the founder and long-time editor of ITcon. As for MEO an interview was conducted with the former editor-in-chief.

Electronic Journal of Information Technology in Construction

The journal, abbreviated ITcon, was founded by four researchers from different parts of the world, active in the same research area, and part of a network meeting at regular yearly conferences (*Björk & Turk, 2006*). The first author of this study was the editor-in-chief, and hence the official publisher was at first his university at the time being. Later when he moved to another university an international organization of building researchers was asked to be the official publisher, but this has in fact been a "rubber stamp." The web server used has all the time been at the university of another one of the co-editors, who also programmed the first software needed to publish articles. The software has undergone

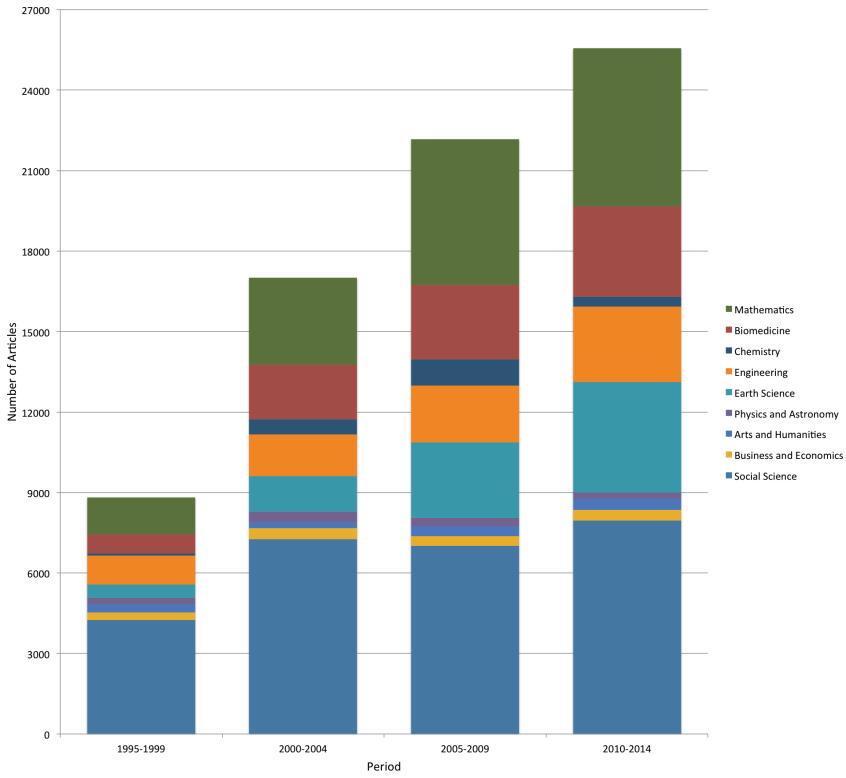

Figure 4 **The distribution of OA article volumes over time and across subject fields.**

a couple of revisions, partly indirectly funded via an EU research grant, and also includes facilities for managing submissions and reviews. That part has however been difficult to use and is no longer actively used. There have been discussions about going over to the use of OJS or some similar open source software, but so far this has not been done.

The first four years the journal was struggling to get submissions and only published 3–5 articles per year. It was saved by the suggestion of one of the editorial board members to start publishing special issues, which previously had been deemed out of the question since the aim was to publish papers as soon as they had gone through the review process. Since 2001 the journal has regularly published more than half of its articles in special issues. The experience is, that researchers are more keen to publish in special issues than to submit individual papers. Also it is usually easy to outsource the whole process to volunteers acting as guest editors for an issue.

Looking at the competition of 3–4 subscription journals with similar topics, ITcon would really have benefitted from inclusion in Web of Science and getting an impact factor. One attempt was made, in 2006, but unsuccessfully. Currently the journal is "struggling" with a yearly output of between 20 and 40 articles. What probably has saved the journal (which

has no income but is fully based on volunteer work and the access to a free server) is the tiered managerial structure of up to ten co- and junior editors, which helps in spreading the workload of overseeing the review of submitted manuscripts. It can thus be characterized as a collective endeavor.

Journal of Medical Education Online

The idea of the Journal of Medical Education Online, abbreviated MEO, came from the founding editor's dissatisfaction around 1995 with how traditional academic publishers were ignoring the new opportunities offered by the Internet. After discussions with several colleagues, David Solomon originally envisaged MEO as a forum for knowledge exchange for both researchers and educators in the field, with a peer-reviewed journal as the centerpiece (*Solomon, 2007*). Over the years the additional features did not really catch on, but the peer-reviewed section has remained. After a few struggling years with below ten published articles per year, the journal started to rapidly gain momentum reaching 100 yearly submissions in 2006.

Similar to many other journals with a heavy involvement of the editor-in-chief MEO has changed publishing venue according to the editor's affiliation, depending on his employer allowing a considerable input of work time. In the case of MEO, the editor in addition to overseeing the reviewing spent a lot of time on developing both the publishing and workflow platform during the first ten years of the journals existence. In 2005, the rapidly grown submission flow necessitated a restructuring of the editorial process so that a number of co-editors helped share the burden. There were also plans to move the journal back to the original university in Texas and for new people to take over the responsibility of the journal, but these plans were partly upset by hurricane Katrina. Instead, one of the people, Ann Frye joined David Solomon in co-editing the journal.

An important goal for the journal has all along been indexing in major indexes, including Medline. A prerequisite for getting accepted in that index was the formatting of articles in XML meeting the National Library of Medicine's (NLM) standards which requires a great deal of expertise. The journal began charging an APC of 100 USD to cover the expense of using a professional service to format articles and create an XML version meeting NLM standards. The fee was raised to 200 USD a year later to cover professional copy-editing. Getting accepted in Web of Science took an additional three years after the journal was accepted into Medline and Scopus.

Around 2009, the two editors decided they wanted to use a professional publisher freeing them to focus on the editorial tasks and providing professional level publishing services. Since an APC of 200 USD had not reduced submissions, they felt it was worth the risk of increasing the APC considerably to have the journal professionally published. Discussions were started with a small OA publisher, Co-Action publishing. David Solomon knew and trusted the owners of the company have worked with one of the principals of the company in forming OASPA. Initially, the two editors retained 50% ownership with Co-Action receiving 50% ownership for taking full financial responsibility for the journal. After two more years, the original editors decided to step down as editors and gave full ownership to Co-Action and engaged new editors who receive a small fee for the work

from the publisher. After an initial APC of 600 USD the APC has been increased in several increments to 1500 USD, while the number of publications per year has steadily increased.

Information Research

The origins of IR were in a newsletter from the centre of user studies at the department of information studies at the university of Sheffield, which from 1990 was transformed into Information Research News, which published working papers in print (*Wilson, 1998*). From April 1995 a parallel electronic version was published and in 1997 the print version was ended. Initially the focus was on publishing un-refereed papers from the department, but gradually the focus shifted to peer-reviewed papers with mainly outside authors. The university provided indirect support in the form of the web server and allowing staff the time to work with the journal.

Later as the editor retired the journal has shifted locus. The journal home page currently says about the journal: "It is privately published by Professor TD Wilson, Professor Emeritus of the University of Sheffield, with in-kind support from Lund University Libraries, Lund, Sweden and from the Swedish School of Library and Information Science." The home pages also contain a plea for sponsorship either directly in money or in kind, as well as advertisements. In particular, the journal is seeking volunteers to help in copy-editing or formatting. In a recent web survey of readers or authors (*Wilson, 2012*) the respondents were directly asked how likely they would be to continue submitting articles to the journal if it had to start collecting APCs.

The journal has a stable output of four issues a year. The journal also contains book reviews, conferences announcements etc. It is highly ranked in the rankings of information system journals in many countries.

In contrast to many other 'indie' journals, Information Research has remained with html for the published papers, assuming readers would read directly from the screen. This format enables hyperlinking references in the text with the list of references.

The key to success for IR seems to have been in quite rapidly being able to publish a full journal with quarterly issues, at a time when major publishers were just starting to publish electronic versions of their paper journals. Probably early indexing in Web of Science, with a resulting impact factor, has also helped the success of the journal.

Despite having its origins in a print departmental newsletter, we feel that Information Research can be characterized as an 'indie' journal, especially after severing the ties with mother organization.

Electronic journal of Geotechnical Engineering

This is an interesting case of an 'indie' journal turned predatory. Published by a now retired professor from an American university, the first issue in 1996 contained invited papers after which the journal was a typical struggling 'indie' journal with a slowly rising publication volume from 4 to 33 papers between 1997 and 2007. After that the volume has dramatically risen to 628 in 2014. Jeffrey Beall wrote a blog accusing the journal for having turned predatory in July 2015 (*Beall, 2015*). Currently the journal pages say "editorial fee is $500 for the entire editorial and publishing work. Following the "supply and demand" rule of economics, this may be modified". The journal website still has an amateurish 1990's

feel and look (authors are instructed that they can also send the files on floppy disks!) and authors sign over the copyright to the journal.

First Monday

The first publisher of First Monday was curiously a Danish commercial publisher (Munksgaard) that was keen on experimenting with the new medium that the Internet offered. In 1999 the journal was bought by the editor Edward Valauskas, whose idea the journal had been from the start, with two colleagues (*Pauli, 2011*). Valauskas had all the time insisted that the journal be OA and that authors retain copyright, whereas Munksgaard had planned for the journal to evolve into a subscription journal after an initial open offering. Since then the journal has been hosted by the University of Illinois in Chicago and is currently using the OJS platform.

First Monday is published on the first Monday of each month, a reference back to the schedule of the first scholarly journal: Philosophical Transactions of the Royal Society. For a journal with no monetary budget it is quite amazing that it has published more than 1,500 articles, and despite the fact that the journal is not indexed in the Web of Science. One of the reasons for the popularity of the journal is that it is a multidisciplinary journal about the phenomenon Internet and that it has achieved a strong following in that niche area.

In 2011 the acceptance rate was as low as 15%, which means that there is a lot of work behind each published article.

CONCLUSIONS

The 'indie' journals that comprise this study are children of their time, early pioneers in adopting a disruptive innovation for scholarship. With no or very little subscription income, and author-fees being an unestablished concept, the circumstances for running an independent journal was certainly a challenge in the 1990s and early 2000s. This study is limited to observing the sustainability trajectories of early 'indie' journals, the thousands of similar journals founded since then might have very different characteristics and warrant focus in future studies.

Nowadays the overall scene for launching OA journals looks very different than it did some 20 years ago. Currently there are a few specialized OA publishers and also the big established subscription publishers. The norm nowadays is also increasingly to collect APCs. Nevertheless early 'indie' journals have played an extremely important role in promoting OA, and some 'indie' journals have become important journals in their niche areas. Comparing the longitudinal publishing and citation metric trajectories of 'indie' journals to commercially-operated counterparts could also be a potential avenue for future studies to explore.

The quantitative study shows that even successful 'indie' journals tend to be rather small, the median being 18 articles per year. A fairly large share of articles is in the social sciences and humanities. Areas such as mathematics and earth sciences have, however, grown in importance over the years. Looking at the mortality rate of journals, it is evident that the years 6–9 are crucial. The initial enthusiasm can sustain even a very low volume journal for a while, but after the journal has to have a reasonably good inflow of manuscripts, both

to be able to ensure the quality of published articles as well as credible article numbers. We also already found that 8% of the surviving 'indie' journals have started collecting APCs as a means to ensure enough revenue to keep the journal running.

The cases studies demonstrate that remaining pioneer journals could consider exploring alternative scenarios in order to ensure survival. Journals operating in the hard sciences may well start charging APCs, given that mechanisms for funding these are evolving in many countries. An important issue for all such journals lacking the backing of a professional publishing organization, old or new, is to provide for a generation shift in the editor function.

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Author Contributions

- Bo-Christer Björk conceived and designed the experiments, performed the experiments, analyzed the data, wrote the paper, reviewed drafts of the paper.
- Cenyu Shen performed the experiments, analyzed the data, wrote the paper, prepared figures and/or tables, reviewed drafts of the paper.
- Mikael Laakso conceived and designed the experiments, performed the experiments, wrote the paper, reviewed drafts of the paper.

Data Availability

The following information was supplied regarding data availability:

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Supplemental Information

Supplemental information for this article can be found online at http://dx.doi.org/10.7717/peerj.1990#supplemental-information.

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RESEARCH ARTICLE Open Access

'Predatory' open access: a longitudinal study of article volumes and market characteristics

Cenyu Shen* and Bo-Christer Björk

Abstract

Background: A negative consequence of the rapid growth of scholarly open access publishing funded by article processing charges is the emergence of publishers and journals with highly questionable marketing and peer review practices. These so-called predatory publishers are causing unfounded negative publicity for open access publishing in general. Reports about this branch of e-business have so far mainly concentrated on exposing lacking peer review and scandals involving publishers and journals. There is a lack of comprehensive studies about several aspects of this phenomenon, including extent and regional distribution.

Methods: After an initial scan of all predatory publishers and journals included in the so-called Beall's list, a sample of 613 journals was constructed using a stratified sampling method from the total of over 11,000 journals identified. Information about the subject field, country of publisher, article processing charge and article volumes published between 2010 and 2014 were manually collected from the journal websites. For a subset of journals, individual articles were sampled in order to study the country affiliation of authors and the publication delays.

Results: Over the studied period, predatory journals have rapidly increased their publication volumes from 53,000 in 2010 to an estimated 420,000 articles in 2014, published by around 8,000 active journals. Early on, publishers with more than 100 journals dominated the market, but since 2012 publishers in the 10–99 journal size category have captured the largest market share. The regional distribution of both the publisher's country and authorship is highly skewed, in particular Asia and Africa contributed three quarters of authors. Authors paid an average article processing charge of 178 USD per article for articles typically published within 2 to 3 months of submission.

Conclusions: Despite a total number of journals and publishing volumes comparable to respectable (indexed by the Directory of Open Access Journals) open access journals, the problem of predatory open access seems highly contained to just a few countries, where the academic evaluation practices strongly favor international publication, but without further quality checks.

Keywords: Open access, Scientific publishing

Background

Introduction

The publishing of scholarly journals has, like so many other areas in business and society, undergone a radical transformation due to the emergence of the Internet. Mainstream publishers of subscription journals started publishing parallel electronic versions of their journals around the millennium shift [1] and today electronic delivery of big bundles of journals via e-licensing is the dominating business model.

A side-effect of this transformation was the prospect it offered for a more radical rethinking of revenue models. New innovative publishers repositioned themselves as service providers to the authors, publishing with them, rather than seeing themselves as content providers to readers. In this model, authors pay the publishers for their services, including that the articles become freely accessible to anybody with Internet access (open access, OA). Other than that, the peer review practices, layout, indexing, and so on, remain largely the same. A major difference is nevertheless that the journals are published only in electronic format and that the delay from

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submission to publishing is usually shorter compared to traditional scholarly journals.

Open access scholarly publishing also includes OA journals without publishing fees and subscription journals, which also make their electronic version freely available directly or after a delay [2]. In addition, the vast majority of subscription journals from leading publishers nowadays make individual articles available after payment, so-called hybrid OA [3]. Direct OA publishing is often called 'gold' OA. In addition, there is a 'green' route in which authors or third parties can legally make manuscript versions of articles published in traditional journals freely available on the Internet [4]. This can be done on the authors' own webpages, or preferably in institutional or subject-based repositories.

The number of OA journals charging authors (using article processing charges, APCs) and the number of articles published by them has rapidly risen in the last decade, and some journals have reached a high scientific status in their field. Publishers have also started experimenting with novel forms of peer review, in particular in so-called 'megajournals', which only check for scientific rigor and validity, not for the significance of the results, which is left to the readers to decide [5]. The spectacular success of the leading megajournal, *PLOS ONE*, which publishes around 30,000 articles per year, shows that authors appreciate this model.

This study is, however, concerned with a peculiar subclass of OA journals using APCs, made possible by the global reach and cost-effectiveness of the Internet. Publishers of this type of journal seem to be in the scholarly publishing business only in order to collect APCs and provide rapid publishing without proper peer review for authors who need publications in their CVs. The information on the Internet about the journals is often strongly misleading, and the publishers spam academics all over the globe with requests for submissions and reviews and for joining editorial boards.

Jeffrey Beall coined the phrase 'predatory publishers' to describe publishers of this sort of journal [6]. Another term that has been suggested is pseudo-journals [7]. Beall has also defined a long list of criteria for identifying such journals and produces a continuously updated index of publishers as well as individual journals fulfilling such criteria [8].

Predatory publishers have caused a lot of negative publicity for OA journals using APCs, partly due to the spam email that they constantly send out to researchers and partly due to a number of scandals involving intentionally faulty manuscripts that have passed their quality control. Predatory OA is regularly discussed and warnings are issued in academic journals, in particular in editorials of scholarly journals [9] and journals widely read by medical practitioners [10]. This indirectly makes it more difficult for serious OA journals to attract good manuscripts and get accepted to indexes such as Web of Science.

Since most of the reporting in the media about predatory OA has been concerned with individual cases and there have been very few scientific studies of the topic, the overall aim of this study was to: estimate the overall size of predatory publishing; examine how it has grown in the last few years; and measure key characteristics of this market.

Earlier research

Reports of substandard or even nonsensical papers having been published in peer-reviewed journals have gained a lot of publicity through coverage in the popular press. In 2009, Phil Davis reported that he and a colleague had submitted a grammatically correct but nonsensical manuscript generated by a software program to Bentham's *Open Information Science Journal*, and that he had subsequently received a mail stating that the article had been accepted for publishing, provided he would first pay the publication charge of 800 USD [11]. An experiment designed by the journalist John Bohannon, in which a spoof manuscript containing major methodological errors and other weaknesses was accepted by 157 journals and rejected only by 98, also caught the attention of the general media [12]. The problem with these types of studies is that they tell little about the scientific quality of the average papers in these journals. They do demonstrate that the peer review practices are often so deficient that just about any sort of paper could be accepted for publishing without revisions in many of these journals.

A few case studies of predatory journals have been reported. Djuric describes in detail the publishing pressures in Serbia, where the government requires publishing in journals having an ISI impact factor for academic appointments and even to obtain a PhD [13]. This has led to a niche market for some local publishers, which have managed to get their journals into Web of Science, in the wake of Thomson Reuter's drive to index more regional journals during the latter half of the previous decade. Djuric sent a purposefully flawed manuscript to one such journal, in which several of his university colleagues had published recently, and got an acceptance the next day with instruction on how to pay the APC.

Lukić et al. discuss a number of cases of 'hijacked' journals. In such cases, the activities are directly fraudulent [14]. The hijackers create websites with the same names as respectable journals and then solicit manuscripts via spam email.

A particularly interesting but somewhat atypical case is offered by *Experimental & Clinical Cardiology* [15]. The journal had for 17 years been published by a respectable Canadian subscription publisher. The journal, which

had a JCR impact factor (0.7), was purchased by investors of obscure background, changed the business model to OA, funded by an APC of 1,200 USD, and rapidly increased the number of articles from 63 in 2013 to over 1,000 in 2014.

The only published empirical qualitative study that we could find which sheds light on the dilemma of predatory publishing is the study by Omobowale et al. [16] who interviewed 30 academics from two Nigerian universities. A central finding was the difficulty of getting published in 'Western' journals, while at the same time, university administrations requiring 'international' publication; two factors that together have been strong drivers for the emergence of the market demand for 'predatory' publishing.

There have been a couple of published studies about the volume and other characteristics of predatory journals. Xia examined 297 journals listed in Beall's list of standalone predatory journals, and found an average APC of 94 USD and a range of yearly articles of between 4 and 2,286 (mean 227 articles, median 86) [17].

Xia et al. also studied the origin of authors in seven pharmacological journals included in the above list and found a strong dominance of Indian authors, with Nigerian and Pakistani authors in second and third place [18]. Ezinwa Nwagwu and Ojemeni studied 34 journals published by Nigerian-based publishers, Academic Journals Inc. and International Research Journals, both focusing in biomedicine [19]. They found that 57 % of authors were from Asia and 28 % from Africa, with Nigeria, China and India being the leading countries.

Research questions

The specific research questions of this study were:

- What is the current number of predatory journals (both active and empty)?
- What number of articles are published in them per year and how have these numbers evolved over the past few years?
- What is the distribution of articles over broad scientific fields?
- In what countries are they published?
- From what countries do the authors come?
- How much do they charge the authors for publishing?
- How rapidly do these journals publish?

Methods

Identifying predatory publishers

The first question to be asked is how to define a predatory publisher (as well as journal). For practical purposes it would have been impossible for us to construct a new or adapted list of criteria and then search the Internet for publishers and/or journals fulfilling these criteria. Instead, the work already done by Beall in compiling his index of predatory publishers as well as individual predatory journals was used as the starting point for empirical data collection. Beall has defined a detailed list of criteria [8] for determining if a publisher/journal is predatory. The list is rather long with 48 criteria, for either the publisher or individual journal, and is grouped under four major headings (editor and staff, business management, integrity and other). The criteria cover a vast array of direct and indirect indicators of the lack of a rigorous scientific quality control of the published articles as well as of the publishers trying to establish a reputable image in order to attract submissions. For instance, it is often very difficult to find out in which country the publisher operates in practice. At the same time, authors and institutions are often assumed to base their evaluation of journals at least in part based on the publisher's location, with a preference for US and Western European locations. Another indicator is that some publishers have rapidly created vast portfolios of journals covering just about all fields of science, many of which lack content. A third is that many publishers advertise very rapid turnaround times from submission to publication, which would defeat the purpose of peer review by competent researchers.

Both of the lists (which are regularly revised) were downloaded on 1 September 2014 [20]. At that time, the list of publishers included 614 items and the list of individual journals had 416 items. The publishers of the latter were classified as single-journal publishers in our study, leading to a total number of 1,030 publishers as a starting point. The next step was to review each publisher's website in order to count the number of journals published and to record the publisher's country of origin. We excluded 64 publishers from the entire population for the reason that they had invalid links, published no journals or provided no journal-related information. Of the remaining 966 publishers, we found a total of 11,873 published journals. This preliminary analysis demonstrated the heterogeneity of predatory publishers in terms of their journal size; most publishers are relatively small with less than ten journals, but there are several publishers with large fleets of journals.

Sampling

It would have taken a lot of effort to manually collect publication volumes and other data for all 11,873 journals, so the only practical solution was to make a sample of journals to generalize from. One option would have been a fully random sample, with each journal having the same chance of being selected. We suspected, however, that journals from small publishers often publish a much higher number of articles than those of large publishers, and this was verified in a small pilot test, using data from ten random journals from small and large

publishers, respectively. Hence, a fully random sample would probably have resulted in an underestimation of the total number of articles, since journals from the large publishers with large journal portfolios would have dominated the picture and very few journals from single-journal publishers would have been included in the sample. Instead we chose a stratified multistage sampling based on the size of the publishers by first splitting the publishers into four size strata (100+ journals, 10–99 journals, 2–9 journals and single-journal) and then randomly sampling publishers within each of these strata. The sampling process is illustrated in Fig. 1.

In the first stage of sampling, we randomly selected a total of 290 publishers from the different strata. In the case of the 100+ stratum, we did not in fact sample but included all 20 publishers in that category. After that, a

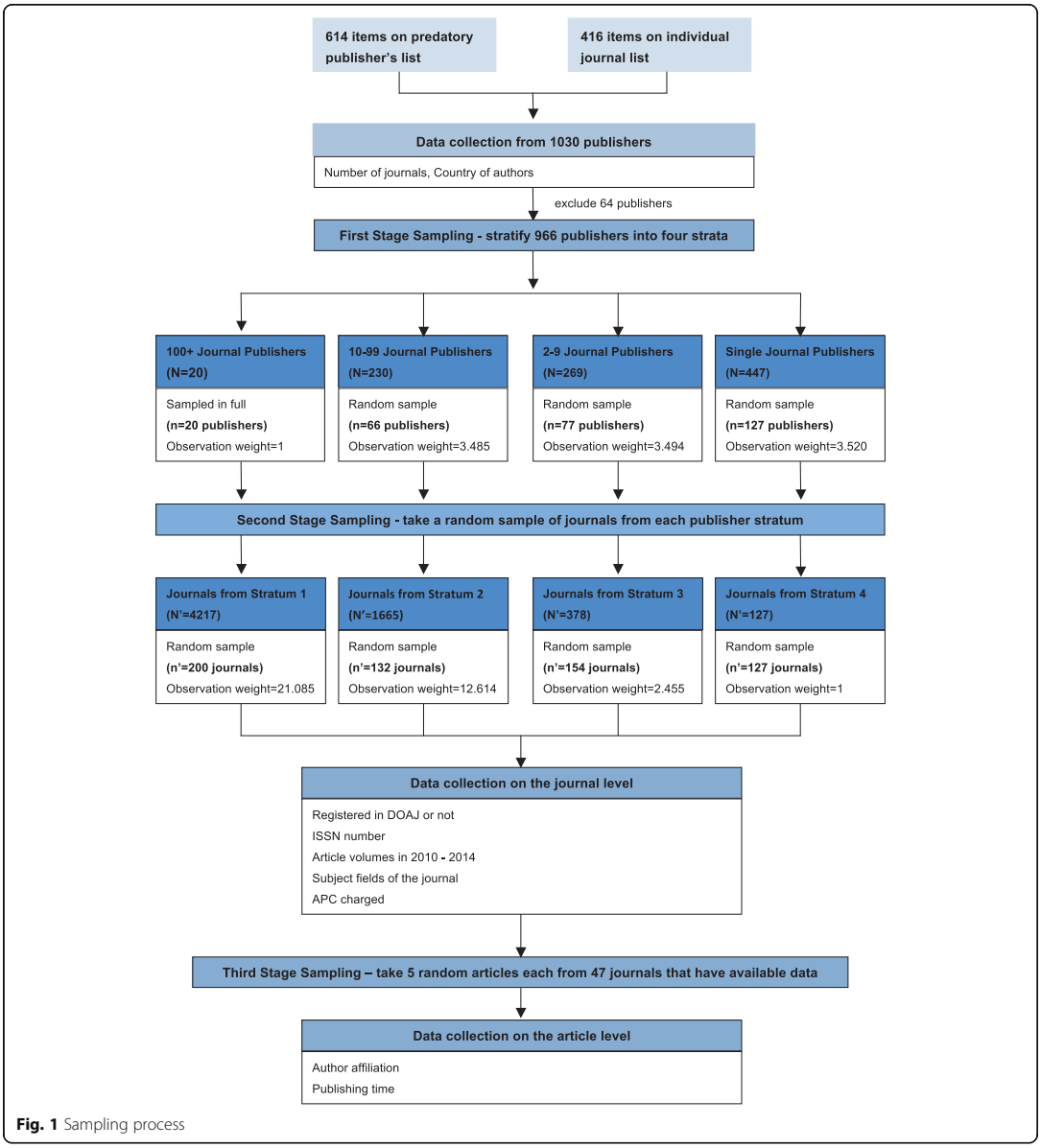

Fig. 1 Sampling process

random number of journals were chosen among the included publishers. In the 100+ stratum, ten journals were sampled per publisher. Both in the 10–99 and 2–9 strata, we sampled two journals from each publisher. In the single-journal strata, considering that such journals are more likely to produce more articles, more journals (n = 127) than in the other strata were fully sampled so that more reliable results concerning the total article volumes from this stratum could be obtained. This resulted in a total sample of 613 journals.

Due to the use of multistage stratified sampling design, the sampling weight W_{ij} attached to each journal is equal to the reciprocal of its overall probability of selection, which is the product of the probability of selecting the ith publisher at the first stage (P_i) and the probability of selecting the jth journal from the selected i^{th} publisher at the second stage $\left(P_{j_{(i)}}\right)$. The sampling weight used in the analysis was calculated according to the following formula [21]:

$$W_{ij} = \frac{1}{P_{i*}P_{j_{(i)}}}$$

Data collection

The following data were extracted for each sampled journal: registered in the Directory of Open Access Journals (DOAJ) or not; ISSN number; subject field of the journal; article volumes in 2010–2014; and APC.

The results obtained from searching journals' titles from Beall's list, on the DOAJ website (doaj.org) were collected in order to estimate the proportion of current predatory journals included in the DOAJ. The discipline breakdown is based on a previous study [22]. In addition, we decided to introduce a new category called 'general' to represent the subject areas of journals that encompass more than one classified discipline. Finding out the APC was mostly straightforward, but some journals had very flexible charges depending on different factors, for instance, the number of authors, their countries (for example low-income, middle-income and high-income countries), identities (for example students, researchers, and so on), and the length and type of articles (for example review articles, research articles, and so on). To determine the average size of APCs charged by such journals, we studied ten articles from the journal, estimated the likely cost and then calculated the average using a method replicated from an earlier study [23]. All the APCs were counted based on the prices listed at the time of data collection. The currency used was the US Dollar (USD) and the prices given in currencies other than the USD were converted according to the exchange rate on Currency Converter [24].

We also wanted to estimate the average publishing speed (submission to publication) of predatory journals as well as the geographical spread of authors. For this purpose we collected five random articles for such journals where the submission and publication date is available in the articles themselves. Since some journals have fewer than five articles in all, this resulted in a sample of 205 articles obtained from 47 journals. For the calculations of speed of publication we produced both means and medians, since we noticed a few outlier articles with very long delays.

Data analysis

The analysis in this study focused on descriptive statistics using Excel. The collected sample data were used to estimate the total number of active journals and the total predatory OA publication volumes between 2010 and 2014 across different strata and overall as well as the annual average number of articles published per journal.

In view of the use of stratified multistage sampling, the following formula was applied to calculate the population total

$$\hat{\gamma}_{st} = \Sigma_{i=1}^{L}\Sigma_{j=1}^{n_i} W_{ij*}y_{ij}$$

and mean

$$\hat{\mu} = \frac{\hat{\gamma}_{st}}{\sum_{i=1}^{L}\sum_{j=1}^{n_i} W_{ij}}$$

where $\hat{\gamma}_{st}$ is the estimated population total, L is the number of strata, n_i is the total sample size of stratum i, W_{ij} is the sample weight for the jth observation in the stratum i, y_{ij} is the value of unit j in stratum i and $\hat{\mu}$ is the estimated population mean.

Since journals for all 20 publishers in the 100+ strata were sampled and the total number of journals per publisher were known, we calculated the total article volume for the stratum by multiplying the average number of articles per journal for each publisher with that publisher's number of journals, and then summing up the results over the 20 publishers.

Regarding the statistical reliability of our results, we calculated the standard error for key mean estimates for the 95 % confidence level. Since we did not use fully random samples, it was not possible to obtain the exact standard error of means; however, what we could do was to provide approximate standard errors for a few results. The standard error is defined as an estimate of the standard deviation of a sampling distribution. We could compute standard error (SE) under the total population size N, the population size N_i in stratum i, the sample size n_i in stratum i, the sample estimate of the population standard deviation s_i in stratum i by the following formula [21]:

$$SE = \left(\frac{1}{N}\right) * \sqrt{\sum_{i=1}^{L}\left[N_i^2 * \left(1-\frac{n_i}{N_i}\right) * \frac{s_i^2}{n_i}\right]}$$

In order to identify whether the average APC and publishing speed of the four publisher strata were actually different from each other, we calculated the *P* value under a statistically significant t-test at the 5 % significance level. If the attained *P* value was larger than 5 % then there was no significant difference between the two groups, and vice versa.

Limitations

Due to the complexity of our sampling method, our results should be treated only as rough estimates showing the overall magnitude of predatory publishing and its central aspects. However, we still believe that our choice of method does not significantly affect the interpretation of the results. The diversified results we obtained for different strata seem to warrant our choice.

Results

In the reporting below we provide both the results within each stratum and the results generalized to the whole population, where the stratum sizes in terms of journals have been taken into account. Particularly for estimating the average number of articles per journal and APC level, we excluded empty journal websites from the calculations.

Number of journals

We found 11,873 journals, published by 996 publishers (of which 447 publish just one journal). Of these journals, we estimate that around 67 % (around 8,000 journals) were active, in the sense that they published at least one article. The share of empty journal websites was particularly noticeable among the journals from publishers with journal portfolios of 100 or more journals (46 %) and much lower in the smaller publisher strata (10–99, 23 %; 2–9, 18 %; and single, 2 %). The problem of empty placeholder journals is a problem specific to predatory journals.

Figure 2 provides the overall development of journal volumes over time and for the different strata. The total number of active journals has grown rapidly from an estimated 1,800 journals in 2010 to around 8,000 journals in 2014. Growth has been particularly strong in the 10–99 stratum.

Article volumes

In total these journals published an estimated 420,000 articles in 2014, after a relatively linear growth from 53,000 in 2010 (Fig. 3). The large publishers dominated the market in 2010 and still in 2011, but after that their absolute article numbers only increased slightly. In 2012, journals from the 10–99 stratum rapidly took over market domination and have consolidated that position even when the two smallest strata also showed continuous fast growth.

Distribution over scientific disciplines

Figure 4 presents article volumes published in 2014 by journals from different scientific disciplines. The article volumes in journals categorized as 'general' were largest with an estimated 162,000 articles. A more detailed analysis would require classifying articles in 'general' journals into some of the other subcategories, which was beyond the resource limitations of this study. Quite noticeable from the figure is the large share of articles in engineering journals (97,000 articles), followed by biomedicine with around 70,000 articles.

Average number of articles per journal

Figure 5 shows the development of the average number of articles per year. The overall averages grew from 30 articles per journal in 2010 to 53 articles in 2012, but after that the number seems to have stabilized. The overall average in each stratum conceals the fact that the average is much higher for single-journal and 2–9 publishers than for the two uppermost strata.

Country of publishers

Figure 6 describes the distribution of the publishers across geographic regions. The distribution is highly skewed, with 27 % publishing in India. A total of 52 publishers quote addresses in several countries, for instance, often a combination of the USA or a Western European country with a country from Africa or Asia. In order to establish how credible a USA/European address was, we took a closer look at the 3D street view of the address using Google Maps. If the result was a location that was not credible or, for instance, a PO Box, we classified the journal according to the alternative address. For some addresses that were very difficult to identify, we put them in the category of 'impossible to determine'.

Figure 7 provides information about how publishers are distributed in each stratum. India dominates the single-journal publisher stratum where the share is 42 %.

Country of authors

Figure 8 describes the regional distribution of the 262 sampled corresponding authors, which is highly skewed to Asia and Africa. Around 35 % of authors are from India, followed by Nigerian authors (8 %) and US authors (6 %).

APC levels

There are clear differences in the APCs of the large and small publishers ($P < 0.05$), as is shown in Table 1, with the large publishers operating more expensive journals.

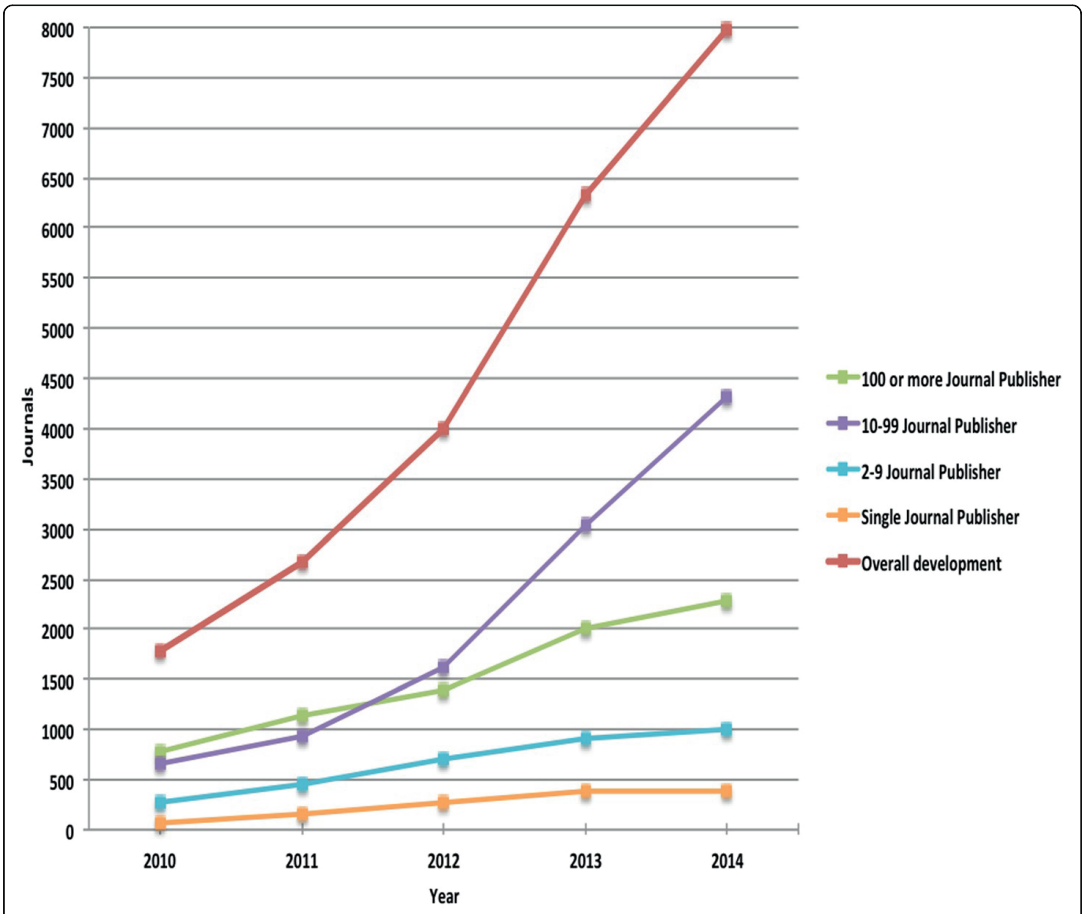

Fig. 2 The development of active predatory open access journals from 2010 to 2014

We calculated the results in two ways. Firstly, by just a direct average (each journal having equal weight). Secondly, by assigning each journal a weight according to the number of articles published in the past five years. The latter calculation better reflects the average APCs paid by authors publishing in these journals. The results turn out quite different depending on the calculation method, in particular for the 10–99 stratum, where the average declines from 239 USD per journal to only 104 USD per article. Also generalized to all predatory articles, the overall average APC is only about half as high (178 USD) per article as the average calculated over journals, indicating a clear author preference for lower priced journals, leading to higher publication volumes. The distribution of APCs as a function of the article volumes in the scattergram (Fig. 9) also illustrates this pattern.

In the scatterplot of the sampled journals, there are four outlier journals (indicated by numbers), which break the clear pattern of diminishing article volumes as a function of increasing APCs. Journal 1, 3 and 4 are published by large publishers (100+), and in particular journal 4 (*Remote Sensing*), which sticks out the most, has a JCR impact factor of 2.6. Journal 2 is the 'hijacked' journal *Experimental & Clinical Cardiology*, which in 2014 still retained its impact factor.

Publishing speed

The average and median publication time for journals and articles published in 2014 (the two measures were calculated in the same way as for APCs) were calculated. The results show that predatory publishers take an average of 3.6 months to publish if we calculated over journals

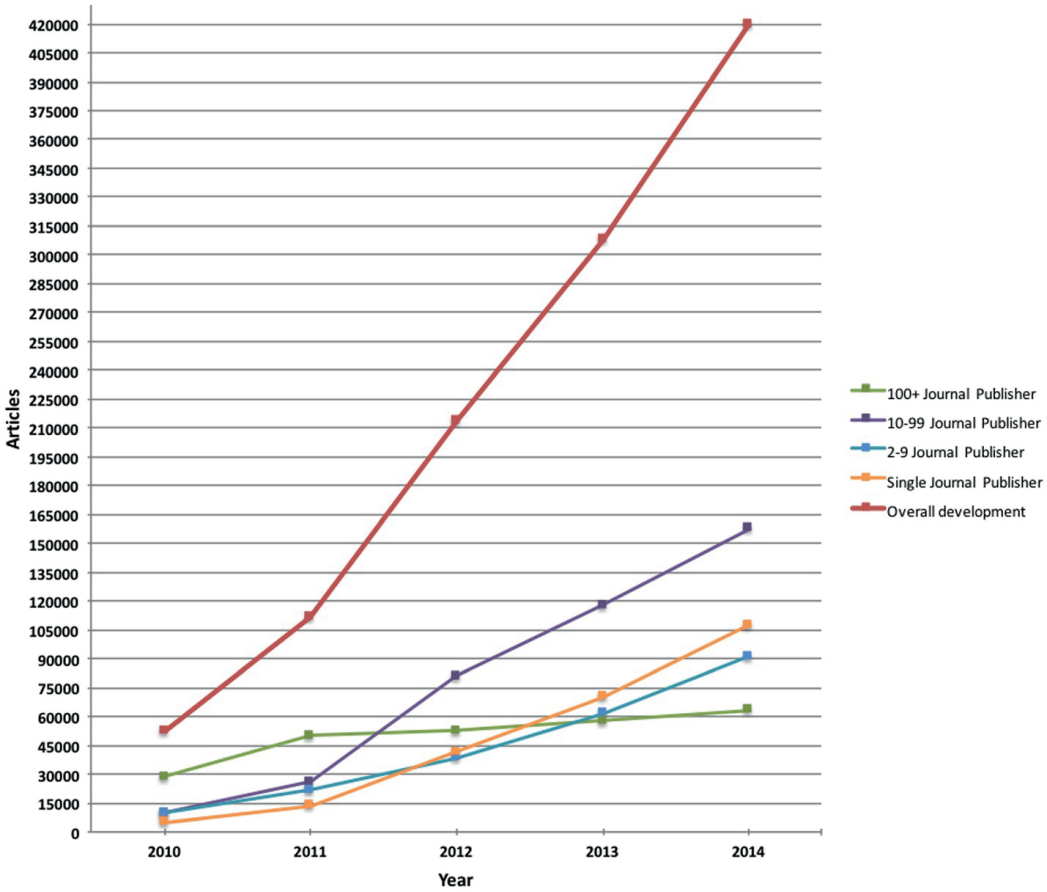

Fig. 3 The development of predatory open access article volumes from 2010 to 2014

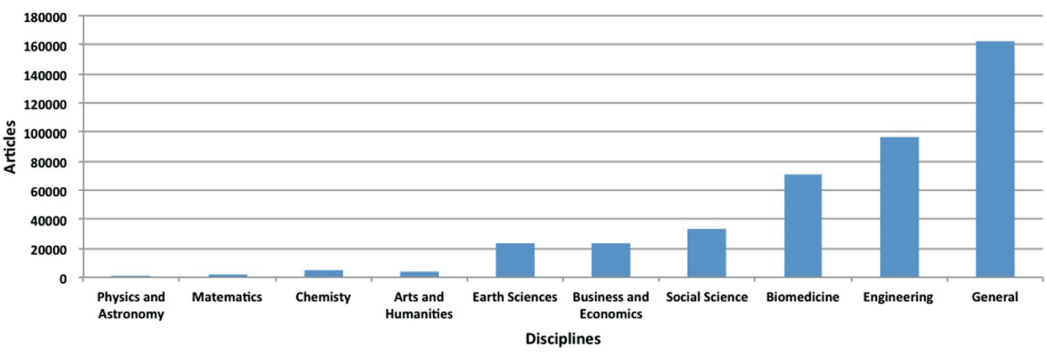

Fig. 4 The distribution of predatory open access articles in 2014 by scientific discipline

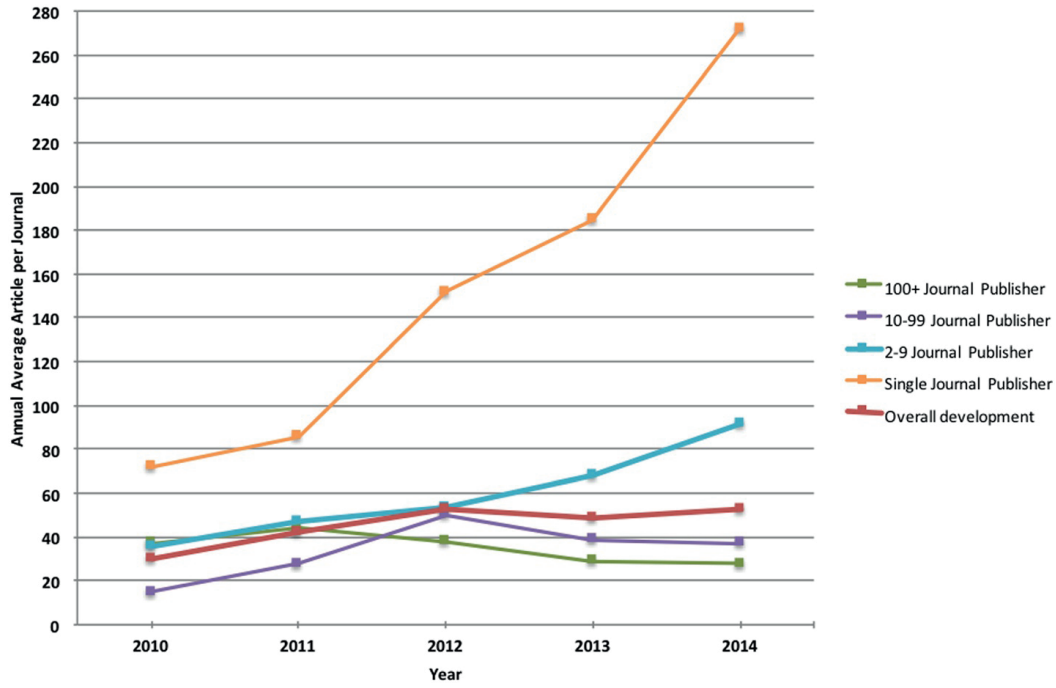

Fig. 5 The development of the average number of articles per journal and year from 2010 to 2014

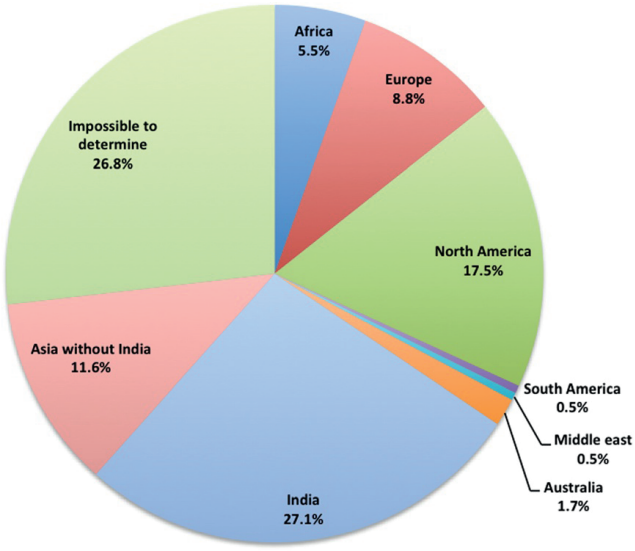

Fig. 6 The distribution of publishers (n = 656) by geographic regions

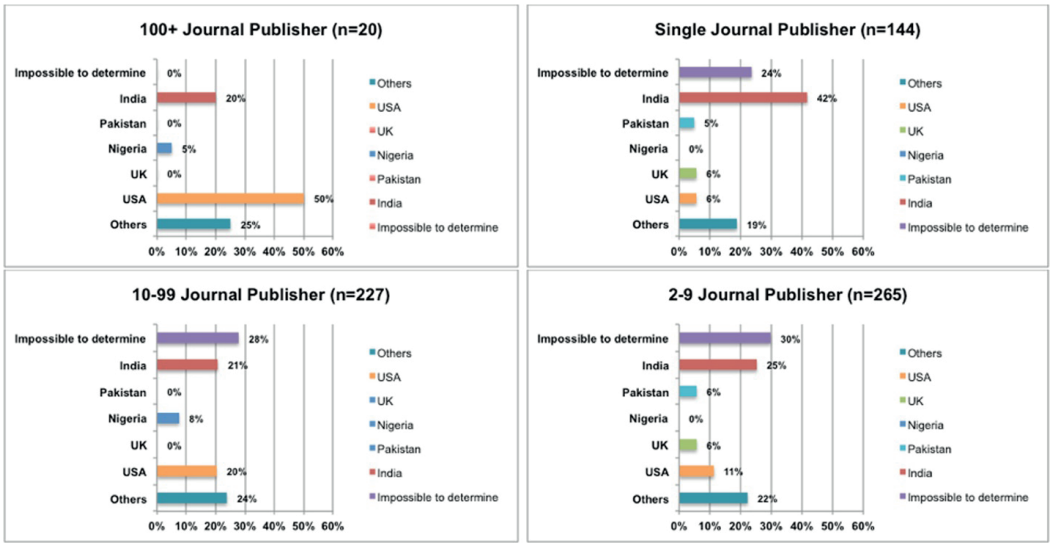

Fig. 7 The distribution of publishers by country for the different strata

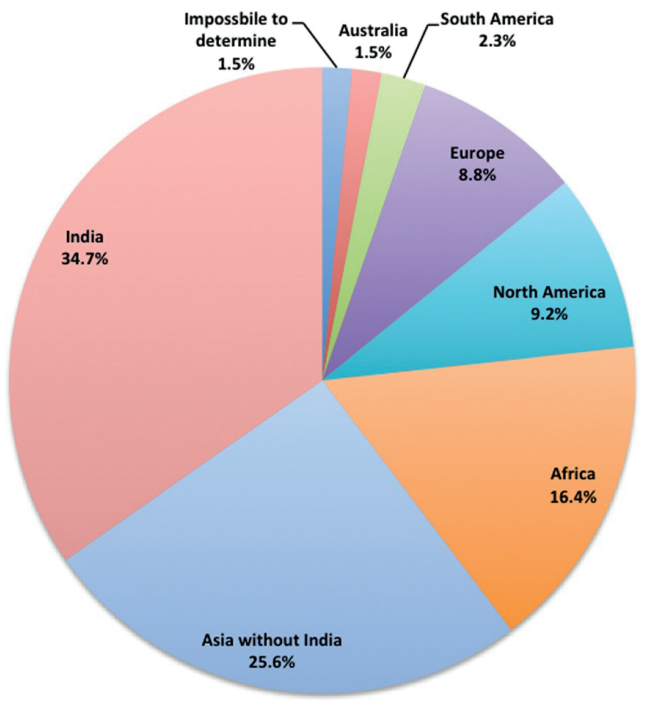

Fig. 8 The distribution of the corresponding authors by geographic regions

Table 1 Average APC for journals and articles published from 2010 to 2014

Publisher stratum	Average APC for journals in USD	Average APC for articles published (2010–2014) in USD
100+ journals	605	796
10–99 journals	239	104
2–9 journals	215	133
Single-journal	98	83
Total	304	178

and 3.3 months weighted by number of articles in 2014. However, we consider the median (2.7 overall) a more meaningful metric, since that eliminates the effects of a few outlier articles with very long delays.

Standard errors and t-tests of the results

The standard errors for some of the key results are presented in Table 2. Likewise the t-tests for some of the stratified data are included in Table 3. Based on the t-tests, we did not find a significant difference among the four publisher strata in terms of their publishing speed (P >0.05), so it was not meaningful to report the stratified results but we reported only the total numbers.

Discussion

Our use of Beall's list of predatory publishers as the main external data source can be questioned, since the list is highly controversial. Our choice of using it as a starting point for data collection was dictated by practical resource constraints. Nevertheless, the process of searching the websites demonstrated tangibly to us that the publishers and sampled journals usually fulfilled several of Beall's criteria, although we did not systematically record our impressions. The multi-tier sampling method used was the most realistic option to keep the time used for manually searching for data reasonable, and also to enable us to study the variations between different publisher strata, which proved to be considerable.

Our estimate of the number of predatory journals is comparable to the 10,606 journals currently (7 June 2015) included in the DOAJ. The overlap is relatively minor. We estimate that 7.8 % of journals from Beall's list are indexed in the DOAJ (the index recently tightened its inclusion

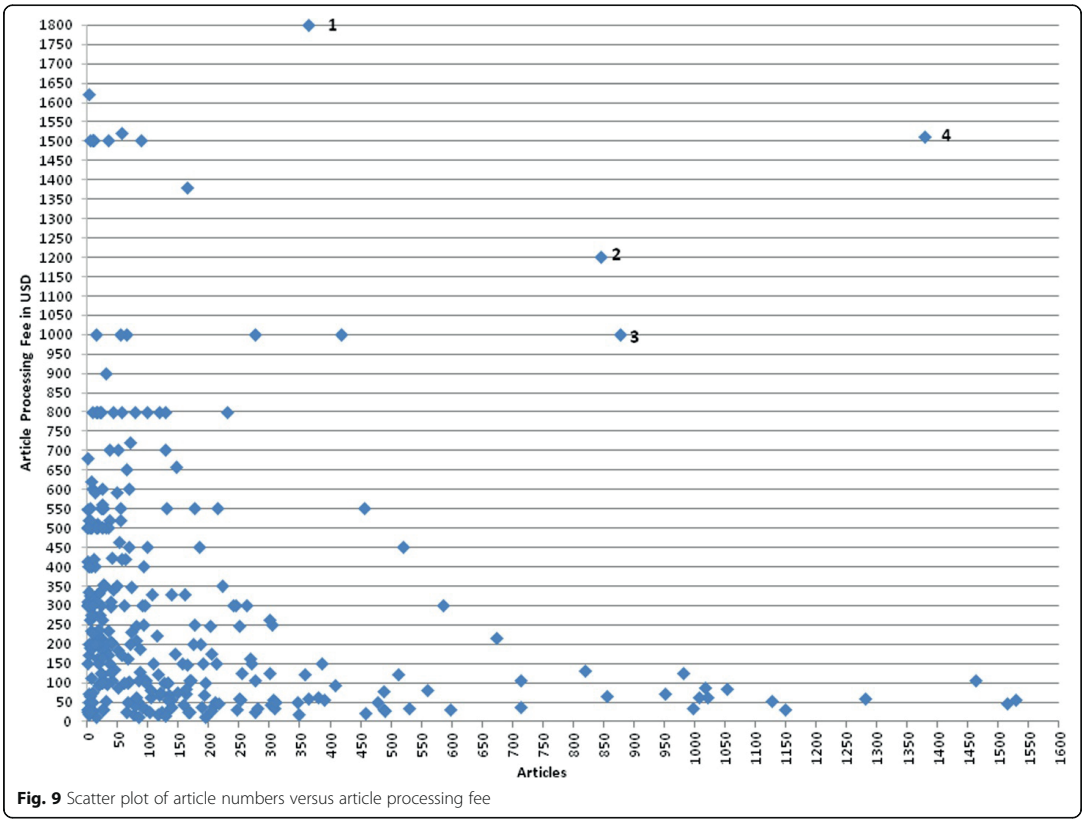

Fig. 9 Scatter plot of article numbers versus article processing fee

Table 2 The standard error for article volumes in 2014, average number of articles per journal, average APC for journals and articles, and average and median publication time for journals and articles

Statistics summary	Estimated value		Standard error (a = 95 %)
Total article volumes published in 2014	419,273		90,954
Average number of articles per journal	2010	30	5
	2011	42	9
	2012	53	13
	2013	49	9
	2014	53	8
Average APC for journals in USD	100+ journal publisher	605	41
	10–99 journal publisher	239	26
	2–9 journal publisher	215	24
	Single-journal publisher	98	16
	Overall	304	20
Average APC for articles published (2010–2014) in USD	100+ journal publisher	796	44
	10–99 journal publisher	104	15
	2–9 journal publisher	133	14
	Single-journal publisher	83	17
	Overall	178	17
Average publication time for journals in months	100+ journal publisher	4.4	0.9
	10–99 journal publisher	2.2	0.4
	2–9 journal publisher	3.4	0.8
	Single-journal publisher	3.9	0.7
	Overall	3.6	0.4
Average publication time for articles published (2014) in months	100+ journal publisher	2.9	0.3
	10–99 journal publisher	2.2	0.3
	2–9 journal publisher	4.2	0.7
	Single-journal publisher	4.6	0.9
	Overall	3.3	0.2
			Interquartile range
Median publication time for journals in months	100+ journal publisher	2.6	(2.1, 4.5)
	10–99 journal publisher	2.1	(1.0, 3.0)
	2–9 journal publisher	3.7	(1.8, 4.7)
	Single-journal publisher	3.2	(2.6, 5.2)
	Overall	2.7	(2.0, 4.2)
Median publication time for articles published (2014) in months	100+ journal publisher	2.4	(1.5, 4.3)
	10–99 journal publisher	1.9	(1.1, 3.3)
	2–9 journal publisher	4.2	(2.6, 5.2)
	Single-journal publisher	3.4	(1.8, 5.1)
	Overall	2.7	(1.5, 4.5)

criteria). The overall volume of articles published in predatory journals is also of the same magnitude as in the journals indexed in DOAJ. Laakso and Björk [22] estimated that number to be 340,000 in 2011, and extrapolating the growth would have meant roughly half a million in 2014. For comparison, the number of articles published in ISI-indexed journals was estimated to be 1,033,000 in 2009 [23].

Until 2012, the growth in predatory article numbers occurred mainly through publishers who set up large (100+) journal portfolios, and who on average charge almost 800 USD, but during the past three years the 10–99 journal

Table 3 T-tests for average APC and publication time for journals and articles

	100+ journal publisher	10–99 journal publisher	2–9 journal publisher	Single-journal publisher
Average APC for journals				
100+ journal publisher	-	$P < 0.05$	$P < 0.05$	$P < 0.05$
10–99 journal publisher	-	-	$P > 0.05$	$P < 0.05$
2–9 journal publisher	-	-	-	$P < 0.05$
Single-journal publisher	-	-	-	-
Average APC for articles published in 2010–2014				
100+ journal publisher	-	$P < 0.05$	$P < 0.05$	$P < 0.05$
10–99 journal publisher	-	-	$P > 0.05$	$P > 0.05$
2–9 journal publisher	-	-	-	$P < 0.05$
Single-journal publisher	-	-	-	-
Average publication time for journals				
100+ journal publisher	-	$P > 0.05$	$P > 0.05$	$P > 0.05$
10–99 journal publisher	-	-	$P > 0.05$	$P < 0.05$
2–9 journal publisher	-	-	-	$P > 0.05$
Single-journal publisher	-	-	-	-
Average publication time for articles published in 2014				
100+ journal publisher	-	$P > 0.05$	$P > 0.05$	$P < 0.05$
10–99 journal publisher	-	-	$P < 0.05$	$P < 0.05$
2–9 journal publisher	-	-	-	$P > 0.05$
Single-journal publisher	-	-	-	-

publishers, who on average charge only 104 USD, have started to dominate the market.

The average number of articles per year in predatory journals (around 50) is comparable to publishing volumes in DOAJ-indexed OA journals, where the average yearly number of articles has slowly risen and was 40 articles per journal in 2009 [23]. Due to the emergence of mega-journals, the average is likely to be higher today. Björk et al. estimated the average number in ISI-indexed journals (mostly subscription) to be 111 in 2007 [25].

Growth in article numbers within predatory journals has in the past two years mainly occurred in the two lowest strata, which tend to have much higher annual publication volumes. Indian journals have a strong position especially in the single-journal stratum.

Our data showed a big difference in APC levels depending on the stratum. The APCs by predators are, nevertheless, much lower than the APCs by more credible OA publishers, which on the other hand often offer waivers from the charges to authors from developing countries. The average of DOAJ journals with APCs is around 900–1,000 USD [26, 27]. Currently leading universities in the UK and Germany, which fund APCs centrally, tend to pay on average 1,200–1,300 USD [28].

Using our data for the number of articles and average APC for 2014, our estimate for the size of the market is 74 million USD. The corresponding figure for OA journals from reputable journals has been estimated at 244 million USD in 2013 [29]. The global subscription market for scholarly journals is estimated to be around 10.5 billion USD [30].

A study by Solomon and Björk [31] about the sources of funding for the APCs showed that in the case of authors from countries with a GDP per capita of over 25,000 USD, only 10 % of the APCs came from personal funds, whereas the proportion for authors from developing countries (under 25,000) was 39 %. That study concerned DOAJ-indexed OA journals of relatively good reputation, a third of which with JCR impact factors. If authors from low-income countries to a large extent need to pay the APC out of their own pockets, then this explains the generally low average of 178 USD and the fact that predatory journals with lower prices tend to have grown much faster recently.

Our results concerning the regional distribution of authorship can be compared with the results of Xia et al. [18] who studied the authorship distribution for seven pharmaceutical predatory journals, and Ezinwa Nwagwu and Ojemeni [19] who studied 34 journals from two Nigerian-based predatory publishers. The minor differences in the results can be explained by the much more limited journal samples in the above studies, for instance, the

journals studied by Ezinwa Nwagwu and Ojemeni [19] had an average APC of 636 USD, which could explain the lower share of Indian authors.

An interesting finding is the very low share of South America, both among publishers (0.5 %) and corresponding authors (2.2 %). It would no doubt be an interesting question to study the reasons for this, which could be a combination of factors, where the infrastructure in Latin America differs from countries like India and Nigeria.

Above we have reported the estimated geographical spread of predatory article authorship in terms of absolute numbers per year of articles, which is highly skewed with India at the top. A slightly different viewpoint would be a per capita calculation, which takes into account the relative sizes of countries or economies. In our view a particularly interesting comparison is one in which the size of predatory publication is compared to the production of high quality article from the same country. We used figures from the Web of Science (InCites regions report) about authorship for the years 2013–2014 to calculate the ratio of predatory to Web of Science-indexed articles. For the four biggest contributors of predatory articles, the USA had a low ratio of 6 %, Iran 70 %, India 277 % and Nigeria a staggering 1,580 %.

The publishing delays we found were much shorter than for scholarly journals in general. Björk and Solomon [32] found delays of 9–18 months, depending on the field of science, with social sciences having the longest delays. The average delay for the OA journals in that study was 5.9 months, thus clearly shorter than for subscription journals but longer than for predatory journals. The range of average delays for OA megajournals was 3–5 months.

Unlike many writings about the phenomenon, we believe that most authors are not necessarily tricked into publishing in predatory journals; they probably submit to them well aware of the circumstances and take a calculated risk that experts who evaluate their publication lists will not bother to check the journal credentials in detail. Hence we do not uncritically see the authors as unknowing victims. The universities or funding agencies in a number of countries that strongly emphasize publishing in 'international' journals for evaluating researchers, but without monitoring the quality of the journals in question [16, 33], are partly responsible for the rise of this type of publishing. The phenomenon should probably, however, be seen more broadly as a global North-South dilemma where institutions in developing countries are unable to break free from the increasingly globalized and homogenized view of academic excellence based on 'where' and how often one publishes, instead of 'what' is published and whether the results are relevant to local needs. In that sense, these authors and their institutions are part of a structurally unjust global system that excludes them from publishing in 'high quality' journals on the one hand and confines them to publish in dubious journals on the other.

Leading respectable OA publishers have not stood by silently as OA has been given a bad name by predators. Rather than blacklisting journals, which Jeffrey Beall is doing, the strategy has been one of defining quality criteria and accreditations of journals that meet those [34]. For instance, the DOAJ has, since 2014, imposed stricter criteria for inclusion and has filtered out journals that do not meet them [35]. Membership in the Open Access Scholarly Publishers Association (OASPA) is also contingent on meeting quality criteria. An increasing share of respectable OA journals is also nowadays indexed by the ISI.

We are not particularly satisfied with the term 'predatory', since we believe that the term has a highly negative connotation and we feel it is slightly misleading. We would instead have preferred to talk of 'open access journals with questionable marketing and peer review practices'. Nevertheless the term 'predatory' open access is by now so established for this phenomenon that in the end we decided to use it. A practical consideration is that an article using the term in the title or frequently in the text is more likely to be picked by readers searching the internet for more information about this phenomenon.

Conclusion

In this study, we used a multistage stratified sampling method to take a look into the predatory publishers and journals on Beall's list and generated their development trend over time. We found that the problems caused by predatory journals are rather limited and regional, and believe that the publishing volumes in such journals will cease growing in the near future. Open access publishing is rapidly gaining momentum, in particular through the actions of major research funders and policy makers. This should create better opportunities for researchers from countries where predatory publishing is currently popular, to get published in journals of higher quality, in particular since most journals have a policy to waive the APCs for authors from developing countries.

Abbreviations

APC: Article processing charge; DOAJ: Directory of Open Access Journals; ISI: Institute for Scientific Information; ISSN: International Standard Serial Number; JCR: Journal Citation Reports; OA: Open access; OASPA: Open Access Scholarly Publishers Association; SE: Standard error.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

The study was planned by CS and B-CB and in cooperation, and CS collected and analyzed the empirical data. Both authors contributed to the reporting. Both authors read and approved the final manuscript.

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CS is a doctoral student in Information Systems Science at the Hanken School of Economics, Helsinki, Finland. B-CB is professor of Information Systems Science at the Hanken School of Economics, Helsinki, Finland.

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Open Access Scholarly Journal Publishing in Chinese

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Abstract: The research literature on open access (OA) publishing has mainly dealt with journals publishing in English, and studies focusing on OA journals in other languages are less common. This article addresses this gap via a case study focusing on Chinese-language OA journals. It starts with the identification of the major characteristics of this market, followed by eight semi-structured interviews to explore the key motivations behind Chinese-language OA publishing and perceived barriers. The majority of Chinese OA journals are published in Chinese, and most of them are published by universities and scholarly societies. Nearly 80% of journals were launched before the digital age and were converted to OA later. The subject distribution is highly skewed towards the science, technology, engineering and medicine (STEM) fields. Publishers are motivated to convert journals to OA by an expected increase in academic impact, which would also attract more submissions. The lack of a sufficient number of high-quality submissions is perceived as the largest barrier to the successful publishing of journals. The financial instability of journals is identified as the main obstacle hindering internationalisation. The central conclusions of the study are that Chinese-language OA journals need to increase their visibility in journal indexes such as the Directory of Open Access Journals (DOAJ), and that an OA publishing platform (similar to the Latin American SciELO) should be established for Chinese-language OA journals.

Keywords: scholarly publishing; open access; Chinese-language journals

1. Introduction

Scholarly journals published in English have for a long time been the main medium for global scholarly communication. The report from the STM Association estimates that there were about 28,100 active peer-reviewed English-language journals in late 2014, more than four times the number of journals published in other languages [1]. There is also an increased demand from non-native English-speaking researchers to publish in English-language journals, which is corroborated by the evidence that the number of publications originating from non-English speaking countries is on the rise [2,3]. Chinese scientists, for example, have over the last two decades increasingly written excellent academic papers in English, and published them in journals from leading international publishers [4]. The underlying motivations behind non-native English-speaking researchers are almost consistent across geopolitical contexts and are indeed multifarious [3]. It is partly an effect of national policies to assess research productivity and performance, which give greater prominence to publications in mainstream English-language journals. As such, researchers tend to opt for these journals as optimal publishing outlets so that they can satisfy one of the most important criteria for research assessment. Despite linguistic difficulties faced by researchers using English as a foreign language, they choose to invest their time and efforts to write their best work in English for publication in international mainstream journals that can lead to further rewards such as recognition, prestige, and career development [3,5,6]. The desire to communicate the research results to the international academic community and enhance the impact of the published papers can also be a driving force for researchers deciding to publish in English-language journals, as papers written in English are more

likely to be cited [7]. For all these reasons, scholarly journals publishing in native languages aside from English are in danger of losing high-quality academic papers authored by domestic researchers, which will lead to a decline in journal impact and poses a challenge to the survival of such journals.

The dominance of English-language journals published by the major, predominantly Anglo-American, publishers in the worldwide scholarly publishing market has made the Chinese government realise the urgent need for the development of China's own English-language journals. In recent years, such journals have attracted keen interest and active support from the government in line with an apparent determination to extend the international influence of local science and technology journals, thereby raising the country's international profile in the scientific community [8]. By 2016, more than half of 239 China's English-language scientific journals were indexed in the Science Citation Index (SCI) [9]. The continuous growth of English-language journals in China can be viewed as a major step towards overcoming linguistic barriers in order to gain better international visibility and reach a wider international readership, and therefore stem the flow of high-quality manuscripts written by local researchers to non-Chinese publishers [10,11]. The rise of China's English-language journals, nevertheless, makes the development of Chinese-language scholarly journals increasingly difficult.

The emergent open access (OA) publishing model, made possible in the digital age, seems to offer a great opportunity for traditional journals published in languages other than English. OA publishing partly addresses non-native English-speaking researchers' concerns over limited visibility and international circulation (and as a consequence the lower impact of scholarly work if published in such journals) caused by closed access and linguistic disadvantages [12]. The increased visibility and impact of Latin American publications through various OA programs such as the development of regional OA publishing platform SciELO [13] illustrate this [14,15]. The share of gold OA journals in Scopus for Latin America is much higher at 74%, compared to 9% of all journals in that index [16]. In connection with the adoption of the OA publishing model as a solution to the distribution challenges faced by traditional journals in languages other than English, their publishers may even consider directly converting their journals into English or multiple languages to transcend national boundaries so that linguistic hurdles are no longer an issue [17].

English-language OA scholarly journals remain dominant in the global OA publishing market. In the Directory of Open Access Journals (DOAJ), only 24% of included journals are in other languages [18]. It is, however, worth stressing that the DOAJ selects OA journals on the condition that they satisfy the most stringent Budapest Open Access Initiative (BOAI) definition of OA [19], therefore, non-English language journals that offer free access to content but no reuse rights granted by the Creative Commons [20] or similar licenses are not accepted for inclusion. Since major studies on OA tend to use DOAJ, often in combination with Web of Science (WoS) [21] and/or Scopus [22], as the basis for data collection, they often exclude many non-English language OA journals from developing countries. A few descriptive studies have been carried out to examine the situation of scholarly OA publishing in countries without a substantial international publishing industry, where journals published in the local languages occupy an important role [23–26]. Nevertheless, there is a clear lack of empirical research focusing on OA journals in languages aside from English and reviewing their development in response to the changing global scholarly journal landscape.

In this article, a case study of Chinese-language OA journals is reported. In terms of research strength, China has in recent years completed the transition from being predominantly a consumer of science to a major producer, becoming the world's second largest contributor to research output [27]. In 2014, the numbers of papers authored by Chinese scientists in the SCI and Engineering Index (EI) were 263,500 and 172,900, accounting for 14.9% and 31.6% of the total in the respective databases [28]. Based on the data from UlrichsWeb, the global scholarly publishing market was estimated to include 76,294 peer-reviewed journals as of May 2017. Of that number, Chinese publishers take the third largest share at 12% behind the US (28%) and the UK (18%) [29]. Despite China having gained a competitive advantage in the number of published scholarly journals over most other countries, its domestic market continues to be dominated by Western publishers. According to the STM report,

international publishers claimed a market share of about two-thirds of the Chinese STM market in 2014 [1]. In addition, China's growth of research citations is dramatic, reflecting an improvement in the visibility and impact of scholarly papers authored by Chinese researchers [30].

The open access movement in China has witnessed some progress due to all kinds of support from the Chinese government, funders, libraries, and scientific communities. The major achievements are, for example, the participation in the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP3) and the announcement of the Open Access Strategy of the Chinese Academy of Sciences (CAS). Although there are not yet many formal strategies and operational policies related to gold OA in China, it is anticipated that the number of domestic journals using the OA model will grow [31]. Therefore, the current position of the Chinese-language OA journal market is an issue which merits discussion. In fact, for this study it was almost a prerequisite that the author be from China, because, for instance, all of the participants in the qualitative part wished to conduct the interviews in Chinese. This study begins by identifying the major characteristics of the market. It then goes on to explore key motivations behind Chinese-language OA publishing and perceived barriers, reporting a set of semi-structured interviews with members of the Chinese publishing community. Last, it proposes some recommendations for the future development of the Chinese-language OA journal market.

The specific research questions of this study were as follows:

RQ1: What are the main characteristics of the Chinese-language OA journal market (number of journals, distribution across types of publishers, distribution across subject fields, distribution of subject fields across types of publishers, and distribution across year of launch)?

RQ2: What is the percentage of Chinese-language OA journals indexed in DOAJ, Scopus, Web of Science (WoS) and Directory of Open Access Scholarly Resources (ROAD)?

RQ3: What motivated the interviewed publishers of Chinese-language OA journals to adopt an OA approach?

RQ4: What do the interviewed OA publishers perceive as the major barriers for successful publishing of Chinese-language OA journals?

RQ5: What are attitudes of the interviewed Chinese-language OA journal publishers to converting their journals into English or bilingual journals, and what are perceived as the main barriers to such a conversion?

2. Previous Research

To date, research on OA in China has mainly focused on issues such as policy development [32,33], the status of OA [34,35], the quality of OA journals [36,37], the impact of OA [38], institutional repository development [39], and copyright issues [40]. Of these studies, a few quantitative studies have focused on the growth of OA in China by examining China's OA journals in their entirety in terms of longitudinal development and OA-related characteristics.

2.1. General Studies

Chen [34] analysed the position of mainland China in the global scholarly OA journal landscape based on Chinese scholarly journals indexed in DOAJ. She found that the number of OA journals from mainland China registered in DOAJ increased from 0 in 2002 to 33 in 2011, which were mostly in the field of natural science. Among them, six journals applied various Creative Commons copyright licenses and 22 uploaded their article metadata to DOAJ. Her study indicated a slow growth in the number of Chinese OA journals and a narrow coverage of disciplines as well as a low journal publishing standard.

Hu et al. provided a more comprehensive study on the conditions of Chinese OA journals in an analysis of 8114 scholarly journals indexed by the Chinese National Knowledge Information (CNKI) database [35]. A key finding was the small share of either full OA or delayed OA journals (8.44%).

The regional and disciplinary distributions of these were highly skewed to Beijing (39.42%) and the fields of natural science and engineering (78.54%), respectively.

2.2. Subject-Specific Studies

There have been also some subject-specific studies about Chinese OA journals. Cheng and Ren examined the OA availability of 1608 Chinese scientific journals indexed by the Chinese Science & Technology Journal Citation Report (2005 edition) and found that less than 6% of the journals were full OA journals (91 journals), of which only 8 were published in English [24]. The study also reported that about two-thirds of full OA journals made their content freely accessible online only through their journal websites, which were not easily findable by readers if they did not know the journal beforehand. Cheng and Ren concluded that this OA system was inefficient, and this made it difficult to attract the attention of the science community. The need for a nationwide platform for OA journals to improve their visibility and impact was highlighted.

Zhang and Pan [41] also conducted an analysis of OA journals examining the quantities of Chinese scientific and technology journals, distributions across geographic regions and subject fields, and other article characteristics in terms of full-text availability. The study was based on 1994 scientific journals identified from the Chinese Science & Technology Journal Citation Report (2009 edition) and A Guide to the Core Journals of China (2008 edition). Out of the 1994 scientific journals, 325 (16.7%) offered free access to more than 20 volumes, and were classified as OA journals in the study. However, in the case of 139 journals (42.8%), online publishing lagged behind the printed copies, and 24% of journals failed to provide openly available content continuously.

Zhong carried out a survey which focused on 61 scholarly journals in library and information science. The study focused on their OA availability and level of support for retrieval and usage, and identified 38 journals in which the full-text was freely available to readers online simultaneously with the printed format, mostly through individual journal-specific online domains, but the journals varied in the number of volumes that were made OA [42]. In sum, the results showed that the level of openness measured by reader access and reuse rights remained low in mainland China.

In a more recent article, Cheng and Huang looked at the availability of OA journals, disciplinary distribution, and type of OA routes for 533 philosophy and social science journals indexed by the Chinese Social Sciences Citation Index (2014–2015 edition) [43]. In total, 40.5% of the journals made their content OA through individual journal websites, 75.6% of which were immediate OA. Other journals (59.5%) provided OA articles through the National Social Science Databases (NSSD), of which only 3.2% were immediate OA. Although the NSSD was the major OA platform for Chinese philosophy and social science journals, it has an obvious lag in disseminating articles. Journals archiving OA content on their own websites, nevertheless, were found to have better time-effectiveness.

None of the above studies were particularly concerned about OA journals published in Chinese only, nor did they examine the current situation, which is the focus of this study, in order to add a deeper understanding of OA publishing in China.

3. Methods

This study consists of a quantitative and a qualitative part. The quantitative part was used in the first phase to identify the situation of the Chinese-language OA publishing market through a descriptive bibliometric analysis to answer RQ1–RQ2. This was followed by qualitative in-depth interviews with publishers of Chinese-language OA journals to explore RQ3–RQ5, where their key motivations to OA, barriers to publishing journals, and attitudes as well as barriers to converting into English or bilingual OA journals were evaluated.

The China Open Access Journals (COAJ) index was used to search for OA journals published in the Chinese language. The COAJ index, initially an OA portal of the Chinese Academy of Science for its affiliated scientific journals, has since 2010 expanded targeting to become a national index for all scholarly OA journals from China [44]. The COAJ index uses the BOAI definition of OA, which

in addition to free full text access also requires extensive reuse rights for readers commonly granted by the scholarly publishers under Creative Commons licenses. It is, however, necessary to draw attention to the fact that its inclusion criteria applied to each individual journal's application do not cover the questions regarding copyright and licensing issues, so OA in this study refers solely to free electronic access to articles published in scholarly journals. It is likely that there are some Chinese OA journals existing outside this index; however, a search on the Internet for such journals is a very time-consuming manual task. For the purpose of this study, it is believed that COAJ is still a suitable journal index that has covered the majority of the target population.

All journal information was harvested from the COAJ index during August 2016. Using the "Language" field as a filter, English-language OA journals and bilingual OA journals (Chinese and English) were excluded in the next step. The data gathered included "Chinese title", "ISSN", "CN-ISSN" "Publisher", "Subject" and "The established year". Some data was manually collected from the journal's website if it was not available in the COAJ index. The entities "Publisher" and "Subject" were further coded using the same classification as in two earlier international OA studies [45,46]. It is noted that the "general" category represents the subject areas of journals encompassing more than one classified discipline.

The eight participants in the interviews were selected based on some previous contacts of the researcher and by suggestions received during the first interviews. All participants met three selection criteria: they were knowledgeable about OA publishing, worked for Chinese-language OA journals, and currently managed or played active roles in the operation of the journals. Table 1 shows that the participants are from major types of publishers in various subjects and sizes, and that most of them are senior executives. Data was collected through semi-structured online interviews held in either Shanghai or Finland between October and December 2016, after informed consent was obtained from each participant. The interviews were carried out in Mandarin Chinese, lasting on average 40 min, and they were then transcribed into English. The interviews aimed for a more comprehensive understanding of the results of the bibliometric analysis. In the following reporting, participant was a term used to describe those who were interviewed.

Table 1. A profile of the participants.

Interviewees	Subject Fields	Type of Publishers	Size of Publishers	Position
Participant 1	Earth Science	Society	3	Section chief
Participant 2	General	University	3	Editor-in-chief
Participant 3	General	University	2	Editor-in-chief
Participant 4	Engineering	Government agencies	3	Associate editor-in-chief
Participant 5	Social Science	Society	125	Section chief
Participant 6	Social Science	University	3	editor
Participant 7	Business and Economics	Society	14	editor
Participant 8	Earth Science	Society	7	Associate editor-in-chief

4. Results

4.1. Number of Journals and Share Indexed in DOAJ, WoS, Scopus and ROAD

In total, 595 out of the 654 OA journals indexed by the COAJ index published the full texts of their articles in Chinese only, suggesting a dominance of Chinese-language journals among the country's OA journals. The share of these 595 journals that are currently included in DOAJ, WoS and Scopus, are 1%, 1%, and 19% respectively. None of these journals are indexed in ROAD.

4.2. Types of Publishers

Figure 1 presents the distribution of the 595 journals across different types of publishers. University-published journals formed the largest category (40%, 228 journals). Three other publisher categories were roughly of equal size: scholarly societies (22%, 128 journals), professional publishing organisations (19%, 114 journals), and government agencies (18%, 109 journals). One publisher, Science

Press (105 journals), a leading STM publisher in China, dominated in the professional publishing organisation category.

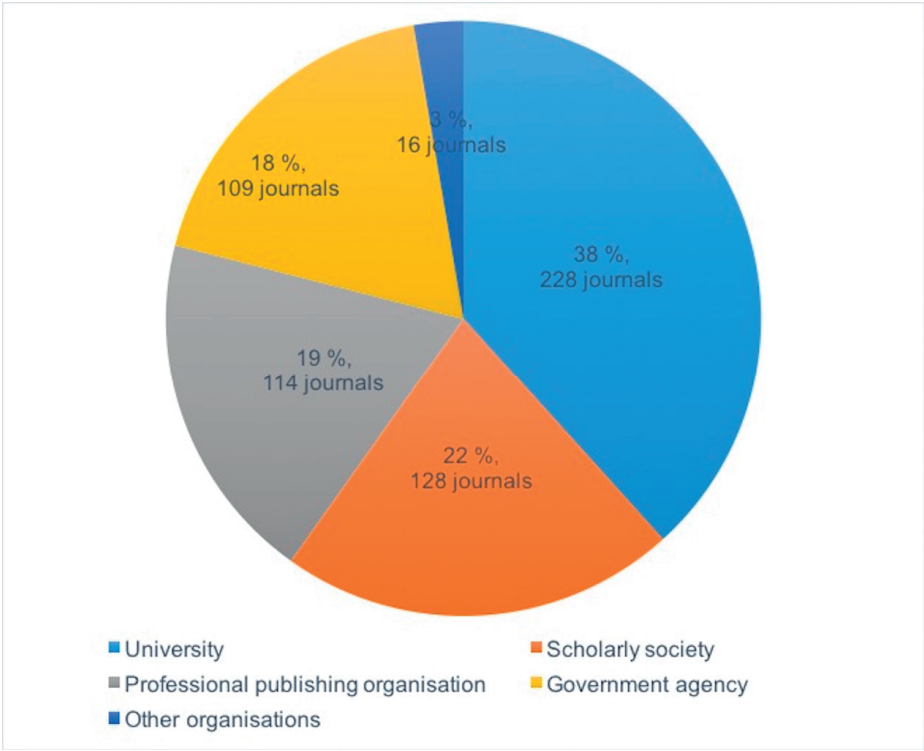

Figure 1. The distribution of Chinese-language open access (OA) journals by types of publishers (N = 595).

4.3. Subject Fields

Figure 2 describes the distribution of the journals over subject fields. Journals categorised as "general" were the largest group, with a total of 164 journals (28%). The second-largest category was earth science journals (25%, 146 journals) followed by engineering journals (20%, 121 journals). Biomedical journals ranked fourth in the quantity (16%, 97 journals). The results indicate a highly skewed distribution of Chinese-language OA journals towards the STEM fields.

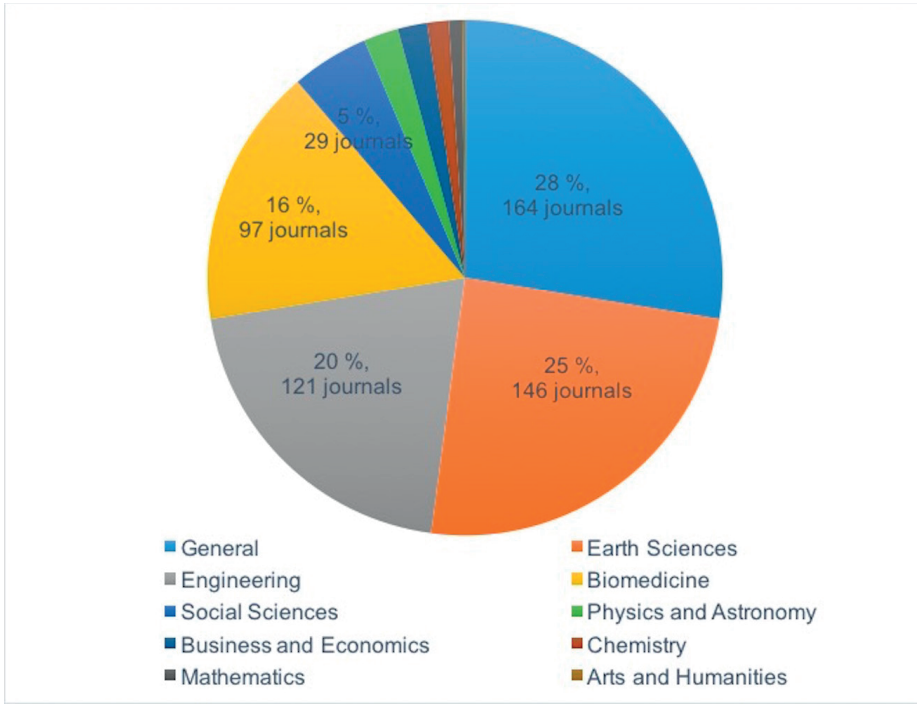

Figure 2. The distribution of Chinese-language OA journals over subject fields (N = 595).

With regards to the subject field distribution across different publisher categories, Table 2 shows that about 40% of university OA journals were classified as "general", which was the largest subject category. More than half of scholarly society journals were in the fields of biomedicine (28%) and engineering (27%). This was also true of journals published by other organisations, in which biomedicine (44%) and engineering (31%) were also dominant. Professional publishing and government agency journals presented similar distributions, both of which had the largest share of journals in earth science.

Table 2. The subject field distribution by types of publisher (N = 595).

	Number of Journals				
Subject Field	**University**	**Scholarly Society**	**Professional Publishing Organisation**	**Government Agency**	**Other Organisations**
General	91	18	23	29	1
Earth Sciences	35	24	53	32	1
Engineering	32	35	23	26	5
Biomedicine	39	35	8	7	7
Social Sciences	26	1	0	2	0
Physics and Astronomy	1	6	2	4	0
Business and Economics	1	3	0	6	1
Chemistry	0	4	3	1	0
Mathematics	2	1		2	0
Arts and Humanities	0	0	1	0	0

4.4. Journal Age

Figure 3 presents the distribution of the journals by the year they were founded. The largest group consisted of journals launched between 1980 and 1989 (40%), with the 1950s being the second

most popular start period (17%). Very few journals have been established from 1990 onwards, after the emergence of the World Wide Web, (8%).

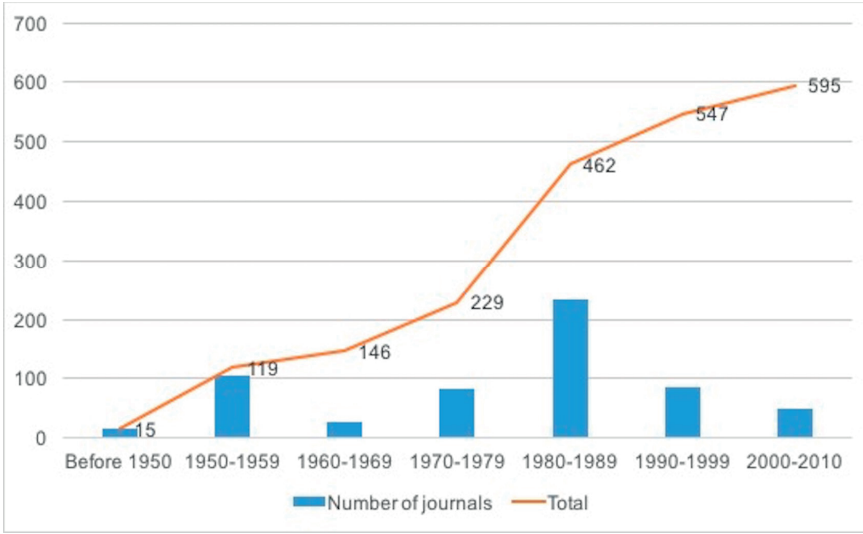

Figure 3. The distribution of Chinese-language OA journals by year of launch (N = 595).

4.5. Motivations for Adopting an OA Approach

All the participants in the interviews were asked about the key motivation for their journals becoming OA. In more than half of cases the reason was a belief that OA helps to improve the impact of the journal, whether it was converted to or founded as OA. The participants felt that wider readership, quicker dissemination and additional citation advantages would increase the academic impact. One of the participants particularly noted that authors' decisions about where to submit depended on a journal's academic impact (i.e., Journal Citation Report (JCR) impact factor), and that OA could be a means for making the journal more competitive.

Participant 7 argued that OA could provide an additional source of income to compensate for the reduction in subscription income resulting from a decrease in demand for printed journal copies. Participants 2 and 4 felt that Chinese scholarly journals had a moral obligation to communicate academic research findings to the general public. OA publishing was precisely the sort of a model that they needed in order to achieve this aim.

4.6. Barriers for Successfully Publishing OA journals in the Chinese Language

Relating to this, the lack of a sufficient number of high-quality submissions was recognised as a major barrier by most participants. Three participants criticised the national research evaluation system with its strong favour towards publication in the international journals indexed by SCI and EI which has led Chinese journals to suffer from a great loss of excellent papers written by the country's scholars.

Surprisingly, only two participants noted that the language used in their journals was a barrier, because it restricted submissions from non-Chinese speaking researchers and narrowed the journal's readership. Participant 1 felt that international readers could understand articles in Chinese provided that there were good English summaries given by journals, but for articles in arts and humanities that method might not be applicable. Chinese poetry, for instance, was much harder to translate accurately into English. Participants 2, 6, 7 and 8 also reported some specific problems with their respective

journals, including the lack of clear positioning, long-term sustainable business models, and adequate publishing service abilities.

4.7. Attitudes and Barriers to Converting to English or Bilingual OA Journals

All the participants were asked about their attitudes towards converting their journals into English or bilingual ones and what they felt would be the main barriers in such a transition. The majority of participants were interested in such a change, while three participants were not. One of these emphasized the importance of maintaining an OA journal in the local language in order to target the domestic market only.

The most common barriers mentioned to a change of the language were cost issues. This seems primarily because it would require a large financial investment in the initial stage to recruit highly skilled English-speaking editors and reviewers as well as international experts to serve on the journal's editorial board. Participant 1 also stated that their top-down management style would make it time-consuming to reach a consensus on such a major change. Participant 6 felt that it would take a lot of time to improve the journal's quality to get wide international recognition.

The lack of a well-established large publishing platform was seen as a problem by three participants. On the one hand, both Participants 1 and 2 called for such a platform with high global visibilities like SpringerLink to promote local journals. Participant 2, on the other hand also pointed out the drawback of self-promotion through a journal's independent online domain, compared with such a platform. The current situation has led to a relatively low level of content integration containing isolated and small pieces of information, which might cause a problem in attracting a wider audience.

Participants 3 and 7 felt it challenging to attract submissions from abroad. Firstly, due to the wide adoption of journal ranking systems in universities around the world, authors tend to publish English-language articles in predominantly Anglo-American journals which have an overriding presence in these ranking lists. Secondly, they felt that the scope of their journals seemed not to be interesting to international researchers. Two participants worried that this would be likely to narrow the readership. One of them also expressed the concern of losing Chinese readers who are unable to read English.

The competition from existing similar, but more prestigious international academic journals was seen as another barrier. Several participants felt that they were not confident in competing with them. Only one participant expressed doubts concerning copyright and research evaluation issues, specific to bilingual journals. In copyright agreements it was generally not permitted that an article in an English language journal be republished in Chinese in another Chinese-language journal. It was also not yet clear how same publication released in different languages would be assessed in the existing research evaluation system.

5. Discussion

This study showed a dominant position of the Chinese-language OA journals in the current OA publishing market in China. Since there is a lack of reliable studies of the overall number of scholarly journals in China, the Chinese Science &Technology Journal Citation Reports (2016 extended edition) was used to estimate the target population, in which their source journals were included in the Chinese Science and Technology Paper Citation Database (CSTPCD) [47]. This is the most complete report of Chinese legitimate scholarly journals in the fields of natural sciences and social sciences, which as of 2016 include 7174 titles. On the basis of this, the share of Chinese-language OA journals in the entire Chinese scholarly publishing market was calculated to be about 8%. Compared to an estimated global share of the gold OA market of between 15% and 18% based on Scopus data as of April 2017, the OA journal's coverage in China remains low [22]. The international visibility of Chinese-language journals that become OA is still limited, with small shares in DOAJ, ROAD, WoS, and Scopus, all of which are considered as important proxies to make the journals known by a more international audience. This is

possibly due to the fact that many OA journals published in Chinese lag in terms of their publishing standards and lack high academic impacts.

The total share of Chinese-language OA journals published by universities and scholarly societies is larger than that of their counterparts indexed in Scopus, while the ratio of professionally published journals was smaller than that of Scopus's journals [45]. The application of the approval system would best explain this skewed distribution. In China, scholarly publishing is run as a government-regulated and not fully market-oriented business. The government hence implemented such a system, executed by the State Administration of Press, Publication, Radio, Film and Television of the People's Republic of China, to strictly examine the publisher's qualifications for publishing journals [48]. Universities and scholarly societies are regarded as the entities which are better qualified for academic publishing and better able to meet the necessary conditions of running a scholarly journal than publishing companies without affiliations with a university or government agency, in other words, professional publishers. Unlike China, most other countries commonly employ the registration system, which implies the free right to create scholarly journals.

The distribution of Chinese-language OA journals across subject fields is highly skewed towards the STEM fields. Nearly two-thirds of journals are from these fields, while less than 10% of journals were from social sciences, arts and humanities, and business and economics. The difference between the proportion of STEM journals and journals in other fields is 40%, much greater than that in the complete Chinese scholarly journal landscape (2016, Chinese S & T Journal Citation Reports, extended edition) [47]. Compared to the OA situation in Latin America, where there is a high adoption rate of OA in their journals published in local languages, the results show that there is a more balanced distribution across different subject fields [13].

The major reasons for a skewed distribution to STEM fields in the Chinese-language OA market could be attributed to a combination of factors. First, the gold OA model is traditionally more established in the science, technology and medicine (STM) fields than in the humanities and social sciences (HSS). OA journals from these disciplines are far more common. Chinese STEM journals are thus more open and willing to adapt in order to succeed in the changing global publishing environment by adopting OA. Moreover, monographs are the dominant publication form for academics in the HSS fields, which means fewer OA journals are needed. Compared with HSS journals, Chinese STEM journals receive much more financial support. Various programmes are also being implemented by the Chinese government dedicated to funding the development of China's STEM journals. The "high quality scientific journals" project organised by the China Association for Science and Technology (CAST) since 2006 is a good example; about 150 STEM journals were funded with over CNY 30 million within the first two years [49]. Another major reason might be that a large part of Chinese journals in the HSS fields offer OA indirectly through the more cost-effective NSSD rather than through their independent online domains, the approach of which falls outside the traditional definition of gold OA [43].

Journals which cover a broad multidisciplinary field represent the most common form in China's scholarly publishing system, which is particularly obvious in the example of university journals. In the Chinese language OA publishing market, university publishers continue to have the largest number of these journals. One possible explanation for this finding is that in China such journals have the primary goal of serving the faculty staff as well as postgraduate and doctoral students from almost a range of different research fields in their parent universities by showcasing their work. Compared to other highly subject-specific journals, these journals generally do not have clear disciplinarily boundaries. It is then difficult to attract readers who want to identify research in one area of interest [48]. Moreover, the names of these journals, especially university journals, are often directly and strongly associated with their sponsoring institutions. This possibly makes authors from outside hesitant to contribute because these journals appear to be mainly intended for researchers at the same institute [50]. Therefore, the effectiveness of employing an OA model for such journals remains a question unless their inherent disadvantages could be overcome.

The distribution of journals by year of launch follows the developmental trajectory of China's society. Since the beginning of China's centralized command economy era in the 1950s, the Chinese scholarly publishing industry started to resume and re-establish in order to develop and fulfil the needs of socialist scientific, educational and cultural undertakings. As a result, a relatively high number of Chinese-language scholarly journals was founded during that decade. In the period 1960–1969, China was in the midst of the Cultural Revolution, causing the destruction of the Chinese scholarly publishing industry. After 1978, with the national economic reformation and opening-up of policies, the increasing social demands led to a boom in China's scientific research and promoted the growth of Chinese scholarly journals again. The number of newly established Chinese-language scholarly journals then reached their peak. In summary, about 80% of journals emerged before the arrival of the Internet, which implies that most of the current Chinese-language journals were started as printed subscription journals that then converted to digital and OA. This is apparently different from Western scholarly journals published by commercial publishers, mostly operating an OA business model from the outset. However, many journals published by university and scholarly society publishers have chosen to become OA in a similar fashion as in China [45].

Increased academic impact is the most anticipated benefit by the participating Chinese scholarly OA publishers in this study. This is probably closely related to the widespread economic model of most Chinese scholarly journals, which are largely subsidized by national or provincial governments directly or indirectly through, for example, scholarly societies, academies and institutions [24]. Even though some of them continue to charge subscription and publication fees as other sources of revenues, relying solely upon them is much riskier for sustaining both the actual production of the journals and the operations of the editorial office. On the one hand, many Chinese scholarly journals have small distribution quantities of print copies every year, thereby largely influencing their incomes from this part [51]. On the other hand, three giant Chinese aggregators, including the CNKI database [52], Wanfang [53], and Chongqing Vip [54], play a major role in helping China's scholarly publishers provide end users with the e-content of published journals because they are granted non-exclusive or exclusive distribution rights by the publishers. The Chinese scholarly resource is then being monopolized by these third-party aggregators, through which they have made the largest financial gains while providing very little compensation to scholarly publishers [48]. Due to their wide coverage of almost all full-text scholarly journals, well-developed digital infrastructure, and professional customized services, subscription through scholarly publishers becomes less attractive to both individual and institutional users when they consider purchasing the online content. It could thus be estimated that the subscription revenue for Chinese scholarly journals per year is not comparable to the situation of Western commercial publishers where their high profit margins come from. The OA publishing model might further manifest a negative influence on the journal's subscription income. Moreover, charging publication fees existed long before the arrival of the author-pays OA model in China. In 1987, an experiment with publication fees started, permitted by the Chinese government but not recommended. Up to 2006, more than ten government ministries and the provincial journal management divisions issued documents of concern, and controversy remains regarding the rationality of such charges [51]. In this model, charging authors by the length of articles is the primary pricing principle of most Chinese scholarly publishers. There are clearly variations between different journals in terms of the fees charged largely due to a lack of unified standard in implementing the publication fees at the national level. From the interviews, the average publication fees of these journals is considerably cheaper than the global average article processing charges (APCs) at around USD 900, and some of them are much below the average cost of publication [55].

However, the eligibility for government subsidies is essentially determined by the impact of the scholarly journal, primarily measured by impact factor and other citation data provided in the Chinese Science Citation Database–Journal Citation Report (CSCD–JCR) Annual Report [56,57]. Low-impact journals are less likely to receive the financial support from the government and invest in their own

development. As a result, financial restrictions make it difficult for them to bolster the impacts and can even lead to a survival crisis, resulting in a vicious circle.

The lack of sufficient numbers of high quality papers with respect to important scientific research achievements is perceived as the biggest obstacle to successful publishing of journals by the participating Chinese OA publishers. There also have been several studies reporting the scale of this problem. Dong estimated that at least 135,598 papers written by Chinese-speaking scholars were published in international journals in 2011, based on the data from Science Citation Index Expanded Database [58]. Wu et al. analysed the extent to which Chinese science and technology papers outflowed from China to abroad between 1992 and 2011, and found that the annual outflow rate has continued to increase over the past two decades, reaching 67.1% by 2011 [59].

The papers outflow might be the negative effect as a result of the existing academic assessment systems at both the institutional and national levels [4]. Adopting the number of publications in SCI and EI-indexed journals or their equivalents as key indicators of a university or an institution's academic level by major national research funders has made Chinese institutions incentivize their researchers with monetary rewards to publish more papers in such journals. Worse still, career promotion, project funding, and obtaining academic degrees are all determined on this basis [58]. However, international indexing systems such as SCI favour English-language journals based in English-speaking countries, such as the UK and the USA [60]. Because the scientific quality of papers in Chinese-language journals in general is quite low, they have little chance of being indexed. It is therefore natural that Chinese researchers choose foreign journals with high impacts. A rapid expansion of Chinese research publications, in particular, publicly-funded papers in English published in SCI source journals has been witnessed in the last decade [58]. Broadly speaking, China's method of academic evaluation is highly influenced by a reliance on the pervasive concept of "academic excellence" used to identify the best researchers and institutes in all regions of the world. This is nevertheless criticized and questioned with respect to actual efficiency and reliability [3,61].

Surprisingly, although language is confirmed to be the main factor that limits the international communication of journals published in Chinese [62], language is not acknowledged by most OA publishers participating in the interviews as a major barrier. The primary reason for this situation is that they have developed various strategies to deal with language issues, including providing detailed English summaries of published Chinese articles, translating a selection of good Chinese papers into English and promoting them through domestic recognized full-text databases such as Wanfang and CNKI, and even setting up a "twin" English journal.

There remains some interest among the participating OA publishers in converting their journals to publish in English directly. However, a major concern over cost issues, especially regarding financial resources, hinders these interested publishers in internationalising their journals. Economic instability puts Chinese-language OA journals at risk, since it affects long-term financial viability. This points to the importance of the need for finding a long-term sustainable solution that is suitable for the Chinese context in an OA environment. The APC-based model is currently a major funding method for full OA journals, but a pure APC model may not be applicable in the Chinese context. There is a correlation between APC price and quality in terms of citation rates. Authors are thereby more likely to select OA journals that can offer a better quality level with respect to what they have paid [63]. Since Chinese-language OA journals continue to have a relatively low impact, the increase in the amount of publication fees that suffices for covering the total cost of publishing may intensify the pressure to attract Chinese authors. Hence, the setting of publication fees must be reasonable and take into account costs, quality, author's ability to pay, and disciplines.

A complete subsidy model from a government source can offer one solution to this problem, but this can be a slow process due to a lack of governmental strategies for gold OA in China. Alternative models, for example, the library partnership subsidy model created by the Open Library of Humanities (OLH) might be seen as another potential solution, as the Chinese library community is the strongest supporter of the OA movement [31]. In this model, libraries play a more important

role than just a sponsor, as they are also involved in some management processes [64]. The author believes that this will form a much firmer basis for long-term cooperation, enabling publishers to achieve more sustainable financing. In addition, building China's OA publishing portal appears to be one good alternative that can help to address this challenge. This portal can partly replace commercial aggregators to provide Chinese-language OA publishers with digitization and dissemination functions at a low or even no cost by means of government funding. Some open source software solutions, in particular Open Journal Systems (OJS), can play a crucial role in terms of its technical infrastructure [65]. Furthermore, it is worth pointing out that authors' source of funding to pay publication fees varies across different disciplines. In comparison to STM disciplines, HSS scholars are granted much fewer funding opportunities [66]. Because of this, Chinese authors from HSS fields are more reluctant to accept the author-pays model [67]. Thus for Chinese-language OA publishers in these disciplines, sufficient governmental commitments are needed to financially support them to survive and develop. Other obstacles identified in the interview, including the fear of competition, the lack of confidence in self-promotion and the difficulty of attracting submissions, shed light on the lack of competitiveness of these journals published in the Chinese language.

6. Conclusions

By and large, this study demonstrates that Chinese-language OA journals are dominant players in China's OA market, with most of them launched by universities and scholarly societies firstly as subscription journals with a later conversion to OA. There is a high concentration of journals in the STEM fields. Chinese-language OA journals are still not competitive enough, particularly because their low presence in some major international indexing organisations, difficulties in attracting high-quality research papers, and long-term financial instability. However, their vital role in promoting knowledge exchange among domestic researchers should not be ignored. Adopting the form of OA has made Chinese research results more visible and accessible to the widest audience possible, including not only domestic and overseas Chinese-speaking researchers but also foreign researchers studying China-related topics when their institutions generally do not subscribe the journals in Chinese. Publishing in Chinese-language journals would also allow domestic researchers to gain recognitions for their scholarly contribution from their Chinese-speaking academic communities [6]. Due to the limited number of participants in the interviews, this study only provides some qualitative insights into OA publishing in Chinese that future research could and should follow up in many ways based on the current findings. For example, a survey or focus group in the research design would be useful to deepen the understanding of this topic. On the basis of the findings in this study, some recommendations are proposed for the future of the Chinese-language OA market.

6.1. Increase the Visibility of Chinese-Language OA Journals and Their Articles in International Indexes

The results show significantly low global visibility of Chinese-language OA journals when measured by their proportion in DOAJ, ROAD [68], WoS, and Scopus. To remedy this situation, it is suggested that Chinese-language OA publishers become more active and take the first step to participate in the worldwide network of scholarly publishing, such as DOAJ, Scopus, Open Access Scholarly Publishers Association (OASPA) [69] and Committee on Publication Ethics (COPE) [70], and engage in more interaction with their counterparts outside China so that they can be a part of a global publishing and academic community, keeping a sharp eye on new trends in OA publishing. As well as journal information being included by these indexes, article-level metadata can also be covered if it is available in order to further strengthen the discoverability of the content in local journals. For example, in DOAJ, more than 2.5 million articles are searchable as of August 2017 [10]. Nevertheless, a high-level publishing standard is the precondition for being indexed by these databases. Finding ways to ensure Chinese-language OA journals comply with the international standards and practices adopted by the global scholarly publishing community is thus of prime importance. Principles of transparency and best practice in scholarly publishing and OASPA's code of conduct are most recommended [69].

6.2. Promote a Balanced Development of Chinese-Language OA Journals

This study also indicates that Chinese-language OA journals are concentrated in three major STEM categories, namely earth science, engineering, and biomedicine. Less than 7% of journals are in arts and humanities, social science, and business and economics. This calls for the shareholders in the Chinese scholarly publishing industry to take essential measures that can help to bridge this gap across disciplines.

6.3. Reform the National Research Assessment Systems

The biggest reason behind a lack of sufficient numbers of high-quality papers occurring in Chinese-language OA publishers is the implementation of current China's research assessment systems. This can be seen as a direct consequence of North–South imbalance where publishing in internationally indexed journals is a means for researchers from the South to participate in international science. However, such systems put journals published in Chinese at a disadvantage in terms of attracting excellent papers from Chinese researchers. The reform requires the collective effort of the government, major research funders, and universities to find out reasonable criteria, avoiding being largely dependent upon SCI and EI indicators. Foremost, the most feasible option is to encourage Chinese researchers to publish publicly funded papers first in Chinese-language journals and consider OA to increase visibility.

6.4. Build a National OA Publishing Platform

In the present study, the lack of long-term approaches to maintain financial viability has been identified as related to the motivation of Chinese-language journal publishers to become OA, and has also been found to be the biggest obstacle jeopardizing the internationalisation of these journals. The author thus proposes a large, non-commercial national OA publishing platform for Chinese-language OA journals as the best potential solution to this problem. The objective is on the one hand, to help professionalize the production of journals at no cost to the journal publishers, and on the other, to develop their reputation to make Chinese research more visible and accessible to the rest of the world. In order to build such a platform, the author suggests that maximum use be made of the existing infrastructure. For example, the COAJ index could be used as a starting point. This index already performs some basic functionalities related with searching and indexing of the distributed Chinese OA journals but is not yet fully functional. Compared with other well-developed platforms such as SciELO [13] in Latin America and J-STAGE [71] in Japan, the COAJ index lags much behind in its selection criteria, metadata integrity of publishers and journals, full-text retrieval, and languages as well as other added value services, such as altmetric reports and manuscript peer review tools. Since these platforms from non-English speaking countries have been proven to be effective and helpful in addressing the challenges of scholarly journals published in local languages with respect to visibility, accessibility and impact [72,73], a platform in China can be developed taking into account their methods, while offering Chinese-specific characteristics to satisfy the needs of local readers, editors and authors. This platform also needs adequate financial support from the government, making it more competitive and attractive to the publishers. Development of a national OA publishing platform will enable mass promotion of Chinese-language OA journals to the global market, as well as making them more visible to the Chinese market.

Conflicts of Interest: The author declares that she had a role as the DOAJ Ambassador for China in the collection of data.

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Cenyu Shen

A Study of Three Alternative Open Access Publishing Models

Digital technologies have brought good opportunities for innovation in the scholarly publishing industry, including the Open Access (OA) model, which makes peer reviewed journal articles freely available on the Internet. Over time, alternative approaches and strategies to fund and support OA publishing activities have surfaced.

The primary mechanisms for providing content OA include journals publishing articles directly as OA (Gold OA) or by authors archiving manuscript of articles in subscription journals in other web-based services (Green OA). Among different business models for gold OA publishing, the article processing charge (APCs) model has been a common path chosen by established major publishers. However, the introduction of APC-funded OA has also given rise to the problem of 'predatory' publishers, which has seriously damaged the reputation of OA publishing. Another problem is the increasing difficulties faced by the non-APC funded publishers either to sustain their journals financially or stay competitive to attract authors.

This thesis examines the situation of three distinct types of gold OA journals, which includes early independent scholar-led ('indie') OA journals, 'predatory' OA journals and Chinese-language OA journals. The overall purpose is to offer a varied perspective on the landscape of gold OA journals and therefore provide a fuller understanding of gold OA. Quantitative methods using bibliometrics and web observations were used, further complemented by qualitative methods in the form of case studies and interviews.

The thesis consists of three articles each focusing on one specific group of gold OA journals. The study of 'indie' journals shows that nearly half of them remain active with a relatively small publishing volume beyond the initial 6-9 years and that most of them had found other alternatives than to rely on APCs to finance themselves. The five related case journals present different development trajectories. The longitudinal development of the number of journals and article volumes of 'predatory' OA publishers indicates that this market was rapidly growing between 2010 and 2014. The estimated volume in 2014 rivalled that of OA journals indexed in DOAJ at the time. However, 'predatory' OA publishing can be seen as mainly a regional problem in terms of the distribution of publishers and authors across countries. The study of Chinese-language OA journals finds that most of the OA journals in China are published in Chinese and that they are mainly published by universities and scholarly societies. A prominent problem for the successful publishing of the journals which were studied with the support of interviews is the lack of a sufficient number of high quality manuscript submissions. Their operational situation is further exacerbated by their financial instability which is identified as the main barrier to internationalization.

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