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Understanding Open Knowledge in China: A Chinese Approach to Openness?

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This paper examines the development of open knowledge in China through two case studies: the development of Chinese open access (OA) journals, and national-level OA repositories. Open access and open knowledge are emerging as a site of both grass-roots activism, and top-down intervention in the practices of scholarship and scholarly publishing in China. Although the language, vision and strategies of the global open knowledge movement are undoubtedly present, so too are the messy realities of open access and open knowledge innovation in a local context. In attempting to position open access developments in China within a diverse and contested global landscape of open knowledge innovation we draw on Moore's (2017) conception of open access as a boundary object: an object that is understood differently within individual communities but which maintains enough structure to be understood between communities (Moore 2017; Star and Griesemer 1989). Viewed as a boundary object, the concept of open knowledge is making it possible for China to engage with the global open knowledge movement, as a beneficiary of the innovation of others, and as an open knowledge innovator in its own right.

Keywords: Open knowledge; Open access; China; Publishing; Scholarly communication

Introduction

Over the past decade, the rhetoric of 'open' has shifted from the fringes of science, education and communication discourses, to the centre. To a greater or lesser extent it is now to be found in the language and policies of research and research funding globally (Fry, Schroeder et al. 2009; Scanlon 2013; Bartling and Friesike 2014; Suber and Darnton 2016). The challenge that the open knowledge movement now faces is one of shifting beyond the advocacy focus that characterised its early phases, towards more critical engagement with the complexity and diversity of open knowledge concepts, movements and organisations operating in diverse national and cultural contexts. Unpacking the role of diversity in increasingly global open knowledge systems will be necessary if the dangers of one size fits all approaches to investments in open knowledge infrastructure, business models and governance frameworks are to be understood and managed. Failure to do so risks reinforcing the established North–South divides that continue to dominate global knowledge institutions such as higher education and publishing. It also risks underestimating the effect of new (open) knowledge powerhouses on larger global knowledge systems (Veugelers 2017).

In this paper, we engage with this challenge by exploring developments in the emergence of open knowledge approaches in Chinese scholarly communication. We also consider the implications of these developments for the ways in which 'open knowledge' is framed and understood beyond China. Open access and open knowledge are emerging as sites of both grass-roots activism, and top-down intervention in the practices of scholarship and scholarly publishing in China. But while the language, vision and strategies of the global open knowledge movement are undoubtedly present, so too are the messy realities of open knowledge innovation in a local context. Some of the nation's most influential 'open' initiatives fit uncomfortably with internationally accepted definitions of open access and open knowledge such as those

advocated by the Open Knowledge Foundation and the Budapest Open Access Initiative. In spite of this, China's achievements in the open knowledge space are real and impressive.

This paper examines the development of open knowledge in China through two case studies: the development of Chinese open access (OA) journals, and the emergence of national-level OA repositories. In attempting to position open access developments in China within a diverse and contested global landscape of open knowledge innovation we draw on Moore's (2017) conception of OA as a boundary object: an object that is understood differently within individual communities, but which maintains enough structure to be understood between communities (Moore 2017; Star and Griesemer 1989). Viewed as a boundary object, we argue that the concept of open knowledge is making it possible for China to engage with the global open knowledge movement as a beneficiary of the innovation of others, and as an open knowledge innovator in its own right. China offers a particularly valuable case study for scholars interested in unpacking the open knowledge concept because it provides an example of a country in which the values of the global open movement are being actively taken up and adapted (Zhang 2014) in the context of regulatory, social, economic and political circumstances that differ in important ways from those in which the concepts and approaches of open knowledge were first conceived.

The first section of the paper briefly outlines key theoretical and practical challenges arising from the concept of open knowledge. The second section of the paper then goes on to explore some of the ways in which open knowledge tools and strategies are being used to increase transparency and efficiency in China's scholarly communications system. Our focus in this section is Chinese OA journals and national level integrated repositories, two important sites of open knowledge innovation. Finally, the paper concludes by considering how developments in China help to illuminate the potential and the constraints of the concept of open knowledge itself, drawing on Moore's (2017) work on open access as a boundary object (Moore 2017; Star and Griesemer 1989).

The challenge of defining 'open'

According to the Open Knowledge Foundation, in order to be open knowledge must be *'… free to access, use, modify, and share … subject, at most, to measures that preserve provenance and openness.'* ("Open Definition 2.1" n.d.). The Budapest Declaration defines open access as: '*… 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.'* ("Budapest Open Access Initiative" n.d.) The FAIR framework, originally developed as a set of principles for the management of research data, are also being taken up by a growing number of organisations advocating for open approaches in scholarly publishing. (Director 2017) These principles require that research is Findable, Accessible, Interoperable and Reusable (Hagstrom 2014).

Open approaches are providing China with new mechanisms for supporting digital innovation and the development of research and higher education, as well as opportunities to play a leading role in the next generation of digital knowledge systems. These developments have the potential to fundamentally reshape existing global knowledge power structures, as well as the ways in which openness is understood. However, as with many 'open' initiatives operating elsewhere in the world, a significant proportion of the projects that we discuss in the next sections of this paper struggle to satisfy formal definitions of open knowledge and open access.

A poor fit between 'open' initiatives operating locally, and formal definitions of open access and open knowledge, is not unique to China. Hybrid, embargoed, green, gold, freemium, gratis and libre open access are all features of the emergent global open knowledge landscape, as well as the subject of debate and disagreement among and within the communities and stakeholder groups that constitute global open knowledge spaces. Many open knowledge projects involve restrictions on how content can be accessed and used, regardless of where the projects are based. For example, freemium models are being employed by *Open Edition* (France) ("OpenEdition" n.d.) as it searches for ways to balance a genuine commitment to widening access to knowledge against the financial demands of delivering high-quality services to scholars. In the UK the independent, academic-led OA publishing initiative Open Book Publishers works within the limits of available funding and author preferences in order to make content as open as possible – an approach that allows for the sale of 'premium' digital editions of content, and for the use of licenses that preclude downstream re-mixing ("About – Open Book Publishers" n.d.).

As Moore (2017) observes, the term 'open' encompasses a plurality of approaches and values. Rather than constituting a single, unified group, 'open' advocates and practitioners are diverse. The open access and

open knowledge movements draw on a number of different traditions and include groups with different economic and political goals. While some open definitions emphasise the importance of access to research outputs, others are more concerned with the value of re-use, re-mixing and the possibilities of distributed innovation. Rather than being a weakness, the diversity of definitions, approaches, and perspectives that exist across global communities of 'open' knowledge may, in fact, be a strength.

Moore cautions against focussing too much on either the necessity or the value of consensus in defining 'open'. Instead, he argues for a theorisation of OA as a boundary object. The term boundary object was first used by Star and Greisemer in 1989 (Star and Griesemer 1989). Boundary objects are understood differently within individual communities but maintain enough structure so as to be understood between communities (Moore 2017). According to Moore: *'Theorising [OA] as a boundary object allows us to conceptualise OA as a community-led process without fixed meaning and continually open to interpretation. This will allow a number of individual experiments to blossom, thus working against enclosure by any particular group. The important thing is that the diversity of approaches makes open access useful, rather than enclosure at a general policy level'* (Moore 2017).

Approaching open knowledge as a boundary object is especially useful in attempting to understand open knowledge developments in a system that is changing as profoundly, and as rapidly, as China's. A shift away from a legalistic focus on copyright, licensing types, and forms of access allows for emphasis of the groups, strategies, and actors that form China's complex emerging open knowledge system. In the following sections of this paper we take a closer look at two important areas of open knowledge development: Chinese OA Journals; and national-level OA repositories.

Case Study 1: Chinese Journals and Open Access

A fundamental and striking difference between scholarly communication in China and scholarly communication in North America and Western Europe is the absence of a Chinese equivalent to the 'serials crisis.' The term 'serials crisis' has come to be used by many in the Anglophone library, publishing and open access communities as short-hand for runaway increases in the costs of subscription journals – which some commentators argue have grown by as much as 400 percent since the mid-1980s (Belluz 2016). Although the factors involved in changing serials prices are complex (Anderson 2016) they have been closely associated with pressure on library budgets to absorb price increases (hence the term 'serials crisis'), as well as strong critiques of the business and pricing models of private commercial publishers (Pantich and Michalak 2005). In this context OA has been presented as a practical alternative to established, closed, models of journal publishing with the potential to widen access and lower the costs of publishing and distribution.

In China, on the other hand, journal publishing is an area in which the state continues to play a central role. Scholarly publishing and scholarly communication infrastructure are viewed as central to China's economic ambitions and too important to be left to the vagaries of commercial markets. State support for scholarly communication is widespread, ranging from government investment in the Chinese National Knowledge Infrastructure network (CNKI): a national level database for journals, theses, conference papers and other scholarly outputs ("Chinese National Knowledge Infrastructure Network" n.d.), to subsidies paid directly to individual, often small-scale, journal publishers. As a result, China's scholarly publishers are able to operate in a funding landscape that is relatively protected from the financial challenges of a market-based sector. For their part, Chinese libraries are not faced with insurmountable budget pressures associated with increases in subscription prices – at least in the case of domestically published content.

The narrative of open access as a mechanism of ensuring 'public access to publically funded research', which emerged in opposition commercial journal publishing models that depend on the capacity to exclude readers who have not paid for access (Vollmer 2015), is also absent in China. Chinese-language scholarly content is readily accessible for most Chinese academics and university students and widening access to research beyond Universities is not seen as a priority for either researchers or the government. The problems facing scholarly communication in China tend to be framed as relating to quality and transparency, rather than to cost and access (Ren and Montgomery 2015). Predatory 'pay to publish' operators and academic fraud and corruption are seen as particularly urgent problems that will need to be solved if China is to succeed in transforming its research and innovation sectors (Lin and Zhan 2014). The value proposition of Chinese open access journals thus centres around notions of quality, credibility and transparency, rather than public access: a key difference between China and other publishing markets.

In contrast to other Chinese publishing and media industries, which have seen government support wound back since the 1980s, government funding for academic publishing has increased since the mid-2000s in line with the expansion of China's Higher Education, research and innovation sectors (Xu et al. 2007).

These conditions are particularly favourable for the high-quality journals that have been the fastest to embrace formal OA models: a situation that helps to explain why China's OA journals are generally more financially sustainable, higher quality, and more frequently cited than their closed Chinese language counterparts. A national policy-focus on developing internationally competitive academic publishing houses has resulted in an enviable funding environment which includes the ready availability of grants to support improvements in journal quality and impact, and very little pressure to prove the commercial viability of scholarly publishing operations. For example, the National Ministry of Finance, in collaboration with the Chinese Association of Science and Technology and other institutions, provided ¥291 million RMB (roughly AU$57 million) in financial support for 135 academic journal titles between 2016 and 2019. This was the second round of the National Ministry of Finance's targeted funding scheme, which seeks to increase the international competiveness of China's scientific journals (Hui 2016; "Heavily Weighted, the 2018 Periodical Industry Has Great Advantages, and the Policy Support Holds Great Actions!" 2018).

China's established academic publishing industry is fragmented. Despite recent corporate mergers and acquisitions, the academic publishing landscape remains relatively diverse, particularly when compared to the concentration that now characterises journal publishing in western markets (Larivière, Haustein et al. 2015). Of the 5020 academic journals listed in the 2017 Blue Book of STM Journal Development, almost 96% belong to a publisher that publishes just a single journal title (CAST Service Centre 2017). Low levels of dependence on either subscription revenues or commercial income are the norm for Chinese journal publishers. In addition to enviable access to government subsidy, Chinese journal publishers also benefit from state-protected monopolies over commercial opportunities associated with the provision of publishing services. In contrast to other markets OA is not regarded either as a serious threat or a major disruption to established approaches to academic publishing. Instead, many Chinese publishers believe that OA is likely to improve visibility and accessibility, and thus increase the impact and reputation of their journals; a strategy likely to help them to attract more resources in the future.

It is difficult to calculate the exact number of OA journals operating in China. By adding up the numbers of OA journal titles operated by major publishing groups and visible within respected digital platforms, a conservative estimate would be nearly 1,000 titles (for example: 308 supervised by the Chinese Association of Science and Technology; 222 in Science Paper Online and mostly supervised by the Chinese National Ministry of Education; 108 published by the institutes of the Chinese Academy of Science). Chinese scholars are often reluctant to read preprints and remain distrustful of grey literature. As such, OA journals that make the final, published version of a paper openly available are popular with Chinese researchers. However, Chinese OA journals continue to suffer from poor international visibility: in August 2017 only 58 Chinese journals had been indexed by DOAJ (the directory of OA journals), a community-curated list of OA journals that indexes 'quality, peer reviewed OA material.' This may, in part, be a result of the diversity of Chinese OA journal models and polices. Those providing immediate full OA to journal content, a requirement for DOAJ listing, account for only a fraction of the Chinese journals providing some form of OA. In spite of this, there is evidence that OA journals have better citation performance than closed journals in China (Cheng and Ren 2008, Jiang 2011).

Despite rapid development and diverse models, China's OA journals also face significant challenges. Closed journals continue to outnumber open journals by a ratio of approximately 5:1. The rapid expansion of China's research and innovation system is fuelling demand for publication credentialing among Chinese researchers. This has been associated with the emergence of large numbers of predatory journals that generate revenue by charging authors for publishing services. These predatory journals remain hostile to OA – arguably because paywalls help to shield low quality content from public scrutiny. In recent years Chinese academics have been the focus of widespread public criticism – as accusations of excessive self-interest and corruption have played out across both social and mainstream media (Tenzin 2017). The prosperity of China's predatory journals thus depends on their ability to ensure that authors will be able to claim publication credit and avoid scandal. Open access – and the increased visibility of published articles that this would allow – is something that low-quality journals must avoid if they are to remain attractive to authors.

Growing concern over the activities of predatory journals, combined with access to alternative sources of funding, have led high-quality Chinese OA publishers to eschew revenue models based on article processing charges (APCs). According to a survey of the 308 OA journals published by Chinese learned societies, 55 percent make content OA immediately upon publication (no embargo is applied) and 91 percent do not charge APCs (Chu, Li et al. 2013). While Chinese academic communities publishing high-quality research are generally unwilling to pay for OA journal services offered by domestic publishers, they are willing to pay APCs charged by international journals. This reflects the preferential status accorded to international publications

within the Chinese research and promotion systems. Publishing in a peer-reviewed international journal is now perceived as a gold-standard for the certification of the quality of work carried out by Chinese researchers and serves as a currency in applications for promotion and national grant funding (Feng, Beckett et al. 2013).

It is also arguable that there is an emerging trend towards OA status as a mark of quality within the Chinese domestic journal space. One reason for this is that high-quality journals find it easier to access the government funding and institutional support needed to allow them to operate without either subscription or APC revenues. Reputable publishing groups are also more likely to be in a position to cross-subsidise new OA journals with revenue generated by leading 'closed' journals. According to Jiang (2011), approximately 1/3 of China's 1,868 'core journals' provide some sort of 'OA'. It is important to note that Jiang's definition of OA includes both delayed and hybrid OA. 'Core journals' enjoy a status that is roughly equivalent to that of top quartile journals in the international academic publishing system.

For highly-regarded Chinese journals OA is an opportunity to consolidate established reputation and impact and to ensure that digital publishing and open innovation approaches are framed within a larger national shift towards open science. Tsinghua University Press's Journal Publishing Unit is an example of an OA journal publishing group that is investing heavily in this approach. They publish 16 OA journals in both Chinese and English, and co-publish 6 English-language OA journals in collaboration with other Chinese universities, learned societies and international publishers like Springer Open. Tsinghua University Press has built its own online platform to provide full text access to all of its OA journals: http://oa.tsinghuajournals.com/index_en.html Although most of the press's OA journals employ delayed OA or partial OA, the scale and quality of OA publishing by Tsinghua University Press nonetheless marks it out as a leader in the development of high quality OA journal services in China.

International collaboration and investment in English-language OA publishing services are also emerging as an important theme among China's leading journal groups. Access to institutional funding and government subsidies provide Chinese-published English-language journals with a competitive advantage in international markets. This has made it possible to lower or remove Article Processing Charges while maintaining high-quality value-added services for authors and learned societies. An example of this approach is the Chinese Laser Press: a journal-publishing group specialising in the fields of optics. The Chinese Laser Press is supported by the Shanghai Institute of Optics and Fine Mechanics, the Chinese Academy of Sciences and the Chinese Optical Society. It publishes 4 top-ranked Chinese journals and 3 English-language journals. In 2013 the Chinese Laser Press established a collaboration with the Optical Society of America, launching a co-published OA journal *Photonics Research.* The journal achieved an impact factor of 3. 719 within two years of its launch ("Optics Journal Net" n.d.). The Chinese Laser Press has also developed an information portal for the industry called *The Optical Journals Website*, which includes a partially OA journal database of 49 journals published in China, as well as news services for academics and industry professionals. The site attracts more than 30 million visits annually ("Optics Journal Net" n.d.).

Case study 2: National Open Access Repositories

Another important driver of expansion and innovation in open scholarly communication is OA repositories. Many of these operate outside the formal publishing industry. OA repositories originally emerged as grass-roots initiatives in China in the early 2000s when a growing number of academic websites, usually operated by a couple of volunteer scientists or students, created online spaces for sharing or self-archiving scholarly publications. Such websites tended to emerge from blogs or Bulletin board system (BBS) forums and were small scale, discipline-oriented services. The most influential of China's grassroots OA repositories is Miracle Repository (Qiji Wenku), founded by the Physics Professor Ji Yanjiang in 2003. The repository, which ceased operating in 2015, amassed more than 11,000 registered users and archived 2,500 items (Baidu Baike n.d.).

Grassroots initiatives like Miracle Repository played an important role as a conduit for the concepts and language of open science, and were key drivers of the Chinese open knowledge movement in its early phases. However, as services that operated outside the formal scholarly communication system they relied heavily on volunteer labour. With limited resources they also struggled to attract and maintain the high quality content and large user communities necessary to establish themselves as credible alternatives to established scholarly communication platforms (Han, 2005). As publisher backed online repositories and, more recently, government-backed OA repositories have expanded many grass-roots initiatives have found it impossible to compete and have closed down.

In contrast to grassroots repositories, China's government-backed national level OA repositories are supported by key government agencies. This not only increases their financial stability, it also boosts their credibility: making it possible to attract content and users to the platforms. There are obvious risks associated

with the centralisation of open knowledge infrastructure, particularly in the context of concerns relating to censorship and control in single party states. The influence of National level OA repositories also tend to marginalise grass-roots, bottom-up innovation, which undoubtedly has an important role to play in the continued evolution of open knowledge tools, communities and practices.

Nevertheless, national level OA repositories are increasingly operating at the forefront of open knowledge innovation in China. These repositories offer much more than author self-archiving: serving as integrated platforms for open scholarly communication and supporting researchers in the context of new technological possibility. These repositories are helping China's policymakers to address criticisms of the quality and efficiency of the closed journal system; improve national infrastructure for research management, funding and promotion; and to manage sensitivities relating to censorship and control of access to published work. In the following section, we outline two national level OA repositories operating in China: The Chinese Academy of Sciences IR Grid and Preprints platform. These two repositories provide insight into how national level OA repositories function under the management of a national research funding body, as well as the key role that the Chinese government is playing in the development of innovative approaches to research communication and the use of OA to create a more effective scholarly communication system.

The *Chinese Academy of Sciences Institutional Repository Grid (CAS IR Grid)* is a leading national-level OA repository. Launched in 2013, the CAS IR Grid is an integrated platform linking 89 existing institutional repositories operated by CAS research institutes. The CAS IR Grid provides author self-archiving for high quality published papers. The majority of the papers within the CAS IR Grid are publications by CAS researchers in international, English-language journals. The Grid was set up to improve visibility, discoverability and ease-of-use of the OA resources archived by individual institutional repositories. In the context of the CAS OA mandate the Grid also assists CAS in monitoring OA compliance, as well as in evaluation processes associated with its research and researchers. As with many western research institutions, CAS researchers are required to deposit their final manuscripts in the IR Grid in order to have them counted for assessment, grant and promotion purposes.

The CAS IR Grid is focussed on making high quality academic publications written by Chinese researchers more widely accessible. It is especially important in making English-language journal articles, which would otherwise be confined to subscription-based journals, accessible to Chinese audiences. Such papers account for one third of the full text items archived by the CAS OR Grid. As such the CAS IR Grid plays a significant role in ensuring public access to the top-tier research outputs of projects funded by the Chinese government. The Grid is having a measurable impact on both domestic and international access to top-level research publications by Chinese academics. 782,965 resources from 112 institutions have been deposited in the CAS IR Grid to date (Huang et al. 2017). The Grid had recorded more than 14 million downloads, nearly 40 percent of which originated from outside mainland China, arguably suggesting that the Grid is also helping to increase the international visibility of high-quality Chinese scholarship (Zhang 2014).

In 2017, alongside the CAS IR Grid, the Chinese Academy of Science also launched a preprint initiative called *ChinaXiv*. *ChinaXiv* is still at a very early stage of development and its model and strategy are yet to crystallise. Unlike Science Paper Online, ChinaXiv does not provide open peer review. Rather, it aims to provide a platform for instant publication of the latest research outputs. ChinaXiv hopes to encourage more academics and researchers, especially those outside the CAS institutes, to self-archive their preprints: a shift that is being supported by a growing number of Chinese funder mandates requiring OA self-archiving of the outcomes of funded research. ChinaXiv is also encouraging Chinese journal publishers to collaborate with the platform to develop new approaches to publishing such as 'online first' (Sage) or 'digital early publishing' (Issuu). The platform is exploring opportunities to assist small-scale journals in transitioning to digital publishing.

On its website, ChinaXiv is being promoted as '…the first preprint platform operated according to international standards and models in China.' Its managers bill themselves as building '…a next-generation platform for sharing research outputs, self-governed by academic communities' ('"China Xiv' Is Officially Launched" n.d.). In other words, their ambition is to go beyond simply providing an open access service. Rather, ChinaXiv is seeking to drive profound changes in Chinese academic systems, employing open approaches to addressing structural problems related to academic integrity, transparency and accountability. ChinaXiv is also hoping to take up an important innovation developed by *Science Paper Online*: providing a time-stamped certificate acknowledging publication of an output on its platform. This feature is intended to assuage fears of plagiarism and 'scooping' among researchers, as well as addressing concerns that publication via a non-traditional outlet might prejudice future patent applications. Ultimately, *ChinaXiv* hope that such certificates may be accepted as formal evidence of publication within China's research system, where publication certificates play an important role in the evaluation of researcher performance.

Discussion and Conclusion: Diversity, Complexity and Opportunity

In May 2014, Premier Li Keqiang made a landmark speech to a meeting of the World Research Council, pledging his government's commitment to '… *establishing a publically funded mechanism for Open Access (OA) to scientific knowledge to bolster the common development of scientific research in China and the world*' (Li 2017). Over the past fifteen years China has made significant achievements in the construction of open knowledge infrastructure, including via the Chinese Academy of Science (CAS) Institutional Repositories Grid, Science Paper Online and the China Open Access Journal database (COAJ) – all of which we have discussed in this paper. China is now the second largest contributor of OA publications indexed by Science Citation Index Expanded (SCIE) after the US, and No 7 in the world in SSCI (Social Science Citation Index (Liu and Li 2017). China's commitment to open access is also helping to shape the international development of OA markets. In 2016 Chinese authors paid RMB 450 million Yuan (US$ 71 million) in Article Processing Charges (APCs) for SCI journals making China one of the world's largest markets for gold OA (Cheng and Ren 2016).

In this paper we have explored two important areas of open knowledge development in China: OA journals and national level OA repositories. China's OA journals are developing in the context of high levels of state support for OA, the availability of financial subsidies that allow them to operate without subscription revenues, and little pressure to broaden access to research outputs beyond established research communities. National level OA repositories are serving as a mechanism for ensuring that OA publications are accessible and discoverable to readers within and beyond China, and as a site of ambitious innovation in the ways in which scholarly work is made available to communities. In presenting these case studies we have sought to draw attention to the close relationship that exists between China's ambitions to transform its economy by boosting research and innovation, and the creative use of open knowledge approaches to address the very real difficulties that continue to face scholarly communication in China.

Support for open knowledge at the highest levels within China's science, economic and education policy frameworks is making it possible for the potential of open knowledge to be explored at unprecedented scale. However, China's open knowledge landscape is not only interesting because of the scale of its operations. In contrast to other markets, the imperative of 'public access to publically funded research' is conspicuously absent from the rhetoric and practices of open knowledge innovation in China. So, too, is a focus on identifying cost-effective alternatives to closed publishing models and countering the negative impacts of commercial monopolies in order to protect library budgets. Instead, open knowledge approaches are viewed as a useful investment within a scholarly communication system that operates as part of the nation's knowledge infrastructure: providing new mechanisms for tackling problems of transparency, accountability and credibility signalling at a system-wide scale, enabling more effective communication across research communities and promising new possibilities for global projects of science and innovation.

The success with which recognisably 'open' approaches are being used to address the local challenges of scholarly communication in China highlight the resilience, and the usefulness, of the concept of open knowledge (Ren 2015). Open Knowledge initiatives in China suggest that, rather than representing a reactive movement, able to operate effectively only within the specific economic, cultural and political contexts in which it originated, open knowledge is a concept that is being taken up and applied for different purposes by different communities operating at different scales and in vastly different contexts. As such, Samuel Moore's (2017) observation that open access might be most productively conceptualised as a boundary object provides a useful theoretical anchor for future work in this space. Viewed as a boundary object, the concept of open knowledge is making it possible for China to engage with the global open knowledge movement, as both a beneficiary of the innovation of others, and as an open knowledge innovator in its own right.

Although concepts, ideals and strategies familiar to the global open knowledge movement are evident at all levels within China's open knowledge landscape, so too is a sense of pragmatism and willingness to develop new approaches in order to suit local agendas and conditions. China's open knowledge initiatives thus reflect the political and economic priorities of the Chinese government, the funding and commercial realities that open access projects must operate within, and perceptions of public interest that are shaped by accepted norms of scholarly communication and accountability.

The ability of the government to concentrate resources and centrally nominate policy directions is making it possible for open knowledge approaches to be implemented at unparalleled scale. However, the role that the state is playing in shaping the Chinese open knowledge agenda also raises important questions about the extent to which open knowledge is either a catalyst for, or an object of, democracy, accountability and self-organisation. The open knowledge initiatives discussed in this article are notable in their lack of concern with access to research by communities beyond academia. Researchers themselves remain less concerned with the philosophically informed ideals of the open knowledge movement than with the

practical challenges of navigating the day-to-day demands of research, publishing, grants and promotions. Aspirations that open knowledge projects will empower ordinary citizens to access the results of research that they have helped to fund, or of open knowledge as a mechanism for addressing imbalance of power within the Chinese state, are very much removed from the realities of a system in which the Internet and the media remain tightly controlled.

Perhaps, then, the lesson that China might offer the global open knowledge project is that relationships between open knowledge, democracy, accountability, and national power are as complex and potentially diverse as the communities that make and use knowledge. As the concept of open knowledge shifts from periphery to mainstream moving beyond simplistic contrasts between open (good) and closed (bad) is necessary to understanding digitally enabled knowledge systems, and to identifying the infrastructures, policies, and forms of regulation most likely to produce positive change for the communities that use them. The case studies explored in this paper also highlight the extent to which new approaches to understanding the realities of open knowledge are becoming both necessary and possible. As OA infrastructure develops, so to do the opportunities for large-scale quantitative investigations of the role that open access is playing in either challenging or deepening established hierarchies, discipline structures and patterns of collaboration.

Investigations of the relationship between open access performance and university rankings suggest that rather than lessening inequality in landscapes of scholarly communication, OA may be mirroring the patterns of privilege and prestige that exist within traditional publishing systems. The Open Scholarship Ranking (Fan and Liu 2016) identifies a significant correlation between the Open Scholarship achievements of Chinese Universities and the results of existing comprehensive university rankings. This is consistent with recent work on stratification within OA the literature relating to global health research, which finds that authors working at lower-ranked universities are less likely to choose journals that involve an Article Processing Charge and more likely to publish in closed or paywalled journals (Siler et al. 2018). This may be because comprehensive university rankings relate closely to the resources available within an institution. Lower-ranked universities are often those with less access to the funds to pay for open access publication and infrastructure.

Although beyond the scope of this article, there is clearly much more work to be done to understand the complex dynamics of open knowledge as it is being practiced in China. As digital platforms and centralized infrastructure make OA publications visible and discoverable at scale the possibilities of engaging deeply with the quantitative data about them that is now becoming available are growing. There are new opportunities to explore the relationship between centrally funded OA services and infrastructure and patterns of OA publication and use. Are some disciplines more active than others in the Chinese OA space? Are some kinds of institutions engaging with OA more than others? Are Chinese OA publications being used and cited more often than their closed counterparts? Or producing different types of collaborations? Research that engages thoughtfully with the scale and diversity of open knowledge developments in China may shed important light on how, or even if, state support for a large-scale shift to OA enables more 'open' knowledge landscapes.

Competing Interests

The authors have no competing interests to declare.

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