

RESEARCH PAPER

Data Sharing in Low-resourced Research Environments

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‘Open Data’ has recently emerged as a prominent label for renewed attempts to promote greater scientific exchange. As part of such efforts, the posting of data online is often portrayed as commonly beneficial: individual scientists accrue greater prominence while at the same time fostering communal knowledge. Yet, how scientists in non-Western research settings assess such calls for openness has been the subject of little empirical study. Based on extended fieldwork with biochemistry laboratories in sub-Saharan Africa, this article examines a variety of reasons why scientists opt for closure over openness with regard to their own data. We argue that the heterogeneity of research environments calls into question many of the presumptions made as part of Open Data. Inequalities in research environments can mean that moves towards sharing create binds and dilemmas. These observations suggest those promoting openness must critically examine current research governance and funding systems that continue to perpetuate disparities. The article proposes an innovative approach to facilitating openness: coupling the sharing of data with enabling scientists to redress their day-to-day research environment demands. Such a starting basis provides an alternative but vital link between the aspirations for science aired today as part of international discussions and the daily challenges of undertaking research in low-resourced environments.

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Introduction

Questions about who should share what data, and with whom, have long accompanied research. Today, ‘Open Science’ serves as an umbrella label for a diverse range of initiatives including the Open Access, Open Data, and Open Software movements. Although multiply conceived, Open Science has generally been associated with calls to ensure research is available to the maximum extent possible (OECD, 2007). Policies pursued under this label seek to realize the norm of openness so long associated with science as well as to achieve greater egalitarianism in research. In this way, the Open Science movement seeks to maximize the benefits accrued from research for the benefit of humanity.

Nonetheless, as elaborated in the next section, despite the enthusiasm that often characterizes Open Science, it has become apparent that realizing its ideals is challenging. A crucial element is the need for buy-in from practitioner communities. In light of this, in this article we ask: what concerns do scientists working in low-resourced research environments have about participating in Open Data activities?

The findings of the fieldwork draw attention to the critical role played by ‘contextual factors’ in the research environment (Olmos-Peñuela *et al.*, 2015; Oyelaran-Oyeyinka, 2006) play in shaping opinions about openness and Open Data. Section three details the observational and interview fieldwork with biochemistry laboratories in sub-Saharan Africa to illustrate how the contextual demands of sustaining research at all in low-resourced laboratories mean the logics for sharing in Open Data discussions have little traction with many of these scientists given the perceived downsides of sharing. In section four we offer a sense of the complicated intersections between how reward and credibility can be perceived within low-resourced settings vis-à-vis forms of data engagement. Taken as a whole, sections two, three and four offer a contribution to the traditional of critical scholarship regarding the potential for science policy to exacerbate global disparities (e.g., Lamberton, 2001). Section five considers what alternative support strategies could enable research and thereby data sharing.

While the argument is geared towards redressing conditions frequently experienced in laboratories in low/middle-income countries (LMICs) and specifically sub-Saharan Africa, the

considerations that delimit sharing and the recommendations offered are meant to be applicable to low-resourced laboratories whatever their geographic location.

The Promises and Challenges of Openness

Openness in data is commonly understood to refer to situations in which: ‘anyone is free to use, reuse, and redistribute [the data] – subject only, at most, to the requirement to attribute and/or share-alike’ (Open Knowledge International, 2016). Recent initiatives to promote openness are justified with reference to varied normative, pragmatic and instrumental grounds including: facilitating ‘self-correction’ through peer scrutiny; realizing the norms of science; making most effective use of public funds; ensuring commercial innovation; responding to demands by citizens for evidence in support of public policies; and enabling novel forms of science through utilizing new computational and communication technologies (see CODATA, 1997; Royal Society, 2012; Leonelli, 2013). Funding bodies, publishers, professional societies and others are bringing in policies justified through appeals to openness and accessibility (e.g., European Science Foundation, 2008; European Commission, 2011; RCUK, 2013).

While the general goals of Open Data are widely endorsed, what they should mean in more detail is often much less a matter of accord - especially in relation to data sharing. Scholars and policy-makers alike have acknowledged that moving from general principles to specific policies requires governments, funders, universities, and others to address potentially thorny questions such as: What counts as ‘data’? Which elements of research need to be open? Who pays for that? How should openness be balanced against other priorities? In what ways does promoting the availability of research facilitate forms of commercial capture? (Wessels *et al.*, 2014).

Against such questions it is commonly responded that when it comes to releasing datasets, no “one size fits all”. Thus, while imploring those involved in science to make their data accessible to those beyond their formal collaborators, the majority of current data sharing statements leave the *how*, *where* and *what* to the determination of scientists and/or their organizations (International Council for Science *et al.*, 2015). The non-mandatory nature of many current data sharing calls also raises questions as to the practicability and sustainability of current models (Mauthner and Parry, 2013). Increasing pressure to make

data available have heightened the requirements for processing and curating it too, though the forms of labor needed for such work are generally poorly recognized and rewarded within professional and organizational structures (Ankeny and Leonelli, 2015).

Reasons for Data Sharing

Against these type of widely recognized issues, how scientists can be encouraged to be more open has been identified as a matter of considerable urgency (Hayden, 2010; Leonelli *et al.*, 2013). Recent studies concentrated on Western Europe and North America on why scientists share data highlight the role of perceptions of intellectual credit and peer recognition (Tenopir *et al.*, 2011; Borgman, 2012; Fecher *et al.*, 2015a). For instance, a survey distributed to scientists (mainly high incomes countries) conducted by the publishing house Wiley (Ferguson, 2014) concluded that 55% of respondents felt that the increased impact and visibility of their work would motivate them to share data. Similarly, a study by the Research Information Network (RIN) interviewed UK scientists regarding the benefits of sharing data (Research Information Network, 2009). Respondents highlighted the enhanced visibility of research, the increased efficiency due to reusability and exposure, the identification of new research questions and directions, the fostering of scientific integrity and replication, as well as the enhancement of collaboration and community building as key reasons to participate in data sharing activities.

Reasons not to share have also been identified (Fecher *et al.*, 2015a). The sample of concerns collected by Ferguson *et al.* (2014) included intellectual property or confidentiality issues (42%), fears of being scooped (26%), and not getting proper credit (22%). A 2010 report by RIN and the National Endowment for Science, Technology and the Arts further highlighted perceived lack of evidence of benefits, lack of time and skills, cultures of independence, as well as concerns about quality and about ownership (RIN/NESTA, 2010).

Despite such concerns, however, the release of data online is recognized by many of the surveyed scientists in North American and Europe as having professional benefits in addition to its philanthropic good, and, critically, the benefits can justify the additional time and effort spent on curation and dissemination activities. For some, data sharing activities are portrayed as enhancing the ability to win grants, securing greater recognition from their peers, and to advancing their careers (Research Information Network 2009, p. 2).

And yet, while recognition, credit, and reputation are acknowledged as topics that need to be addressed, policy and academic literature about Open Data typically lacks a wider theoretical framework for understanding of how reward, recognition, and reputation are linked together in the (re-)production of factual claims and professional careers. Fecher, Friesike, Hebing, Linek and Sauermann (Fecher *et al.*, 2015b) offered some initial pointers along these lines in their proposal to situate data sharing in the ‘reputational economy’ of science.

Literature in Science and Technology Studies (STS) would suggest a broader backdrop for understanding sharing vis-à-vis recognition. For instance, through their notion of ‘credibility cycles’, Bruno Latour and Steve Woolgar’s (1979) contended the central preoccupation of the scientists they observed was building-up ‘credibility’; this defined generically as the underpinning ‘abilities [to] actually [...] do science’ (Latour and Woolgar, 1979, p. 198). Latour and Woolgar’s formulation of credibility cycles emphasized the distinction between *reward* and *credibility*. Reward (including forms of award and reputational credit often mentioned in Open Data today) referred to recognition for achievements, while credibility pertained to the ongoing capacity required for doing research.

Understanding individual participation in data sharing through calculated decisions – be they based on based net benefits, reputational gains, or credibility accrument – has important implications for the presumed potential for Open Data. First, it assumes that those who *want to* participate in data sharing *can*. Second, it assumes that the terms of calculative logics of scientists are similar regardless of nationality, physical location, or cultural background. The evidence given below offers a critical unpacking of these assumptions. Based on the fieldwork undertaken in support in this article, in section five we return to consideration of frameworks for understanding scientists’ data practices.

A Limit to Openness: Low-resourced Research Environments

Perhaps unsurprisingly, the vast majority of studies of data sharing to date have examined Western laboratories (Carr and Littler, 2015, p. 315) – and within this well-resourced labs. As such, discussions about both the motivations to share data and the ways in which data are

made open are tied to specific understandings of resource distribution, infrastructure provision, and governmental involvement (as in OECD, 2015, Chapter 3).

Open Data discussions do recognize, at times, that scientists in some countries are less well placed to make their data open (e.g., Royal Society, 2012), this due to shortfalls in the provision of research resources and infrastructures. In response, calls have been made to enhance physical hardware infrastructure, soft behavioural infrastructure, and skill-based capacities in these countries (CODATA, 2014; International Council for Science *et al.*, 2015) in order to ensure that scientists are better able to participate in the universal call for openness.

While such initiatives are important, it is open to question how much they can ameliorate the differences in research environments between high-income countries (HICs) and LMICs. Most obvious are the disparities in internet connectivity. Less visible, but not necessarily less severe, problems relate to the wider research environments for undertaking science. How these issues impact on scientists' understandings of – and interactions with – Open Data is largely absent from current policy and academic discussions.

Further complicating this picture is that the existing literature on data sharing in developing countries focuses on comparatively well-funded and well-connected research networks or consortia (de Vries *et al.*, 2011; Parker and Bull, 2015; de Vries *et al.*, 2015) that deal predominantly with clinical research. While these studies raise important concerns, the issues raised are often very specific to clinical research with vulnerable patient populations. Indeed, previous studies have noted a strong divergence in the experimental practices, goals and values between biologists and clinicians (Kelly and Geissler, 2012; Leonelli, 2012). Although this situation is improving with regard to researchers who donate their own data (Bull *et al.*, 2015a), rather than *using* others', the vast majority of studies on data sharing in LMICs still focus on clinical trials or public health research, with minimal attention given to other fields (e.g., Pisani and Abou-Zahr, 2010).

Research Questions and Design

In recognition of the need for evidence on data sharing practices in low-resourced research environments, we undertook a study that sought to address the questions:

- Do low-resourced research settings influence scientists' perceptions of the value of data?
- Do the conditions in low-resourced laboratories influence scientists' perceptions of the potential gains and risks from data sharing activities?

We selected fieldsites through a series of strategic decisions. First, it was decided that all of them would be in Africa, as this continent is largely missing from discussions about Open Science and Open Data in particular. Second, two countries were selected – one in southern (South Africa) and one in eastern Africa (Kenya) – based on the existence of the robust national research programs in these countries compared to elsewhere on the continent. As country background, Kenya has 22 public universities, many of whom conduct research. It also has a long history of international research collaboration – a prime example being the long-standing KEMRI-Wellcome Trust partnership. While the government encourages research, financial support for it remains limited and the focus of national universities is primarily on undergraduate teaching. South Africa has 25 public universities, all of whom conduct research. As a country, South Africa has a long history of academic research, one which continues to be actively supported by the government.

Third, we sought examples of vibrant, “homegrown” research. While some of the researchers at the sites visited collaborated with others in Europe and North America, by design none of the fieldsites were formally affiliated to large internationally funded research consortia or networks. Fourth, within these two countries, four departments/groups in academic institutions were selected for inclusion based on their common disciplinary focus (the interaction of chemistry and biochemistry) and research interests (medicinal chemistry). These decisions were to minimize the differences in data sharing practices and perceptions between scientific disciplines noted in previous Open Science discussions (e.g., Royal Society, 2012; Wessels *et al.*, 2014) as well as argued for within information studies more broadly (Macdonald 1998).

Within Kenya, site 1 (KY1) and site 2 (KY2) were both chemistry departments of well-established universities. Both had over 15 full time faculty members, however student to faculty ratios were high and the teaching loads considerable. KY1 had a large number of MSc and PhD candidates, the majority of whom were full-time and a number of whom had

financial assistance. In contrast, KY2 had a very high number of MSc students, the majority of whom were self-funded and part-time (and thus conducted their laboratory work during holidays). In both departments space in laboratories was at a premium and students shared working space and equipment. Neither department had any postdoctoral researchers.

Within South Africa, site 1 (SA1) was a research group within the large chemistry department of a well-established and comparatively well-resourced university with a tradition of research. Site 2 (SA2) was the chemistry/biochemistry department of a university that had previously been designated as for marginalized population groups under the Apartheid system. Both sites were the recipients of numerous national and international grants. SA2 had one postdoctoral researcher at the time, while SA1 had none.

Empirical data was gathered using a combination of qualitative methods including embedded laboratory observations and semi-structured interviews. Each site visit took between three and six weeks, during which time one of the authors (LB) participated in departmental activities, interviewed faculty and graduate students, and observed social and physical working environments in the departments and laboratories. Data collection was undertaken over a period of five months between November 2014 and March 2015, with 56 semi-structured interviews in total conducted with faculty and graduate students. Follow-on visits to each site were made in late 2015 by both authors to solicit feedback on our analysis.

Commonalities between Sites

While the four sites visited varied in terms of age, financial provision and size, they nonetheless shared certain commonalities. This sub-section briefly highlights some of those similarities. In the next section, we turn to distinctions. Some salient similarities for the purpose of this article include:

Division of Labour: All the departments relied heavily on Masters and PhD students for data generation, and the vast majority of the research conducted in all the laboratories was done as part of graduate degrees. The absence of postdocs, lab managers, and dedicated research staff - in combination with high teaching loads for faculty - meant that these students assumed responsibility for undertaking daily research procedures, data analysis, and (peer and undergraduate) laboratory training.

Moreover, driving research activities according to thesis requirements had additional implications for the ability of [Principal Investigator]s to create long term research agendas, to find funding for research projects, and to bring together and synthesize data produced from different students.

Precarious Funding: Common to all sites was the problem of acquiring core funding for facility maintenance and improvement. This was not only due to low governmental contributions (particularly in Kenya), but also because most grant awards did not make provisions for facility maintenance or upgrading. Thus, the purchase of general equipment, ICT hardware, and software was regularly reported to be problematic.

Systemic Issues: Participants at all four sites mentioned challenges in their daily research activities that related to broader infrastructural issues. These included regular power cuts and varying provision of backup generators, complicated and time consuming border controls and reagent delivery, problematic or absent effective sample transport options, difficulties with adequate technical support and issues with equipment maintenance.

Promotion Systems: At all four sites, the promotion of faculty was directly linked to publication outputs in the form of journal articles. Other forms of sharing or public engagement were not recognized explicitly in promotion criteria. In addition, in the South African sites the publication of journal articles was directly linked to the acquisition of funds through the government's Research Incentive (RINC) scheme. This works by funding universities per each peer-reviewed article, conference proceeding or book published, thus providing strong incentives for maximizing the number of officially recognized publications over other research outputs.

ICT Provisions: While all the sites had access to the Internet and at least some computing, and library facilities, all interviewees agreed that challenges existed when accessing online resources. Issues such as power cuts, low bandwidth and varying wifi signal were regularly identified as daily challenges to working online. Moreover, additional complications were noted in relation to off-site access to university resources, as none of the sites except SA1 had functioning proxy servers. In addition,

many participants noted problems associated with the acquisition of soft and hardware. Importantly, many were working with older hardware and software as they were required to make ICT purchases out of their personal – instead of research – funds.

Open Access: Interviewees often equated Open Access (OA) publishing solely with pay-to-publish journals, and, as such, they were viewed as inferior in status to other journals. None of the Kenyan interviewees were aware of international financial assistance schemes for publishing in OA journals available to them. This was aggravated by some researchers reportedly using their own personal money to make their publications OA.

Professional Self-promotion: It was salient that none of the interviewees were particularly interested or engaged with professional profiling sites. Although membership to professional networking sites were often reported (e.g., LinkedIn) the majority of interviewees saw little value in their membership and did not actively contribute. None of the interviewees had considered using social media (e.g., Twitter) or professional monitoring tools (e.g., almetrics) to promote their research. Similarly, personal websites or extensive university webpages were also absent. At the same time, as explored more below, the feeling of professional isolation stemming from geography and peripheral community position was a recurring theme.

Research in Low-Resourced Environments: Some Site Vignettes

The interviews highlighted something that, while perhaps unsurprising, has been little explored in current international discussion about openness: namely that physical and organizational aspects of the research environment significantly influenced scientists' involvement in practices aligned with Open Data and in particular how they thought about sharing data. What became evident was that the day-to-day challenges of conducting research in these low-resourced environments - and thus the (reduced) speed at which research progressed - affected scientists' perceptions of data sharing, their fears of being scooped or exploited, and their understandings of the rewards of releasing data online. In the following sections, vignettes from each fieldsite are presented that illustrate these concerns.

Funding and Research: Balancing Openness with Gain in KY1

At the KY1 site faculty faced teaching demands that seriously curtailed the time that could be spent conducting research. The faculty interviewed regularly made reference to the high numbers of students in their classes. One faculty member, for instance, detailed these pressures saying: ‘between September last year and August this year I’ve had to teach 830 students ... They had a double intake and we weren’t told about it last year. Just in the middle of teaching we were told there is a new group that is coming’ (KY1/1). Indeed, the existence of parallel teaching programs was observed to increase the number of undergraduate students dramatically, thus increasing the work loads of individual researchers. Similarly, the lack of teaching assistants, practical supervisors or marking assistance made teaching duties significantly time-consuming.

Discussions with faculty members confirmed that purely research appointments were very unusual, and that teaching was the primary duty expected from faculty members. Nonetheless, all promotions were directly based on publications and qualifications. Faculty members who needed publications for promotion thus faced a difficult situation because they often had little time or support for research. As one lecturer said: ‘[i]t’s not an environment that values research and development. It’s not a...I mean, it’s kind of a lonely thing. You have to do it out of your own push’ (KY1/8).

This situation was compounded by issues relating to funding. Funding for research at KY1 was secured outside of Kenya; government support only covered basic core infrastructure costs such as salaries, electricity and building maintenance – and not laboratory running costs. While some faculty members had secured funding as part of international projects (e.g., the US National Institutes of Health), all reported that finding the time to apply for funding and establish collaborations was taxing. Most of the research was conducted as part of graduate degrees – commonly small projects with clearly defined objectives (such as isolating compounds from a specific plant with known medicinal properties). These projects were united by methodological similarities and curtailed by the resource limitations (such as the need to send compounds out of the country for activity testing, which entailed costs as well as delays).

In order to circumvent the problems associated with building up a body of research necessary for promotion, several of the faculty explicitly mentioned that they used their own personal money to cover their research costs. One academic put this explicitly, saying: ‘for most things I have used a lot of my own money on the research because I don’t think you get government whatever. Though occasionally there are some committees called Dean’s committees where you can apply for funds, but the funds are limited and they are mostly limited to students who are doing research, PhD students. But for staff, what do you do?’ (KY1/1).

The use of personal money for research, combined with the high stakes of finding time for it, created a situation in which academics strategically limited the accessibility of their data to others. As one participant succinctly put it: ‘here you often find that people pay for their own research. They wait to patent their findings, but this means they can sit - for 5 or 10 years - on the data without a patent or a publication’ (KY1/9). Concerns of losing control of the data – and thus the benefits of the data – was regularly verbalized as a fear of “being scooped”. This led to a considerable reported reluctance to share data prior to publication, with interviewees frequently offering statements along the lines of: ‘I know people tend to handle the data in a way that they do not share before publishing’ (KY1/2). This corresponded with wider preferences around revealing visibility online – with a marked preference against too much online openness.

The pressures of conducting research and publishing it together with the lack of support for these activities created an environment in which data was often perceived as a personal rather than collective property, in other words as “means to an end” for the researchers who have invested in data production in the first place. Linking publishing to the remuneration of promotion reportedly had significant impact on how scientists viewed their responsibilities to disseminate data - particularly as it took them a lot of effort, time (and, again, often personal money) to generate the data. Such observations were reinforced by a number of statements by *senior* faculty regarding the (lack of) reward incentive to do research at their stage of career progression.

It is important to note that while the concerns of being “scooped” through data sharing activities is not new to discussions on Open Data (see Ferguson, 2014), the repeated and

explicit link of these concerns to scientists' research environment was notably pronounced in KY1. Scientists at the site felt that their working conditions left them in a position where being "scooped" was the likely outcome of any data sharing.

Time and Space: Part-time Students Ensuring Data Release in KY2

As (similarly to KY1) the faculty at KY2 relied primarily on graduate students to generate research data, this created a difficult situation in which data was appearing only sporadically and research took a long time to complete. As one faculty member put it: '[i]t's difficult to build up a body of data when the research is all short-term and ends with a student' (KY2/13).

At the KY2 site a part-time Masters program had recently been introduced. This increased the number of graduates registered at the department and thereby the student to faculty ratio. Most of the part-time graduates were high school teachers and came during school holidays to complete their laboratory research. As a result, the vast majority of graduates at KY2 were enrolled on a part-time basis taking 3-4 years to complete. Both faculty and students that were interviewed found this a frustrating situation. As one part-time Masters student said: 'it is difficult to work like this because you must come for a short period of time, take a little data and then go away. When we are away it is difficult to do work, and also to get hold of our supervisors' (KY2/12). The duration required for graduate students to complete also frustrated the publication of their research and, as well, publication was not a criterion for passing a Masters. Moreover, without a wider program of curation, synthesis and re-analysis it was likely that a large amount of the data produced by students – even their theses – would not be effectively used.

Compounding these considerations, research was also hampered by the state of labs which contained little equipment, old benches, few reagents, and so forth. The availability of equipment at KY2 in particular, was identified as restricting the amount and the kind of experimentation that could be performed (for instance, chemical synthesis was not possible). As in the case of a donated nuclear magnetic resonance (NMR) spectroscope, even if the department possessed equipment, it did not have funds for spare parts or a serving technician. One faculty member addressed this explicitly, saying: 'the lack of equipment limits the extent to which you can do research – and even the type of research that you want to do' (KY2/3).

The lack of equipment in turn played an important role in some scientists' self-perceptions of their position within their field vis-à-vis their geographic position. As one faculty member stated: '[t]here is a constraint. Even the conditions aren't right, so you cannot work as fast. One of the limitations is of facilities. I mean facilities that can't be considered credible for some publication' (KY2/15). Similarly, another said: '[h]ere I will publish and unfortunately when I do that here even that person in research and development in industry will not read my paper unless someone has said something. So the tragedy is I do all the work, I publish it, the audience that I am looking for already has a prejudiced view, if I may put it so, about my ability to do the research, so they won't value it or read it, right, unless they know me – unless they know me as a person ... They don't even know I exist. So it's quite a depressing situation' (KY2/4).

The interviewees at KY2 thus highlighted the difficulty of gathering, curating, and disseminating data accrued from numerous student projects. They also highlighted the additional difficulties associated with limited equipment and the limitations it put on the type of research possible at their institute. Together, these difficulties contributed towards an environment with low levels of data sharing.

Geographies of Research: Managing Historical and Geographic Legacies in SA2

The institution in which SA2 was located was in a geographically isolated part of the country three hours away from another major city. Historically, it had been started as a university for disenfranchised populations during the Apartheid regime and continued to struggle to overcome its legacy as a "previously disadvantaged" university. As one lecturer said: '[t]he traditionally advantaged institutions in South Africa are still advantaged. The disadvantaged are still disadvantaged and that is the fact of the matter. The government may be willing to address the gaps, but there are still gaps' (SA2/1).

In terms of geographic challenges, a number of interviewees made reference to the difficulties of getting reagents, equipment and technical support – all of which considerably slowed down the pace of research at the department. One faculty member offered a story that eloquently described these challenges. He said:

[i]n terms of technical support in the lab, it's not there. At times we have a plug that isn't getting electricity and to have someone to come out and get it fixed may take a week so perhaps you need to move the freezer and send it to another building, find a plug and hook it up for a while. So sometimes the plug just goes dead for a day and there's nobody on site who will come and find out what the issue is. To make a report may take a few days. In the interim you need to find a solution to save the biologicals from breaking down and deteriorating. So those are challenges. I find I go to Johannesburg to get stuff, but it speaks to the culture because when you understand what it takes to run research as a program and to put the bits and pieces together such that if you're in the lab you stay in the lab because you're not worried whether things will be supplied or not (SA2/10).

The geographic challenges also meant that acquiring and maintaining the equipment necessary for research was a continual challenge. A number of faculty members made reference to the NMR spectroscope that is extremely important for the chemistry research undertaken. This machine: 'was sponsored by the government. But now it's not working and we are squeezed. You must remember that we are far from the city here and sometimes there are challenges with filling of the liquid helium and the liquid nitrogen' (SA2/2). Similarly, in order to get the liquid nitrogen: '[w]e installed liquid nitrogen plant and that has been quite challenging also but it has been working, then when it broke down we had to depend first on [another university] then they were not active anymore we had to send the person on a weekly basis to ... fetch liquid nitrogen [from a city 12 hours round trip away]' (SA2/6).

Despite the considerable advances made by the university in the years post-Apartheid, the challenges of the historic legacy were still evident within the university structures. One of the key concerns was the lack of core funding from the institution to improve research facilities. Such issues were a challenge for researchers, particularly as one interviewee said: 'the university doesn't offer a start-up fund for equipment. ... I would need to pay bit by bit and one by one. When I have funding then buy one piece of equipment and maybe after 5 years I would have my lab' (SA2/11).

Many of the interviewees also made reference to issues relating to basic infrastructure, and how they impacted on the speed and efficiency of activities. There was also awareness that these were problems not easily addressed by individuals or departments:

‘[i]t’s really bad – the bureaucracy of it. It’s how the money is transferred, technical services, procurement, all those ... but those are like “grand problems” that you can’t solve’ (SA2/3).

Interestingly, there was also awareness that these systemic issues would not necessarily be resolved simply by more research funding. One participant clearly discussed this, saying: ‘[o]ur challenges are unique and very different and so you should come with a purse of money and hand it out you may address some of the issues but you would not address all. In fact, I don’t think you could address even 50% of them. So again, you know they call us to meetings and they say we have funding for this and that. And I think “great stuff”, but I wish they would ask me what the real issues are. I’ll probably tell you 100 other things outside of money’ (SA2/1). Issues with systems of procurement, budget allocation, and maintenance were all commonly cited as key elements slowing down research processes.

The interviewees regularly linked these daily pressures into their answers about data sharing. They took pains to enumerate how much effort it took to do high-quality research in such a geographically isolated environment, and how these daily pressures took time away from possible data sharing activities.

It’s a Matter of Speed: Competing Internationally in SA1

Compared to the other departments, SA1 was the best supported and resourced. Funded by large national and international grants, this department was by far producing the most internationally competitive body of research. Nonetheless, when discussing their science and the dissemination of data concerns of being “scooped” by better resourced foreign laboratories were routinely reiterated as a concern. When unpacked further, it became apparent that such fears turned on two important issues.

First, despite the comparative resources available at SA1, researchers were aware that the additional time necessary to acquire reagents (‘you’re twiddling your thumbs trying to find out what you’re supposed to do for a couple of months while you’re waiting for chemicals’ (SA1/7)) and their reliance on graduate students for data meant that it ‘just takes longer’ to do research than in many highly resourced labs. Thus, while interview participants were, in principle, eager to share, they were often hesitant to disseminate data because there was a perception that: ‘it would just mean that half of the stuff that we do would be taken

over by people with much more resources and they'd do it much quicker than us' (SA1/7). In practice, data sharing activities were largely limited to established personal or formal connections – colleagues, long standing contacts, or international project collaborators.

Second, there was continual reference to South Africa's current governmental structures of research funding. As a result, researchers described themselves as under considerable pressure to publish in RINC [research publication incentive]-approved journals. While separate from project funding, the 'money for publishing' funding structure played an important part of research life, as it was the primary way in which individuals and departments accrued funding for departmental activities and conference travel. Thus, as one participant put it: 'I think it's [Open Data] great, but in terms of funding and output recognized grant proposals and things like that I don't think it's working right here in [South Africa]. So we're judged by how much output we get out there and first time publications and first authors and things like that' (SA1/7). The keen awareness of the need to get publications out of research activities thus significantly influenced how interviewees described their research and influenced how they discussed openness.

While the practicalities involved in decisions to share data (or not) should not be surprising – and indeed are not limited to LMICs – they are rarely explicitly addressed in discussions on Open Data. While issues of credit are extensively discussed in relation to attribution (Fecher *et al.* 2015a), these are less often extended into discussions about hierarchy, promotion, job security and stability.

Speed and Data Sharing

The previous section suggested how attitudes towards openness (in particular data sharing) hinged on the working conditions of each laboratory. While the participants widely agreed on the importance of openness and sharing data for science as a whole, with reference to their asymmetrical positions within highly stratified global fields, very little data sharing activities beyond project collaborators were in evidence in any of the sites visited. When justifying these decisions, interviewees repeatedly spoke of the professional perils that might be encountered through the general release of data. It would seem, in contrast to more optimistic discussions on Open Data, that simply telling scientists in such conditions about

the possible benefits of data sharing was nowhere near sufficient for convincing them to engage in such activities.

In all four vignettes presented above, it is evident that the interviewees' dissociation from engaging in data sharing activities was in some way related to the relatively long time between planning and publishing experiments due to the day-to-day factors hampering research. As a result of pervasive concerns about being scooped in priority contests, many said that the extent and nature of sharing had to be limited and expressed reservations about data sharing initiatives. In short, those we spoke with did not regard themselves as having the luxury to partake in 'gift economy' (Zeitlyn, 2003) or 'gift exchange' (Hagstrom, 1965) relations with others.

Such reported anxieties echo ones made elsewhere. In relation to clinical and public health data generated in LMICs, the potential for (Pisani *et al.*, 2010) and reports of (Bull *et al.*, 2015a) apprehension about sharing vis-à-vis being scooped have been expressed. As well, as noted in section two, fears about being scooped are not limited to those in LMICs.

In the case of the laboratories we visited, some points are noteworthy against the existing literature: one was the extent of apprehension mentioned in contrast to the data sharing activities reported. Instead of discussing the benefits that could be accrued from sharing, nearly all participants made comments similar to: '[t]o me it's too much of a risk, it's too much of a risk and I'm not at that stage to take such risks, I don't think so [...] We want to be trusting each other but sometimes it's not that easy' (SA2/7). In particular, no interviewees explicitly endorsed the sharing of unpublished data.

Similarly, when discussing sharing of data – particularly unpublished data – it was noteworthy that the lack of engagement in the sharing avenues that increased altmetric exposure created a vicious circle. Many participants explicitly said that they did not perceive overall gain from the professional networking sites they used (primarily LinkedIn). This created a negative perception that was commonly extended to all altmetric-enhancing avenues. Unsurprisingly, the interviewees did not identify the kinds of advantages to sharing (the increased citations and visibility for their research and kudos within the relevant communities - Ferguson, 2014) that are reported in Western countries as offsetting fear about data exploitation.

Furthermore, what became apparent from our fieldwork was that to appreciate the extent of apprehension about data sharing, it was necessary to situate data sharing within the context of the risks associated with doing research in resource constrained environments. Some of those interviewed reported that if they undertook research on topics most prominent within their specialty fields, then they risked losing out on priority competitions to those able to produce publications in shorter time frames. As a result, many contended that openness with data was particularly dangerous for them as researchers given their constrained ability to undertake science. Even garnering international visibility for one's work was a potentially pyrrhic accomplishment as it might attract competitors. However, if scientists undertook research on topics more peripheral to the concerns of their fields, then they risked perpetuating their (typically) marginal positions within their field.

The resultant perceived bind experienced between having enough reputational standing to be taken seriously but the competitive dangers of one's work being highly visible was compounded by the limitations in research capacity overall. Interviewees had few lines of research they could sustain at any given time due to other demands on their time and the taxing requirements of doing research. As a result, decisions made about agendas to pursue were professionally high stakes. The frequently reported option was one of "playing it safe" by setting low, but achievable, aspirations.

Not only were such binds experienced, they were regarded as being difficult for those in other settings to appreciate. At all four sites there was a widespread perception that relatively well funded scientists just "didn't understand" the challenges that those interviewed faced on a daily basis. One participant at SA2 spoke to this when discussing attempts to engage with webpages online:

where I find it difficult is people don't understand our situation – it's not bad will, it's just not being able to figure it out – is for conference registration. Sometimes trying to explain to the conference organiser that I am not able to put my data online because for some reason my system stops – it works for two entries and on the 3rd entry it stops. So, I have tried it several times, I've tried it from other computers on campus, and now I give up. Please help me! Trying to convince people that we are really having a problem of this type is difficult. They cannot imagine what the problem is –

they've never experienced it. ... That is because those sites are heavy. They have lots of fancy things what are very beautiful, but then also the templates you have to fit in things and for some reason if the system is weak the template will not respond (SA2/12).

Additional geographic-related factors associated with the slowness of research vis-à-vis other (competitor) scientists included the challenges of attracting and retaining faculty and graduate students, the difficulty of physically interacting with international colleagues, and so forth. As one participant put it though: doing research in Africa is 'tough, but tell that to someone who's in America and they would say: what are you talking about?' (SA2/7).

Credibility and Reward

The previous sections indicated the importance of situating scientists' attitudes and behaviours regarding data sharing against their professional status, career trajectory, and working environment. The analysis of the binds related to the speed of research signalled the complexities associated with individuals' decision making in relation to such matters within stratified international research systems.

Building on the previous sections, we wish to further contend that the qualms with data sharing extended far beyond concerns associated with reputation itself; rather they were rooted in scientists' basic ability to undertake science. This attention to scientists' ongoing ability to do research is consistent with Latour and Woolgar (1979) analysis of 'credibility' mentioned in section two. As they elaborated, as part of 'cycles of credibility', different aspects of research – data, outputs, funds, reputation, arguments, credentials, prestige, etc. – are converted into one another. By way of expanding on how these cycles are tied to the production of careers and knowledge claims, Latour and Woolgar posited:

[S]cientists' behaviour is remarkably similar to that of an investor of capital. An accumulation of credibility is prerequisite to investment. The greater this stockpile, the more able the investor to reap substantial returns and thus add further to his growing capital...The essential feature of this cycle is the gain of credibility which enables reinvestment and the further gain of credibility. Consequently, there is no ultimate objective to scientific investment other than the continual redeployment of accumulated resources. It is in this sense that we liken scientists' credibility to a cycle of capital investment (Latour and Woolgar, 1979, pp. 197-8).

One of the advantages of the notion of credibility cycles is that it applies to various aspects of science: the status of facts, material resources, and institutional reputation. Within credibility cycles, the factual status of claims made by scientists and these individuals' reputational standing are tied to one another. When deemed credible, researchers can use their associations and credentials to access forms of material infrastructure, that can enable the refinement of skills, that then lead to the production of data and papers, that provides the means for enhancing prestige, that then be converted into high profile presentations that lead to invitations to collaboration, that... As conceived, in relation to such conversions, a prime aim of scientists was 'to extend and *speed up the credibility cycle as a whole*' (Latour and Woolgar, 1979,, p. 207 – emphasis in original).

In line previous research that made use of the notion of credibility cycles (Packer and Webster, 1996; Hessels and van Lente, 2011), fieldwork highlighted the heterogeneous range of skills and competencies required by participants in their execution of daily research activities. In particular, this was needed to address the taxing day-to-day demands of doing research in challenging environments: how to organize research programs without dependable power or without reliable access to basic inputs. These frustrated scientists' ability to do research and, relatedly, their ability to secure non-material forms of symbolic capital that could be converted into other forms of capital as part of credibility cycles.

While the notion of credibility cycles provides a useful framework for understanding of how reward, recognition, and reputation concerns associated with data sharing are linked together in the (re-) production of factual claims and professional careers, a limitation of studies to date using the notion of credibility cycles is that the vast majority of it has related to conditions in high-income Western countries (e.g., Rip, 1994; Hessels *et al.*, 2009; Leisyte *et al.*, 2008). This has meant certain assumptions within the formulation of credibility cycles have gone unchallenged.

For instance, such Western studies have adopted Latour and Woolgar's basic starting point of placing primacy with credibility over reward. In contrast, pressed with the difficulties of conducting and sustaining research in the sites studied in Kenya and South Africa, scientists regularly adopted strategies that made reward an end goal. These strategies, in turn, affected what data was generated and whether it was shared.

To expand, one of the ways this took place was by the termination of active research careers. At all four sites it was observed that given the demands of doing research, some faculty members sought to increase their professional status through bureaucracy advancement rather than through experimental achievement. By being head of department or participating in internal university governance, they were able to gain a degree of visibility that could potentially be translated into membership of national and international funding and policy committees without the burden of maintaining an active research career. Similarly, as a number of high-level faculty members at the Kenyan sites highlighted that for senior staff, participation in research fell off with individuals becoming professor: ‘they have been promoted as far as they can go and there are no financial rewards’ (KY1/8).

The pursuit of credibility also gave way because of the manner in which faculty at some of the sites paid for their research or patenting applications. At times this self-funding supported the accumulation of forms of scientific capital. At other times though the monetary rewards from doing science – i.e. personal salary – were used to fund the obtaining of other forms of reward – e.g., licensing royalties, a higher salary from promotion decisions directly linked to publications (that might then lead to the cessation of research), etc. Complex judgements were made by some about whether to seek credibility or reward in inter-twined economic and science capital cycles operating at the level of universities and individuals.

In the South African universities, the explicit link between publications and research funding also significantly influenced sharing discussions. At both sites the faculty were highly conscious of the need to marshal research outputs so as to accrue the per-publication monetary rewards of the RINC funding. Enthusiasm for sharing data was therefore curtailed by the need to activate reward mechanisms in the short term.

In such ways, long term credibility strategies often took second place behind the pragmatic needs of immediate and near-term career and organizational demands associated with doing research in resource poor environments. In the ways elaborated in the paragraphs above, rather than ‘status, rank, award, past accreditation, and social situation [being] merely resources utilised in the struggle for credible information and increased credibility’ (Latour and Woolgar, 1979, p. 213), they were often the ends of science – even for faculty still notionally designated as research active.

What can be Done?

Taken together, the previous three sections indicate how the exchange of data can be stifled and the prospects for promoting greater exchange diminished. Concerns about the asymmetrical conditions of research justified something of a vicious cycle of practice and action. Rather than engaging in informal peer exchanges, those interviewed repeatedly approached data sharing through market transaction and reward-centred forms of reasoning; with corresponding considerable uncertainties and burdens that imposed on them in deciding how to assess their data (see Macdonald, 1998).

What then can be done to promote data sharing by those organizations wishing to support science in resource challenged environments? Many of the relative limitations in research environments noted above are systemic outcomes of stark inequalities between national research systems and infrastructures. As such, fully addressing them ultimately requires tackling long standing structural disparities. Short of this, the recognition of global inequalities in clinical and public health research has previously led to proposals to enhance data sharing by those in LMICs. Improving professional recognition (e.g., through standards for citations, see Pisani and Abou-Zahr, 2010); fostering international trust-based collaborations (Tangcharoensathien *et al.*, 2010; Bull *et al.*, 2015b); and improving the data management capacities through greater resourcing (Alter and Vardigan, 2015; Bull *et al.*, 2015a) are some of the policies also advocated to bolster sharing.

With our attention to everyday research environments, our analysis would suggest an alternative but complementary approach. As we have suggested, the mundane, day-to-day demands of conducting research in resource constrained environments mean scientists therein are not inclined toward data sharing – and may not be inclined to continuing to conduct research at all. Addressing the sources of what undermines scientists' ability and willingness to do science then, could be one way of fostering conditions more conducive to data sharing.

In terms of how to promote data sharing in resource constrained environments, we propose that Open Data initiatives could benefit from a re-orientation. Attempts to simply impose sharing requirements or implore the importance of data openness for individual scientists (or science in general) are in danger of grating against the lived experiences of those in low-resourced settings. As a result, such efforts are likely to be responded to with

suspicion, estrangement or token participation. Instead of assuming the challenge with promoting Open Data is how to devise support those challenging settings with infrastructure and skills specific to sharing data, an alternative approach would be to hold that greater openness can be link to redressing the considerations the delimit research from being done in the first place.

In this regard, while absolute funding levels are no doubt highly important, this not the only aspect of funding that could be addressed. In the labs visited, resources were sometimes available, but they could not be used in a manner aligned with the specific emerging necessities. Those interviewed highlighted a set of financial obstacles relating to the minor amounts of money – usually below \$100 – required for such matters as professional membership, equipment servicing, off campus access to internet and papers, the provision of necessary ICT hardware and software, and so forth (as more fully discussed in Bezuidenhout *et al.*, 2016) that played a crucial role in how well they could do their science as well as how they thought about data sharing. Not being able to fix an NMR machine, obtain liquid nitrogen, rewire the plugs in the lab, buy software or update, or get buy-out from teaching to write a grant, etc. all become rate limiting steps in the production of data and, consequentially, the sharing of it.

What is further evident from the vignettes is not only this link, but also the reported difficulties that scientists in resource constrained settings have to ameliorate these frustrations. The lack of core infrastructure funding for the laboratories, the difficulty of securing (often foreign) project grants, and the strict limits on what such project funding can be used for all contributed towards these perceptions of lack of capabilities and agency. The very innocuousness and mundanity of many of these issues makes their influence so frustrating.

It follows that one way of engaging scientists in data engagement activities is *enabling them to shape their research in a manner that makes strategical sense to themselves with regards to their particular day-to-day demands*. More specifically, our analysis would suggest that small (‘micro’) sums of funding, easy to apply for, but flexible in how they can be spent would go a significant way toward meeting the challenges of doing science. To put it in terms of the concepts given in the argument above, such support would enable researchers to redress varied hindrances associated with converting between various forms of

scientific capital as part of their credibility cycles. It would also offer an alternative compact for integrating those in low-resourced settings within the Open Data agendas originating from high-income settings. Enabling research, rather than compelling adherence to rules or norms, then could be the basis for promoting data sharing.

In this basic recommendation, we take inspiration from efforts in recent decades to promote forms of ‘micro-credit’ for those without adequate access to conventional financial services (Barry, 2012; Mahmuda *et al.*, 2014). Micro-credit has sought to provide individuals and communities without recourse to such services to readily access small sums of money. We argue a similar imperative for flexible funding exists in the case of science based on our empirical research. In the case of research, rather than monetary return, ‘micro-funding’ could be tied to forms of repayment associated with greater research efficiency in producing outputs or, specific to the concerns of this article, requirements to share data. To extend development literature parallels, enabling scientists in resource constrained conditions to shape their research environments could have a wide range of benefits. For instance, it could enable them define what they need instead of that being prescribed in detail from elsewhere, thus promoting agency and self-confidence. It could also assist them through encouraging engagement with the international research communities, thus decreasing their sense of isolation.

In undertaking in-depth fieldwork, thereby limited in the number and diversity of sites that could be visited, the applicability of these recommendations needs further examination and elaboration. For instance, who exactly should be able to access such micro-funding is a critical issue. Certainly though our experience suggests that there are scientists in low-resource settings in South Africa and Kenyan that are managing (though struggling) to undertake high quality research despite all of the additional day-to-day demands they experience compared to their colleagues in well-resourced labs. Additional flexible support targeted to such individuals could go some way toward enabling their science.

In line with our focus on the local contextual factors though, it would be important to recognize that not all scientists in LMICs are necessarily faced with similar taxing demands as those spoken about in this article. But conversely as well, the proposal made here might also apply to those in HICs who -- despite the overall conditions within their countries -- are

markedly hindered in their ability to do science and thus to engage in data sharing. The extent of the applicability of such funding thus is a matter for detailed further consideration.

Concluding Comments

Much of the policy promotion of Open Data and data sharing today not only starts with belief in the importance of openness, but also an assumption that *all* scientists will benefit from releasing data, no matter where they are based. The previous argument though suggests that given the inequalities across the globe, sharing mechanisms and openness strategies may not be equal in their consequences.

In discussions about data sharing and openness in science, the highly variable nature of laboratory environments around the world are often overlooked – as are the key roles that they play in mediating the behaviours of scientists working in them. Our study suggests the importance attributed by individual scientists to concerns about credit and recognition should be understood as the product of a dynamic and continuous interplay with the research environment. Indeed, elements of the environmental context can be said to mediate the balance between the acquisition of credit/rewards and credibility.

Such points are of critical importance to Open Data initiatives. Diverse science communities are not justly served by generalised expectations designed with a limited range of environments in mind. In response to the day-to-day conditions that frustrate both science and data sharing, we have suggested that flexible support designed to address the factors scientists identify as hindering their research could go some way toward enabling science. As this is achieved, is it possible to think about how to promote sharing and openness.

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