Article

The Open Access Divide

Jingfeng Xia

School of Informatics and Computing, Indiana University, 755 W. Michigan St, UL 3100B, Indianapolis, IN 46202, USA; E-Mail: xiaji@iupui.edu; Tel.: +1-317-278-2178

Abstract: This paper is an attempt to review various aspects of the open access divide regarding the difference between those academics who support free sharing of data and scholarly output and those academics who do not. It provides a structured description by adopting the *W*s doctrines emphasizing such questions as who, what, when, where and why for information-gathering. Using measurable variables to define a common expression of the open access divide, this study collects aggregated data from existing open access as well as non-open access publications including journal articles and extensive reports. The definition of the open access divide is integrated into the discussion of scholarship on a larger scale.

1. Introduction

The term "open access divide" describes the split between those academics who support free sharing of scientific data and intellectual output including scholarly publications and instructional materials and those academics who do not. Stimulated by an ever-growing cost of periodical subscriptions and facilitated by the new information technologies, particularly the Internet, open access (OA) has experienced dramatic progress in the past two decades, providing a digital outlet for scholarly communication. During its course of development, OA has also encountered many challenges. An open access divide (OAD) has constantly permeated every aspect of the OA movement, despite notable OA efforts to increase participation. The academic community can be readily sorted into distinct groups. To a great extent, this divide reflects differences in how individual scholars perceive and participate in OA initiatives, which are influenced by their disciplinary norms, thematic research concentrations, roles in the OA undertaking, and cultural traditions and regional backgrounds.

Efforts to bridge the gap of divergent OA practices have not been as effective as many have expected. This is most likely because of "*the importance of faculty values and the vital role of peer review in faculty attitudes and actual publishing practices*" and "*the myriad divides that obstruct communication within the networks of the Internet*" [1,2]. A better understanding of the diverse practices will help advocates to better configure OA strategies to promote the involvement of every type of stakeholder. This requires appropriate measures of various OAD dimensions in order to shed light on the divergence and critical differences among key OA concepts and practices and grasp the essence of the open access divide. This is the purpose of the present research.

2. Background

Defined as having "*unrestricted access and unrestricted reuse*" by the *PLoS*, open access has many characteristics [3]. The OA users are primarily in the academic community, in which the major constituencies are either researchers or those that work on supporting research activities, e.g., institutional administrators, academic librarians, and information professionals. The OAD is illustrated by comparing variations in behavioral patterns of researchers within various disciplines, considering the availability and usage of OA resources can vary greatly. Also, because the Internet is the sole platform for the practice of OA publishing, self-archiving, content retrieval, and use, the OAD is not affected by various types of technologies (e.g., phone, computer, and digital TV) that are central to a digital divide.

OA has had many enthusiastic proponents. The Berlin Declaration, the Budapest Initiative, and the Bethesda Statement in the early 2000s symbolized international promotion of OA, with signatories from leading international research, scientific, and cultural institutions lending their support to the open access paradigm. Today, the Berlin Declaration alone has been signed by over 350 institutions, libraries, archives, museums, funding agencies, and governments from around the world [4]. The awareness of OA as both a concept and a mechanism for making scientific data, knowledge, and cultural heritage reachable to everyone has dramatically increased among scholars over the past two decades [5]. Nonetheless, there is still a gap between the OA awareness of scholars and the number of contributions they make to OA repositories. Additionally, mandate policies as the new campaign strategy have only proven effective in accruing valuable free digital content in certain areas. OA proponents are cautiously optimistic that continued implementation of mandates will eventually restructure the scholarly landscape and overcome the divide [6,7].

It has been recognized in the OA literature that dichotomies exist in many areas of the practice. Thatcher highlights an OA publishing divide between books and journals, and predicts that the divide will only become wider due to pre-published journal content that "*is made available in OA while only a trickle of the former gets into that mode*" [8–10]. He finds no evidence that universities have made or will start making necessary steps toward subsidizing OA publishing in book format as they did for OA journal publishing. Xia, Wilhoite and Myers outline a divide between librarians and LIS (library and information science) faculties in regard to the number of OA publications and citations [11]. Librarians are found to have not taken part in OA self-archiving more than the teaching faculty in LIS even though the former has played various roles in open access and are more knowledgeable about the impact of OA. Similarly, many researchers examine other representations of an open access divide between scholars in developed and developing countries; between junior and senior faculty; between

differences of raw data use; between the willingness expressed by scholars to participate in OA self-archiving and their actual OA contributions, and the like [12–16]. The open access divide is readily detectable.

A structured description of the open access divide will help provide an insight into OA progress and challenges. This paper is an attempt to conceptualize OAD by following and modifying the constructs of the *W*s doctrine and its revisions. OAD is streamlined along several distinct dimensions with the purpose of creating a common framework to address the questions of who, e.g., the divide between librarians and faculty, with which characteristics, e.g., the divide in academic rankings, subject area and geography, connects how, e.g., self-archiving activities and OA journal publishing, and to what, e.g., OA awareness, attitudes and actions [17]. In addition to combining these variables to form a collection of choices to define the divide, an attempt is also made to stress the separation between scholars' attitudes and actions concerning open access and to integrate the definition of OAD into the discussion of scholarship on a larger scale. It is hoped that the conceptualization of OAD will help policymakers regulate their efforts in advancing free information access and exchange, and help information professionals and librarians adapt better strategies of dealing with scholars' resistance to self-archiving.

Data utilized for the analysis are drawn from existing OA publications including journal articles and extensive reports, most of which are freely available online. This study relies on measurable variables to define a common expression of OAD, thereby requiring selection of dependable data sources that are scientifically acquired, verified, and reported. To this end, a list of important OA data sources organized in a chronological order is consulted, which is then supplemented by available up-to-date numbers [5]. Whenever necessary, non-OA sources are also referred. However, since this study aims to construct a conceptual framework instead of performing a pure quantitative evaluation, aggregated numbers are generally calculated and incorporated whenever possible.

3. The *W*s Doctrines

3.1. "quis, quid, quando, ubi, cur, quem ad modum, quibus adminiculis"–*Augustine* [18]

The origin of the *W*s doctrines could be traced back to the thirteenth century when a mnemonic verse was developed as a result of the need to help priests question confessors about their sins characteristic of the penitentials. Later, St. Augustine categorized the questions into seven circumstances, namely *quis*, *quid*, *quando*, *ubi*, *cur*, *quem ad modum*, *quibus adminiculis* (who, what, when, where, why, in what way, which supports) [19]. A further development of this form of questions as an analytical model to examine bible studies was made by William Wilkinson, a professor of theology, poetry, and literary figure, in the 1880s, known as the "Three *W*s" (What? Why? What of it?). Trumbull described Wilkinson's "Three *W*s" as a plan of study of alliterative methods for the teacher. To Wilkinson, this model was "*an almost immemorial orator's analysis, first the facts, next the proof of the facts, then the consequences of the facts*" [20]. The usefulness of this method in research and professional practice has been increasingly noticed later and the analysis was often expanded into the "Five *W*s" (When? Where? Whom? What? Why?). It provides a radical way of thinking and is applicable to various types of scholarly as well as individual projects. Among others, journalism,

communications, and political science adopted the constructs as a preeminent device in the early 1900s to regulate their professional undertakings, e.g., in newspaper writing.

3.2. "Who Says What, in which Channel, to Whom, and with What Effect?"–*Lasswell* [21]

In the field of journalism, students have long been taught the importance of answering six basic questions to complete a story. In addition to the "Five *W*s" an *H* was included to ask how it began or operates. It had become the standard that when a press release was written, one would need to follow the six questions: Who is the story about (referring to the people involved)? What is it about (denoting the problems, things, and ideas)? When will it happen (verifying past, present, and future of the topic)? Where will it happen (involving the locations)? How will it take place (concerning history or function)? Why is it happening (regarding the causes, reasons, results, and conditions)? Though some believed that the "Five *W*s" and an *H* were characterized as old-fashioned and fallacious in the 1940s, this staple of questions has been revived in digital journalism with the popularity of multimedia and virtual interactivity [22]. The constructs have been bestowed with new substances as to focus on asking: Who can we connect with (social networking)? What did the journalist read to write this (social bookmarking)? Where did this happen (mapping)? When are events coming up (calendars)? Why should we care (databases)? How can we make a difference (automation)? [23]

Harold Lasswell borrowed the concept of the *W*s doctrines to orient a simple structure of analysis for the studies of communication. After his expansion of the model, a series of basic questions was posed: "*Who says what, in which channel, to whom, and with what effect?*" [21] His prototype aimed at identifying various elements of communication in a political sphere where "who" represents people involved in the political body or agency communicating, "what" contains the essence of the message or idea, "channel" is of the method of communication, "whom" refers to the target audience, and "effect" signifies the outcome. Lasswell published his recognized book Politics: Who Gets What, When, How with the title itself later serving as the standard lay definition of politics [24]. His refinement of the *W*s has helped inspire systematic thinking about political communication and characterize the psychological and policy implications of different systems of communication.

3.3. "Who, with Which Characteristics, Connects How, to What?"–*Hilbert* [17]

In a recent study on the intricacy of the digital divide, Hilbert crafted a four-category structure to accommodate the most relevant studies, approaches and definitions by illustrating its major characteristics and dynamic connections. Grounded in the theory of diffusionism through the social network schema, a common framework was constructed to steer the multi-dimensional analysis that encapsulates every possible variable by focusing the examination on subject (the level of units to be engaged), function (the nature of attributes to be affected), mode (the style of immersions to be conducted), and channel (the type of media to be observed). By his own elaboration, the framework is carefully designed to refocus questions about the digital divide from asking "who is the subject?" and "which attributes matter?" to "how to connect?" and "what kind of technology?" The latter two groups of variables may present the value of "haves" and "have-nots," famous in the discussions of the digital divide, which aligns the two variables on either side of a dichotomy, which, in turn, produces the gap of the digital divide. It is mentioned by the author that different combinations of these four groups of

variables can bring about a sizeable collection of combined choices and may lead to contradictory arguments delineating the complexity of the digital divide. This four-category structure can be summarized as:

- for *whom* (level of analysis): the digital divide existed among individuals, households, groups, organizations, communities, societies, countries, and world regions;
- with *which* characteristics (attribute of node and tie): the digital divide is affected by a great deal of factors including age, autonomy, education, ethnicity and race, gender, geography, income, language, occupation, profitability, religion, skill, type of computer and website ownership, *etc.*;
- connects *how* (level of digital sophistication): measure of the divide taken on internet access, actual usage, and impact;
- to *what* (type of technology): connection accomplished via laptop, workstation, e-reader, digital TV, phone, GPS, Internet, *etc*.

Each dimension consists of a different number of variables which may change along with technology, e.g., the recent popularity of GPS technologies; the adjustment to individual situations, e.g., adopters' attitudes toward innovations; and changing interest from research groups, e.g., adding sub-groups of the target subjects. Yet, even without a dynamic change of the variables, a combination of selected variables across all dimensions will yield a great variety of possible definitions. For instance, starting with only three different choices of the subject units (e.g., households, communities and countries), each being evaluated by using five attributes (age, gender, geography, income, and occupation), differentiating between three levels of digital adoption (access, actual usage and effective adoption), and with five types of technologies (phone, e-reader, laptop computer, digital TV, and general Internet), a combination of 225 choices ($3 \times 5 \times 3 \times 5$) has already been made for an investigation of the digital divide. There is no threshold of variable numbers to be set for an analysis; yet, the formula indicates that for each additional variable being added, the matrix will be substantially amplified. While one may have been overwhelmed by the vast number of the digital divide elements, it is the framework proposed that demonstrates the value of Hilbert's effort for rationalizing complex analyses of the digital divide.

4. The Open Access Divide

The *W*s doctrines, especially Hilbert's four-category structure, can be adopted to discuss the open access divide, although the unique characteristics of OAD require some variations. Among other changes, Hilbert's subject-level analysis can be replaced by the type of subject, e.g., librarians *vs.* faculty, because necessary data is absent for distinguishing analytical levels between individuals and institutions. The attributes of each node are narrowed down to several characteristics of the OA practice that can be supported by measureable indexes and have shown noticeable dichotomies. For a description of the how factor, an effort is made to measure various OA activities, notably authors' efforts to perform self-archiving, publish in open journals, and contribute and reuse free data. The most visible change to Hilbert's constructs is the separation of the what factor, which is no longer about the levels of technology for the OA practice, but instead depicts a larger picture of the open access process, focusing on the discrepancy between scholars' expressed intention to participate in OA and their actual contributions. The structured description also highlights the applicability of the diffusionist model in

the technological as well as cultural context. However, before getting into the actual discussion of OAD using the *W*s theory, let us examine how academics become involved in open access.

4.1. Open Access: From Awareness to Action

In a general sense, OA may be viewed as a sequence of several consecutive phases, *i.e.*, *a*wareness, *a*ttitude, *a*ction and *a*llusion, throughout which *a*dvocacy pushes the process forward and *a*ctor (agent) is the subject who performs every OA task (Figure 1). Of these 6 "a" categories, "action" refers to a participant's work to (1) self-archive intellectual outcomes in the form of article pre-print or post-prints, reports or other types of written work in a digital repository or on a personal or institutional webpage; (2) contribute raw scientific data and data definitions to a free data repository; (3) post instructional content using open courseware; (4) publish peer-reviewed articles in an OA journal; and (5) make open source programs with original code available to the public. Similarly, the "actor" category can include institutional or library administrators, government officials, association personnel, funding agencies, or renowned scientists among those who advocate for OA. "Allusion" represents the actor's reuse and repurpose of raw data or open source code, which involves providing necessary credit to the original contributors. As with any analysis of the digital divide, most of these phases of the open access divide contain multiple variables, leading to a wide range of combinations and making the analysis more complicated.

Figure 1. A conceptual relationship among various types of open access (OA) activities.

An OA activity starts from one's awareness of the urgency and consequence of the digital means of scholarly communication. At the beginning of the OA movement, scholars' indifference to OA journal publishing or self-archiving using open access technology was considered to be the major reason for their unfamiliarity with the innovative approach [25]. OA advocates have since then undertaken a persistent effort to raise the rate of awareness among scholars. A time-series research reveals that in a period of about a decade since the late 1990s, the rate of OA awareness among scholars continued to increase, and is projected to follow the same trend [5]. It is worth noting that awareness has multiple degrees. The fact that one knows of the existence of OA does not guarantee his/her familiarity with the practice. In several author surveys on self-archiving, it has been found that many respondents could not

differentiate a free scholarly resource from a subscription-based resource, probably because they have substantial access to journal databases through their institutional subscriptions [1,13,15]. Few studies have made an effort to focus upon OA concepts and practices as understood by scholars, which demonstrates a critical research need that requires further attention.

Scholars' attitudes toward OA are thought to determine their behaviors in OA activities [26]. Like awareness, attitudes can also be multifaceted. One popular index to measure attitudes in most author surveys is willingness of scholar respondents to comply with a policy mandating participation in OA journal publishing or self-archiving [15,27,28]. A large percentage of scholars surveyed—in many cases more than 70%—show their enthusiasm about contributing to OA. It is reasonable that the ratio of willingness to participation does not match any single reporting time because it usually takes time for intention to be transferred into actual work. Nevertheless, it is unfortunate that over time individual surveys have continued to report a discrepancy in both OA journal publishing and self-archiving (see Figures 2 and 3). These figures show a larger gap in OA journal publishing than in repository self-archiving. Specifically, scholars hold a more positive attitude in favor of submitting articles to an OA journal, but act differently later. Comparatively, if they agree to make contributions to a repository, particularly an institutional repository, they are much more likely to follow through on that commitment.
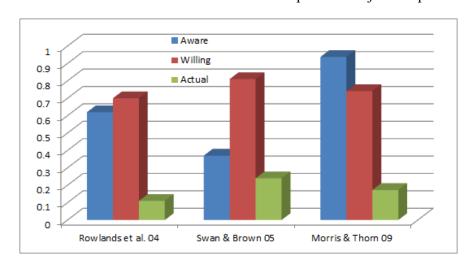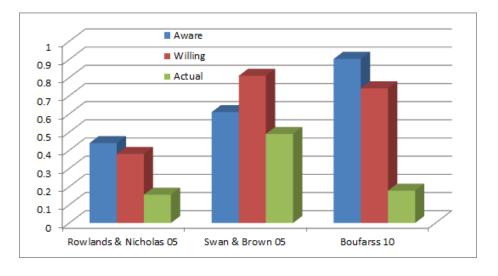
Figure 2. The divide between awareness and action for open access journal publishing [13–15].

Figure 3. The divide between awareness and action for open access self-archiving [14,15,29].

Although there are many reasons attributed to scholars' unresponsiveness to OA, it is generally argued that academic emphasis on impact may "*override the perceived 'opportunities' afforded by new technologies*" [13,27,30,31]. High quality and high impact research is the necessary ticket to tenure and other forms of career success in all research-oriented institutions. Tenure-tracked faculty perform in the same way across many fields by spending more time on publishing articles in the right venues than on anything else, while established scholars may follow the primary modes of scholarly dissemination in their own field, particularly in the humanities, where monographs are heavily valued, and in physical sciences, where traditional publishing is highly regarded [32–34]. Non-traditional dissemination including OA self-archiving and publishing has not yet been weighed as high in the system, especially when systems for peer review have not been well structured. Even though OA mandate policies have changed in the culture of digital scholarship to a great extent in some fields such as in the life sciences, academia is still dominated by the value faculty placed in traditional journal publishing.

The consistent high rate of scholars' willingness to participate in OA does reflect their interest in alternative scholarship. There are concerns about the restrictions of current publication practice by scholars who have experienced the slow publishing cycle and the limited dissemination mechanism. With the potential of the Internet, people are expecting to observe changes, which have fortunately occurred in many areas as a result of the continuous OA advocacy in the past decades. Some institutions have started providing credit toward tenure and promotion to faculty who make OA contributions in the form of data curation, although the amount varies significantly. The implementation of OA mandates has been a positive step for raising awareness among various stakeholders, including institutional administrators and faculty. The future of OA advocacy may need to become focused more upon affecting change in the academic evaluation system as a whole, instead of targeting individual scholars as it did in the past. By incorporating a rigorous peer-review process into data curation and self-archiving, and by publishing high-quality scholarly journals in OA, real change in the effectiveness of OA implementation is possible. Only if the system has been optimized to better accommodate open access will the divide between willingness and action be diminished.

4.2. Subjects: The Divide between Librarians and Faculty

We now go into details of various OAD dimensions following Hilbert's framework. Since the OA literature is mostly scholarly in nature and the purpose of the movement is to restructure scholarly communication, this study reviews only OA practice in the academic community, regardless of the reality that the general public is also the beneficiaries of the effort, e.g., those who are suffering from a disease may get free access to information about new treatments that are released online at the time of, or even before, their formal publication [35]. Scholars are the foremost constituencies as OA contributors and beneficiaries. In most cases, scholars refer to faculty in research institutions and universities, and therefore, the two terms are interchangeably used in this paper. Many other people in the community are also involved in the digital efforts with varying responsibilities, including academic librarians. They have been working on building websites and repository databases, coordinating with faculty to acquire materials, and creating and maintaining metadata to facilitate digital preservation and information retrieval. At the same time, an increasing number of advocates have delved into the promotion of an OA consciousness among faculty, most significantly through using their influence to provide incentives

for faculty or by endorsing the implementation of mandate policies at various levels, such as institutional and funding agency, to direct a constructive change of culture in scholarly communication.

Scholars are known for their reluctance to self-archive raw data and publications in digital repositories with exceptions for disciplines where a culture of information sharing has long been in existence, such as physics and economics. Early reports found that the numbers of items in many repositories were low [15,36–38]. In the following years, a slow growth of repository content has not reflected the aggressive advocacy among scholars and their increasing awareness of the importance of open access [39,40]. Similarly, the rate of OA journal publishing by scholars started very low in the mid-1990s, and was not able to reach a high level by the late 2000s in spite of great continual improvement over the course of the decade [5]. OA advocates have developed some strategies to boost the collection of free digital repositories, one of which is the implementation of mandate policies [7,41–43]. Some types of mandatory policies are more effective than others. For example, policies implemented by journals and funding agencies have been able to increase the number of researchers who are depositing raw data by making it a condition of funding or publication, while institutional policies have not resulted in more e-prints than repository managers expected [44]. Although Sale and others did report an increase of institutional repository items after the implementation of OA mandates in Australia, such an increase is more the result of mediated archiving by repository workers rather than faculty authors as well as the result of other types of OA advocacy launched by individual repositories [41–43,45,46].

In comparison to faculty who are late adopters of the OA practice, librarians are supposed to present more positive behaviors in OA publishing and self-archiving because of their heavily assumed roles in preserving and disseminating scholarly records, although only a small portion of librarians are exclusively responsible for repository management. Most academic libraries in the United States evaluate the performance of their librarians on scholarship, and hence publishing is often a required part of academic librarianship. It is therefore surprising to find that librarian authors in the United States have authored significantly fewer OA publications and have not participated any more in article self-archiving than faculty in LIS, even though faculty themselves are not active in OA. Counting the numbers of articles available through OA yields a rate of 31.08% for librarian authors as opposed to 68.92% for faculty authors [11]. The same study finds that the odds of increasing OA citation counts for faculty's publications are by a multiplicative factor of 0.895. Similar results have also been found by other studies which include faculty in other academic fields [47]. Figure 4 has a simple comparison of librarians and faculty for their making own articles available in all types of repositories and websites, which shows a visible divide with regard to their OA article supplies and consumptions.
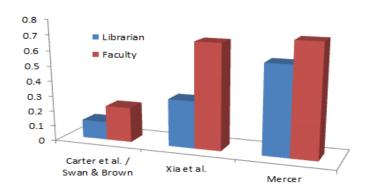
Figure 4. The OA divide between librarians and faculty in self-archiving [11,15,48,49].

Academic librarians as a group of digital facilitators also retain a different view of OA achievements from that of OA advocates. When OA advocates are enthusiastically and unanimously cheerful about the development of the scholarship reforms, librarians and involved information professionals are relatively cautious and pay more attention to challenges faced in practice [50–55]. This vision disparity in OA assessment may be caused by their different roles in the campaign: advocates have more access to diverse resources and thus are able to draw a larger picture and consider scholarly communication as an entire system, while librarian practitioners gain their opinions generally out of their own experience in individual projects. With regard to the discovered librarian-faculty divide, a disciplinary culture in information exchange may have played an essential role in influencing librarian authors' response to OA advocacy, which will be discussed below. The fact that librarian authors have authored much less OA literature may be caused by their familiarity with the capability of, and easier access to, subscribed database searching, and therefore, being inclined to depend less on general Web search engines to acquire free articles for their own studies [56].

4.3. Attributes: Dichotomies in Geography, Discipline, and Academic Status

There are numerous interrelated elements affecting the presentation of the open access divide. This paper focuses on several of these that are both mutable and quantifiable in study, namely academic ranking, subject affiliation, and geographic location of scholars. Other elements are neither applicable to open access, such as computer skills, educational background, occupational conditions, and religious connections, nor coming with sufficient analytical data, e.g., age classifications; gender differences; racial groups; and language practices. Also, types of technology and levels of digital sophistication are not as applicable for the discussion of the open access divide. With the selection of several of the most pertinent attributes, we further limit this study to one particular group of subjects because of the unique position of scholars in the academic community. OA investigations on the subject of librarians and information professionals have been too limited in number to distinguish among different types of digital responsibilities. Similarly, OA advocates do not represent an exclusive group of people; some of them may also be scholars. Of course, this does not prevent future studies from exploring different practices within each of these groups, which are rather interesting topics.
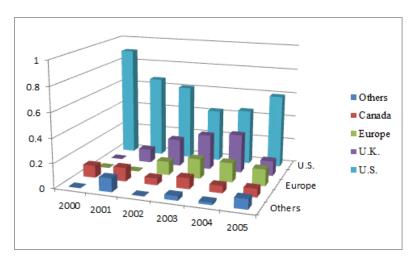
4.3.1. The Divide between Developed and Developing Countries

OA is basically a Western phenomenon, which was initiated in the United States and Western Europe prior to 1990 and was soon accepted by other developed countries such as Australia, Canada, and many other European countries [57]. It was not until the mid-2000s that OA endeavors started spreading all over the world, which gives credit to persistent OA advocacy and expanding access to the internet [58]. Even today, many developing countries, particularly those in Africa and Central Asia, are still struggling with developing a healthy infrastructure to facilitate free information sharing. A trans-cultural and trans-national diffusion of the digital scholarly system has been shaped by regional adoption strategies to suit uniquely local traditions. OA researchers have already paid attention to the spatial characteristics of the innovation and adoption by analyzing OA geography at the global scale, synthesizing models to understand diverse discoveries and using a chronological approach to reconstruct the history of OA spatial expansions [59]. A recent study has examined the conditions of mandate

policy implementations across countries, and other surveys have attempted to differentiate scholars' OA behaviors between developed and developing countries by collecting information about how many scholars are self-archiving and reusing OA data [7].
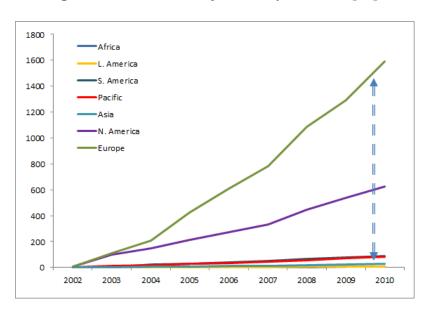
Multiple reports all show a developed-developing split in several OA areas [14,15,60]. Specifically, scholars from Africa, Latin and South Americas, and most Asian countries have a high awareness rate of both OA journal publishing and e-print repositories; and in some case the rate is even slightly higher than that of European and North American scholars. However, when data on actual OA actions by these scholars are collected, a geographic developed-developing disparity stands out so that one can easily find that scholars in developing countries have made far fewer OA attempts than scholars in developed countries. When surveyed for their willingness to comply with a mandate policy, if applicable, respondents from developing countries expressed their interest in open access more often than their counterparts in the West. This may be explained by the fact that scholars in developing countries are more inclined for free sharing of scholarly materials because of their limited access to subscription based journals than their counterparts in the developed countries. Their responses represent direct evidence indicating an inconsistency between scholars' expressed compliance with mandates and their actual level of OA contributions. Figure 5 presents a geographic dissemination of authors whose publications appear in OA journals by major country or region, in which the United States, United Kingdom and Canada are singled out due to their strong performance and all developing countries are summed up for the simplicity of analysis.

Figure 5. Geographic distribution of OA authors in LIS journals by major country or region [61].

This visualization of the international divide in OA progress is further supported by the numbers of OA journals initiated in developed and developing countries as shown in Figure 6. Data for these figures are gathered from the *Directory of Open Access Journals* (DOAJ), which is a Web service that includes most of the open access scientific and scholarly journals that apply a quality control system to guarantee the content [62]. DOAJ offers the most comprehensive list of OA journals with necessary links and metadata for each journal which can be sorted by country and initiation year. To reveal a geographic pattern of the journals, we selected the top 100 countries with the most journals and aggregated the numbers by continent for easy data analysis and visualization. The country designation of a journal

is based on the location of its editorial office, rather than the site of its publisher, as this is how data are acquired by DOAJ. Also, the continent classification may provide a biased result for the developed-developing country separation. For example, Mexico, classified as a developing country based on the UN's Human Development Index, was calculated toward the total journal number for North America which has considerably affected the continental rate after this total number is divided also with two developed countries [63]. Such exceptions are, of course, rare and can be ignored at the continent level.

Figure 6. Number of OA journals by continent [62].

The number of OA journals in each country will become more meaningful if it is compared to the numbers of total journals published in that country. We checked *Ulrichsweb*, a global serials directory of more than 300,000 periodicals, for the latter data and limited our search by selecting journals only. To make a precise comparison, the same 100 countries are examined, and the numbers of total journals are summed up by continent and then divided by the number of countries in that continent (Table 1). A Pearson's correlation coefficient ($r = 0.987$) implies a perfect relationship in a linear equation between the two variables. This may help explain the reluctance to commit to OA by most developing countries, rather than as a result of a lack of funds for scholarly pursuits in these countries.

Table 1. Numbers of total journals and OA journals by continent (averaged by country in each continent) [61,64].

	Total Journals	OA Journals
N. America	85,624	459
Pacific	13,512	82
Europe	7307	56
Asia	2106	31
S. America	1477	86
Africa	635	6
L. America	244	6

An understanding of the OAD between geographic locations may be taken from a diffusionist perspective since OA is also "the process by which an innovation is communicated through certain channels over time among the members of a social system" [65]. Following Roger's model of diffusion of innovations, the OA movement originated in a handful of core countries as an initiative to respond both to a sluggish publishing cycle and an ever-increasing subscription price for scholarly publications [66,67]. Because the early OA adopters shared similar attributes with the Western-originated innovators, they did not encounter major cultural or technological obstacles. As adoption spread, dissimilar systems across the globe started showing strength to block or slow down the channel of diffusion. It is easy to observe that the late adopters and non-adopters represent those countries and regions most affected by technological factors (e.g., the scarce availability of the internet in poor countries), and/or by cultural norms, economic conditions, and political structures, e.g., the tradition of unwillingness for free information sharing in some areas of East Asia. In a paper on OA geography, the author presented evidence to verify the assumption that the OA distribution has not corresponded well to the expansion of the information and communication technology infrastructure in some regions, where OA has been alienated from harmonizing with existing customs [59].

4.3.2. The Disciplinary Divide

It has been commonly recognized that scholars in different disciplines have varying attitudes and practices concerning self-archiving [68–71]. This view is supported by the history of the OA movement. The earliest subject repositories, e.g., arXiv for physics and RePEc for economics, are also the most successful repositories with active contributions by scholars [72,73]. These repositories are developed fields in which there was a preexisting culture of free information exchange, and scholars had been familiar with sharing research among peers [74]. For example, prior to the invention of the internet physicists exchanged their research in the form of pre-print by using mail or fax. By contrast, scholars in other disciplines, mostly in humanities and social sciences, are not acquainted with a preprint tradition and therefore are unenthusiastic about making their research available publicly [75]. As a result, subject repositories have not been able to fully develop even as efforts have been made to promote OA in these fields. Most OA surveys have not provided useful data to validate this disciplinary divide because their classification of "subjects" is not specific enough to reveal self-archiving disparities. The success of RePEc in economics does not represent the condition of subject repositories in all other social sciences.

There is a difference between some scientific fields and many fields in social sciences and the humanities, if we use the size of full-text deposits as a factor to measure the success of self-archiving in subject repositories (Table 2). This is for the purpose of demonstration only, and one needs to be cautious about interpreting the sizes because the total number of available articles will become meaningful only if it is divided by the total number of researchers in the field(s) that a subject repository serves. This piece of data is absent. Another reason that this comparison is suggestive is that content size may not be the only factor of assessment as argued by Carr and Brody in response to Xia and Sun [76,77]. Also, there is no evidence that these deposits are the result of self-archiving to reflect scholars' personal involvement in OA as the acquisition of repository items can be taken by mediated archiving, done by someone else such as students or librarians, or by applying particular computer

programs for loading files automatically. At the same time, mandate policies also cause polarization of content volumes among repositories. Nonetheless, the magnitude of subject repositories, for a quick view, can at least provide a rough idea about the position of the OA promotion among academic disciplines. This table also shows that most subject repositories have expanded their coverage to multiple disciplines.

Table 2. Major subject repositories and their content size as of October 2012.

Repository	Full-text Articles	Subject Areas
PubMed Central	2,500,000	Biomedical and life sciences
RePEc	1,200,000	Economics
arXiv	792,606	Mathematics, Computer Science, Quantitative Biology, Quantitative Finance, Statistics
SSRN	362,200	Accounting, Cognitive Science, Corporate Governance, Economics, Entrepreneurship, Financial Economics, Health Economics, Information Systems & eBusiness, Legal, Management, Political Science, Social Insurance, Sustainability, Humanities
Cogprints	3965	Biology, Computer Science, Electronic Publishing, Journals, Linguistics, Neuroscience, Philosophy, Psychology

The recent discussion of the statement by the American Historical Association (AHA) on policies concerning the embargoing of completed history PhD dissertations highlights a strong disciplinary culture on open access [78–80]. In their June 2013 meeting, the AHA Council provided a statement that strongly suggests the embargoing of newly defended dissertations in digital form for six years. The statement argues that an unlimited access to these dissertations will put history graduates at a disadvantage in their effort to turn their work into book format because publishers may be unwilling to accept book drafts that have been freely available online. It further argues that history has been and is still remaining a book-based discipline, and making dissertations open access presents a tangible threat to the interest and careers of junior scholars in particular. Critics blame the AHA statement for having not made an attempt to change the process of granting tenure to junior academics by raising the value of citations rather than the format of publications. They point to the fact that "manuscripts that are revisions of openly accessible ETDs are always welcome for submission or considered on a case-by-case basis by 82.8 percent of journal editors and 53.7 percent of university press directors polled" [81]. On the other hand, supporters of the AHA statement insist that an embargo will be beneficial to new PhDs who can have more time to fine-tune their graduate work. Debate on the embargo has been sparked on social media and academic blogs.

OA journal publishing provides another piece of evidence showing different practices between various disciplines. The most successful OA campaign to date occurred in the life sciences where the National Institutes of Health (NIH) has played a supportive role by launching a series of mandate initiatives to require the sharing of raw data and publications [82]. In addition to NIH's reputable repositories, e.g., PubMed Central and Gene Expression Omnibus (GEO), a large number of journals are either created as OA or converted into OA, many of which are highly-regarded scholarly publications. Researchers in this inter-disciplinary area have integrated open access publishing into regular scholarship. Recently, many small academic libraries have published their own institutional OA journals to support research in humanities and social science fields [83–85]. The average number of such journals per institution is 4.6 for faculty and 5.7 for student authors according to an examination of 47 small

institutions in the United States [40]. It may still be too early to judge these attempts, but concerns have already been raised about the quality and sustainability of these journals [86].

Disciplinary culture in scholarly communication is largely influenced by a dichotomy of epistemic features between convergent disciplines, which bear uniform standards and a relatively stable elite, and divergent disciplines, which have shifting standards, resulting in more intellectual results and a higher deviance from the norm [87,88]. Convergent disciplines support research that is carried out based on the approaches of others as well as shared by others. Economics, engineering and physics are several examples of convergence, where "...*the exact methods and the hard convergent nature of the disciplinary knowledge seem to provide clearer guidelines for management and academic work,*" and where OA is logically encouraged [89]. On the other hand, in divergent disciplines, knowledge sharing occurs only at limited levels and within a restricted pool of projects, which is represented by diverse research data, interests and schemas. Most disciplines in the humanities and social sciences fall into the category of divergence, e.g., the weak linkages and frequent barriers between sociological works, where subject repositories and OA publishing lag significantly behind the OA movement [90]. It is believed that a strong correlation exists between a disciplinary culture and the health of its subject repository, as well as the self-archiving rate of its scholars.

4.3.3. The Divide between Senior and Junior Scholars

For most faculties, OA is an experiment. Very few of them really realize the advantage of information openness in scholarly communication, although many may be aware of the practice. Among other concerns, faculties usually do not know how to handle the copyright, version control, and many other related issues of an article when depositing it to a repository, e.g., which rules are applicable in which disciplines and which journals, *etc.* or the faculties simply do not have time to make the contribution no matter how easy a self-archiving process is [91–94]. Early career faculty members are particularly concerned with tenure and promotion and cannot envision a logical connection between participation in OA and assessment of scholarship, as there is not an intrinsic reward in the existing academic structure to accommodate their efforts in the experiment [1]. The tenure clock keeps impelling junior faculty to prioritize only proposals for research grants, projects for high quality studies, and publications in prestigious journals, if teaching and service are not taken into consideration [95–97]. There is no evidence that a mandate policy has changed the perceptions and behaviors of these faculty members, unless the policy is implemented by funding agencies or top-ranked scholarly journals as can be seen in data sharing policies and their consequences in life science [98,99].

Faculty members who are later in their career are relatively independent of the tenure and promotion restrictions and thus are "*the most fertile targets for innovation in scholarly communication*" [39]. With tenure, senior faculty members are more willing to take part in various types of experiments than their junior counterparts. An example is senior researchers' quick recognition of the value of online information sharing, considering the rate of downloads "*a more credible measure of the usefulness of research than traditional citations*" [14]. It is not surprising that most OA advocates, in addition to administrators and librarians, are prominent scholars. A strategy to help recruit more content for digital repositories is to use senior faculty as role models for junior ones, as adopted by repository managers for the Cream of Science project in the Netherlands [12]. Seniority is not limited to tenure status, e.g.,

it is found that scholars who have accumulated more than sixteen publications tend to participate more in OA self-archiving regardless of their academic ranking [100]. Another important motivation for attaining senior faculty endorsement in open access lies in the fact that they are involved in academic policy-making and their interests in innovation are likely to have broader influence within their academic areas.

4.4. Connects How? Measure of Activities

4.4.1. The Gap between Journal and Monograph Publishing

One of the earliest open access efforts was the publishing of electronic scientific journals in order to deliver research results to the general public free of charge as early as in the 1970s [101]. It was not until the late 1980s when *Psycholoquy* was published that OA journal publishing started gaining its momentum [102,103]. Since then, diverse business models have been adopted in support of a sustainable operation. Some established journal titles were transferred from subscription-based to open access with sponsorship from governments [104]. In the past decade, academic libraries stepped in to launch peer-reviewed OA journals as a promising alternative to institutional repositories [105,106]. As many as 65% of academic libraries have been found to either have delivered OA publishing services or to be planning to deliver them, which does not count journals published by small-sized universities or colleges [84,107,108]. The major players, however, are professional associations and some professional publishers that have managed the publication of high-quality scholarly journals in many academic fields, such as the American Library Association's support for *College & Research Libraries* and BioMed Central's series of OA journals [109].

Some OA journals charge a fee to authors or research sponsors for each article they publish in order to cover part of the expenses for a peer-review process, journal production, and online hosting and archiving. Among many others, *PLoS* journals are known for following this business model [110]. This author-pay-to-publish style may be appropriate for these fields where research projects are typically supported by grants such as in life science and engineering, but could be a hindrance to increasing OA content in social sciences and the humanities. When an OA journal is managed by an academic library, it usually serves scholarship in the latter fields, and a publication charge is not typically implemented. However, many library-sponsored journals are still in the experimental stage and may lack a rigorous peer-review system, particularly journals designed for student authors [40]. Also, this toll-free-publishing model relies solely on financial support from funding institutions and/or grant agencies. An extensive discussion about the applicability, sustainability and scalability of providing OA journal publishing services has been recently undertaken [111–113]. With regard to peer-reviewed journals in general, DOAJ listed a total of 8286 registered OA journals with more than 915,520 articles as of October 2012 in comparison with about 1200 journals in 2004.

Unlike libraries and professional associations, many other types of publishers, e.g., university presses, set monograph publishing as their core mission. After the golden age of scholarly book publishing in the 1960s, when lavish government funding underwrote scholarly activity, all university presses were faced with challenges [114,115]. The first challenge was and still is financial. When libraries are struggling with increasingly declining budgets, their reactions to rising subscription costs is to reduce

book acquisitions in order to optimize their use of available funds for exorbitantly overpriced journals. As early as the 1970s, it was found that the ratio of monograph to journal expenditures in some major academic libraries had fallen from more than 2:1 to 1.16:1 over a period of five years [116]. This condition has only deteriorated since then. The second major challenge facing monograph publishers is competition from digitization projects and the Internet. An escalating digital tidal wave starting from the mid-1990s has dramatically changed the publishing landscape. Today, scholars and students assume that "*a Google search is a first stop for doing research, that multimedia is an integral part of narrative text, and that content will be available in a variety of formats and devices, with the accompanying tools and functionality to enhance its use*" [117]. Monographs seem increasingly under siege. The book publishing business has to seek short-term and long-term innovations for financial self-sustainability.

Publishing e-books, particularly e-textbooks, is one of the possibilities; so is the strategy of working on collaboratively productive actions. Some institutional publishers have already extended their responsibilities incrementally to implement new initiatives. The key is to balance the reconstruction of a self-supportive business model and the necessity of focusing exclusively on helping scholars create a new means of scholarly communication. Esposito has recently proposed a five-stage book publishing model in which he describes, "*the arc as publishers move from the traditional model (where print books were sold mostly in bookstores and to libraries) through a range of developments using online media, culminating in new forms of subscription marketing*" [118]. Publishers are urged to progressively look for direct relationships with their readers, to become experts in metadata creation, and to create customer databases and become concerned about the life cycles of their customers. Before workable strategies are successfully adopted, we will still observe a gap between journal and book publishing. However, the question remains whether this gap will keep widening as Thatcher predicts, or if it will instead lead to multimodal communication in the scholarly ecosystem [8,119–121].

4.4.2. OA Version Disparities

In OA practice, an article is a pre-print before it receives peer review and a post-print after it is peer-reviewed and accepted but before it is formatted by a journal. An e-print is a digital file of any research document, which may include a pre-print, a post-print, or both. After an article is accepted for publication, the journal will configure it with its printing prototype to add necessary contextual branding such as the publisher's logo, pagination, *etc*., and typically in a PDF format. Most publishers, both academic and commercial, have set explicit policies to regulate self-archiving including the specific version(s) to be allowed for OA. The SHERPA-RoMEO database collects the information of publishers' copyright policies on self-archiving of journal articles, where a total of 18,000 journals are color-coded based on the level of their self-archiving policies as of October 2012 [122]. The RoMEO colors include green (allowing pre-print and post-print or publisher's version/PDF to be archived), blue (allowing post-print, *i.e*., final draft post-referencing, or publisher's version/PDF to be archived), yellow (including only pre-print, *i.e*., pre-referencing), and white (archiving not formally supported). It provides an effective online location for scholars to clarify which publishers grant which levels of copyright to allow authors to post their research results online for free access.

However, one may never expect individual scholars to check the database before conducting any self-archiving activities [15,90]. Several years ago, Antelman examined the self-archiving behavior of authors publishing in leading journals in six social science disciplines and found that publishers' policies have little influence on author self-archiving practice: "*the overall self-archiving rate for the white journals examined in this study is significantly higher than the self-archiving rate for the green journals*" [123]. Scholars have in general made a significant number of articles in the form of post-print or publisher PDF version, which may not be allowed by relevant policies, and the confusion does not seem to have lessened since then [124]. This mix of various versions of scholarly articles will potentially bring up legal issues on one hand, and on the other hand, makes it difficult for scholars to reuse the data and results with regard to research quality control [125]. In another early study, Cave found that "*only 5% of Academics and 6.5% of Information Professionals surveyed found it easy to identify different versions of digital objects within institutional repositories with the figure being even worse across multiple repositories*" [126]. This in particular is still a problem today.

In 2008, the National Information Standards Organization in partnership with the Association of Learned and Professional Society Publishers recommended a classification of journal article versions (JAV) [127]. The recommended terms and definitions for JAV define journal articles at seven stages: (1) author's original; (2) submitted manuscript under review; (3) accepted manuscript; (4) proof; (5) version of record; (6) corrected version of record; and (7) enhanced version of record. These stages can be comparable to the pre-print and post-print distinction.
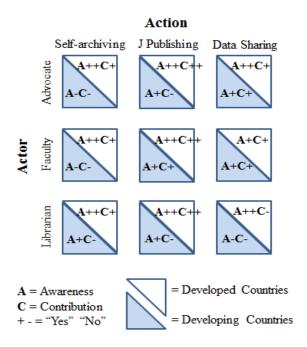
5. Conclusion: Narrowing or Widening?

Will the varying outlooks of the open access divide be narrowed or eventually be overcome? The answer is that it is too early to tell. Because of the heterogeneous sources of variables in practice, it is likely that some aspects of the divide may become even worse at certain stages of the movement. Cultural, economic and political influence in the trans-national environment may give the transition a different look even though the trend of internationalization has penetrated the scholarly system, and differing professional roles will still have dissimilar demands and concerns. Alternatively, gaps such as the one between OA journals and book publishing and the problem of alternate file versions may become less detectable after necessary infrastructure has been fine-tuned and appropriate polices have been created. On the road to closing the divide, immense effort must be undertaken to develop a consensus that academic culture can change in a way that is beneficial to the movement. In analyzing the open access divide, differing definitions and perspectives may also help align our understanding of the OA challenges and accomplishments, thereby directing the OA efforts of advocates and policy-makers. It becomes important for researchers to develop a comprehensive theoretical framework for systematic exploration of OAD from many different perspectives.

This article is a systematic examination of OAD based on the four-category model of a social network approach, covering the most visible gaps in OA activities. In order to summarize the findings, we draw a diagram to show the conceptual relationship among the primary variables, demonstrating the divide in geography, OA players, and types of activities, where the degree of various gaps is signified by the number of plus and minus signs (Figure 7). Comparisons within any single category across either horizontal or vertical lines will demonstrate measurable disparities between one's awareness of an OA

activity and his/her actual contributions. This matrix corresponds to Hilbert's conceptual combinations for the complexity of the digital divide and also fits into a diffusion analysis. Specifically, the higher level of awareness and OA participation in archiving of data from various subject areas in the developed countries correlates with these countries' status as early adopters and/or members of the majority, while all groups of subjects in the developing countries may be viewed as the adoption laggards in all types of OA activity [65]. Although it is currently impossible to quantify the turning point threshold between minority and majority within Rogers' diffusion model, such an undertaking would be a useful area for future studies to address.

Figure 7. Diagram of a conceptual relationship among the primary variables in the open access divide [128].

The purpose of analyzing the OAD is to determine impediments to widespread OA adoption and action as to prioritize possible solutions [129–132]. Among other considerations, it is most useful to iterate here the significance of changing the existing structure of faculty promotion and assessment for minimizing the divide. While this may appear at first to be a difficult undertaking, OA advocates have already exercised an increasing influence on digital scholarship in theory and practice. Faculty members have been conscious of the problems of current scholarly communication as well as of the potential of widespread, free information sharing in the transformation of e-science, and librarians have been consistently providing innovative services in support of high-quality research activities. The recent Berlin 10 Open Access Conference featured many high-profile presenters, including top federal government officials, university presidents, Nobel laureates and major foundation directors; presenting a positive sign of how far OA has come in just a decade. Hopefully, more research projects can be initiated to explore the open access divide in greater depth and to address additional issues beyond the scope of this discussion to further raise awareness on the disparities of open access, including possible gaps in the form of inequalities of resources among different types and sizes of institutions, or among different age and gender groups.

There are limitations in this study. It attempted to cover many aspects of the open access divide in one paper, which made it impossible to discuss in depth some work already published by others on the subject of open access. On the other hand, this study did not address some other issues in open access, such as the green and gold OA models, and links between the various openness movements. Also, the different practices of open data and publications could have been examined more adequately.

Conflicts of Interest

The author declares no conflict of interest.

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