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Science

Free/Libre, Open, Commons and Collaborative Science

Buen Conocer - FLOK Society

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ABSTRACT: Policy making over scientific research is nowadays a key feature of economic and social development. Cognitive capitalist models have enclosed the scientific commons (including results, infrastructure and organization) within the for of strict intellectual property and technological barriers, that slow down scientific progress and its social benefits while providing extraordinary benefits to a small set of corporations. However, alternative models of scientific publication, citizen participation, and research organization and collaborative infrastructures are increasingly gaining momentum at a global scale; challenging the capitalist assumptions of knowledge production and management. Under the label of Open Science, Science 2.0, e-Science and Science Commons, a massive transformation of scientific processes is taking place, including: open access publishing and data where access, distribution and re-use of scientific publications is guaranteed, free of charge or any other barrier, together with the development of open infrastructures for collaborative scientific production within and across disciplines. Moreover, a new movement of citizen and public science, made by citizens and academics, is opening the path for scientific research to address the problems of society beyond the capitalist absorption of scientific production into the market. We develop principles for scientific policy making that boost the a social economy of open and commons knowledge at the levels of access to scientific results, infrastructures and organization.

KEYWORDS: Open Science, Science 2.0, e-Science, Science Commons, FLOK, academic capitalism, Open Access, Open Data, Open Scientific infrastructures, Citizen Science.

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3 https://floksociety.co-ment.com/text/cUPMcBJTgmB/view/

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0. Executive Summary

- The emerging political economy of “global science” is a significant factor in contemporary globalization and a “global knowledge economy”. Policymakers in countries around the world are heavily investing in university research as a means to leveraging technological innovation with the broad aim of stoking the economic performance. In response to a global economy and competition in capitalist markets, scientific research is now largely viewed as an advanced commodity in service to a post-industrial society.
- However, despite the potential of scientific research to benefit society as a whole, its regulation, evaluation and financing has been progressively reduced to its impact in capitalist markets. Academic capitalism is spreading among research institutions in the world, from managerial aspects to evaluation procedures. Moreover, cognitive capitalism enforces a model of science whose global control appears centralized in a few corporate organizations that hold most of the intellectual property rights of scientific production and evaluation. These companies have benefit margins around 40%, that they re-invest on increasing their monopoly over scientific production, whether public or private, thus exploiting and privatizing the commons of scientific knowledge and the academic productive capacity.
- Alternative models of scientific publication, citizen participation, and research organization and collaborative infrastructures are increasingly gaining momentum at a global scale; challenging the capitalist assumptions of knowledge production and management. Under the label of Open Science, Science 2.0, e-Science and Science Commons, a massive transformation of scientific processes is taking place, including: a) Open Access publishing where access, distribution and re-use of scientific publications is guaranteed, free of charge or any other barrier (now including 9,919 journals with 1,692,261 articles from 134 different countries and almost 400 repositories with over 12 million documents), b) Open Data, similar to open access publishing but including structured dataset that anybody can use, and c) open infrastructures for collaborative scientific production within and across disciplines (professional level free software resources exist for almost every aspect of scientific production, online platforms for scientific collaboration and 3D printers and open hardware initiatives are starting to revolutionize scientific infrastructural supplies). Moreover, a new movement of citizen and public science, made by citizens and academics, is opening the path for scientific research to address the problems of society beyond the capitalist absorption of scientific production into the market.
- Openness (free unrestricted access to publications and data, research infrastructure and transparent permeable scientific organization and funding) together with the collaborative construction of a scientific commons is critical to ensuring transparency, advancing human capabilities and guaranteeing access to scientific resources, processes and results. Open and commons-based systems of scientific research empower citizens and communities to participate in the production and access of scientific knowledge without artificially imposed limitations. In addition to the social benefits,

openness of a collaborative scientific commons is critical to the very advancement of science and innovation; it is a demand of the very nature of scientific enquiry knowledge driven economies to be open, reproducible and public. Moreover we show that open science is more just, more efficient, cheaper and more beneficial to society (including the social economy of knowledge) than classical cognitive capitalist models.

- We develop principles for scientific policy making. At the level of policies for scientific **results** we propose to maximize open access to scientific production (papers, books, data, textbooks, and otherwise), both national and international, with particular emphasis on using non-appropriable copyleft licenses and ensuring *fair use* of IP for research and educational purposes. At the level of **infrastructure** we propose to strengthen, develop and promote the free/libre and open infrastructure required for the development of cooperative and open science. At the level of **organization** we propose to open up scientific research to participation and socially valuable interfaces, particularly to the social economy of open and commons knowledge, to enforce transparency, equality of treatment, equity of access and objectivity for research funding calls and academic merit assessment, to promote and develop open, participatory and commons science practices and institutions and to rise social and academic awareness of its potential and possibilities.
- Ecuador has the opportunity to become a regional and international leader in Free/Libre and Open Commons Science. The emphasis made on the National Plan for the Good Living on knowledge as a infinite resource and the revolution of an open and commons knowledge, together with the efforts of SENESCYT to boost the access and quality of higher education and scientific infrastructures, makes for an ideal institutional and political framework towards the development of open and collaborative scientific policies that make possible a social economy of open and commons knowledge.

1. Introduction and focus: general context and background

Science is the institution of the *facts* and *artefacts* through which our society and world is understood, its goods produced and manipulated and its future guided. The central role played by science on defining contemporary society (and shaping nature) can never be sufficiently stated. Moreover science deeply affects almost all the layers of social order (from the socio-political to the economic). To say it with Jasanoff:

> Science and technology account for many of the signature characteristics of contemporary societies: the uncertainty, unaccountability and speed that contribute, at the level of personal experience, to feelings of being perpetually off balance; the reduction of individuals to standard classifications that demarcate the normal from the deviant and authorize varieties of social control; the scepticism, alienation and distrust that threaten the legitimacy of public action; and the oscillation between visions of doom and visions of progress that destabilize the future. (Jasanoff, 2004, p. 13)

The relationships between science, society and economy are baste and complex. There is no room here to provide an overview of the interactions between all three of them, but just to highlight some. The scope of this document will not cover all the dimensions of science and its impact and relationship with society and economy. We shall constraint it to those aspects that are relevant to the new forms of knowledge production and management the emphasize freedom, openness and the commons and to the boundaries that science shares with other policy documents: the issue of patents and innovation (i.e. the relationship between science and industry) is mostly covered in document 2.4, aspects of higher education and its relationship with science are covered in doc. 1.1, software is covered in doc. 4.2 and hardware in 4.3, finally the relationship of domination and exploitative hegemony of science over other forms of knowledge are particularly dealt with in doc. 5.3. Nevertheless this document touches upon some fundamental aspects of the interfaces between science and the topics covered with the above documents. We shall build this document along the following dimensions of science: a) scientific **infrastructure** (including not only hardware and machinery but also software and tools), b) scientific **results** including text (papers, books, encyclopaedic resources and textbooks) and data, and c) scientific **organization** encompassing calls for scientific projects and funding, evaluation, research processes, scientific policy making and research networking.

The emerging political economy of “global science” is a significant factor in contemporary globalization and a “global knowledge economy”. Policymakers in countries around the world are heavily investing in university research as a means to leveraging technological innovation with the broad aim of stoking the economic performance. In response to a global economy and competition in capitalist markets, scientific research is now largely viewed as an advanced commodity in service to a post-industrial society. It is assumed, for example, that substantial economic prosperity can be leveraged through technological innovation and the commercialization of scientific research. Intellectual property (IP) is defended as fundamental to augmenting global science, turning patents and licensing into reference points for national systems of innovation (OECD, 2013). Indeed, as Slaughter and Rhoades argue, knowledge itself is now seen as a kind of "raw material to be mined and extracted from any unprotected site" and then "sold in the marketplace for a profit" (2004: 4).

In the USA and other leading economies, science funding has become the cornerstone of national economic planning. Mazzucato (2011) points to the historic role of government in steering scientific research in the United States and elsewhere. Presenting a broad critique of assumptions undergirding neoclassical economic policy, she deconstructs the myths that have shaped Anglo-American views on innovation strategy. As she argues, early government investments in radar, satellite and GPS, computing, digital imaging, and the Internet, continue to be critical to pull economic growth and are key to the successful economy of the United States. Part of the value of government-led investments has been an ability to leverage the long-term growth cycles needed to catalyze new markets (Mazzucato, 2011). Public funding and managing of scientific research and results has become one of the major national economic accelerators. Recent interest among macroeconomists in the potential of science and technology to stoke economic growth is largely built on theories that emphasize investments in research and development (R&D) in the context of national systems of innovation (Lundvall, 1992).

Situated at the heart of knowledge production, institutions of higher education are envisioned as capital incubators for a *global knowledge age* (Salmi & others, 2002). Unlike other factors of production, however, knowledge is not a scarce resource because it does not deplete with use. Indeed, the challenge with treating knowledge as a capital resource is that knowledge is highly fungible. That is, knowledge can be easily digitized, augmented, and transmitted as information at near zero cost. As a public good, any number of people can construct, consume and use knowledge without necessarily depleting its' value (Stiglitz, 1999).

Scarcity may be a precondition for the economics of supply and demand, but knowledge itself is not a scarce resource. And this is critical to understanding the basic premise of a "Social Knowledge Economy". Beyond models of science and technology that are strictly aligned with capitalist production regimes, the FLOK model of scientific advancement emphasizes commons-based resources and practices. Indeed, the cornerstone of the FLOK approach to the generation and circulation of knowledge is the view that knowledge is inherently a public good and that knowledge is most efficiently developed in conditions of openness and collaboration supported through the use of open licensing and collaborative (sharing and productive) infrastructure. In this way, the FLOK model challenges the predominant view that closed hierarchically organized scientific research is the best system for developing knowledge and innovation. Instead it suggests that open, community-driven models of Open Science are critical to the future of scientific discovery. By democratizing access to scientific research and practice, the FLOK approach seeks to empower communities to participate in the production and consumption of knowledge without limitation.

We are living a stage of techno-scientific development where new possibilities remain wide open ahead: from the risks of new enclosure of scientific knowledge under global and powerful forms of cognitive capitalism to the new opportunities for social economy boosted open and commons scientific knowledge:

> On the one hand, the steep drop in the marginal cost of reproduction and diffusion of information has led to a world in which geographical borders are less and less relevant for research and innovation. Knowledge accumulation and knowledge diffusion are able to take place at a faster pace, involving a growing number of new entrants and providing a threat to established institutions and positions. (UNESCO, 2010, p. 26)

2. Critique to cognitive capitalism in science

Cognitive capitalism in science takes various forms, from traditional economic and proprietary capitalism, to more subtle forms of symbolic and cultural capitalism, often combined with pseudo-feudal forms of domination, exploitation and rent capture in academia. Universities still reflect the medieval power structures that are so characteristic of its birth as an institution and yet, almost as the commons's enclosure that gave birth to early capitalism in the middle ages, scientific production is progressively being enclosed under international IP driven corporations. In this section we review some of the most dominant forms of cognitive capitalism that apply to science and restrain both scientific progress and the dissemination of its social benefits.

2.1. Cultural and symbolic capital in science

At the production or labour side, science is based on a combination of *cultural capital* (cognitive and cultural assets of the dominant classes invested on gaining access to higher educational and scientific positions that become institutionalized in the form of certificates and diplomas), and *social* and *symbolic capital* that will provide with resources and status within the academic research environments (Bourdieu, 1986). In general terms, the higher the symbolic capital of a researcher the higher the resources she can manage. Symbolic capital is achieved by scientific success and productivity and it is quantifiable in terms of publications, patents and research impact and social recognition.

Where no specific laws or academic culture exists to stop it (in terms of promoting or enforcing mobility within academic institutions), it is common that symbolic and social (relational) capital is accumulated by senior researchers that exploit younger ones for long periods of time under low rents and under the promise of a future stable academic position. Thus, often, research labs and university departments become like capitalist factories where the surplus symbolic and social capital is accumulated by the research director or heads of department. The drawback is that, often, only submissive students and academics are ready to work under such conditions and young innovative researchers, with a high potential, are withdrawn from academic careers. Similarly, researchers coming from different institutional frameworks (often those that studied abroad) find themselves, when returning to the national science networks, devoid of the necessary social capital to deploy their research potential thus having to "sell" their cognitive labour to those that “own” the social and relational means of scientific production. Since symbolic capital is difficult to buy directly and since authorship is rarely not-acknowledge (although the contrary is relatively common: i.e. inclusion of social and symbolic capital owners on publication authorship despite their lack of direct, and often even indirect, contribution to it) this situation does not always lead to irreversible systems of exploitation. It does however often discourage valuable researchers, it produces unstable and precarious labour conditions and very often favours the establishment of endogamous, corrupt and even nepotist regimes (Allesina, 2011) in scientific organizing, thus restraining the advancement of science and its social benefits.

2.2. Science at the service of capitalism

The conception of science inherited from the 30s, draws the picture of a human practice that is purely guided by epistemic principles (rationality, rigour, logical consistency, replicability, intersubjectivity, verifiability, etc.) and in an autonomous manner (i.e. not determined or influenced by interests that are external to the very scientific practice), both guaranteeing the excellence and results of scientific progress. Science was, thus, conceived as as self-regulated and disinterested. Within this framework, and after the second world war, Vannevar Bush (1945) published the influential report *Science, the endless frontier* that defined USA's scientific policy making, to be latter adopted by the rest of the world (including communist countries). Public investment in basic research, according to this view, would automatically deliver social and economic benefits to society, and, it was therefore the role of the state to provide unconditional funding to science. Research indicators of this, first generation, science management are limited to the quantity of scientific funding and human resources dedicated to science (input indicators).

It is not until the 50s, and the techno-scientific superiority shown by soviet Sputnik project, that things start to change and scientific research starts to be relatively controlled and evaluated. Specific research agencies are created to ensure the quality of scientific research. Frascatti indicators are introduced to evaluate the output of research and funding: number and quality of scientific publications and patents. In a sense, the notion of a self-regulated science is abandoned yet mostly conserved and just guarantees of increase and quality of production are aimed for. It is during the 60s and 70s that a more qualitative modulation of scientific research is demanded, partly originated on the social movements that demanded a more risk-focused management of science and technology with health or environmental concerns as guiding principles. Thus the EPA (Environmental Protection Agency), the OTA (Office of Technology Assessment) and other governmental institutions are created to evaluate the risks and constraint of technological and scientific production. Parallel to these transformation the inherited conception of science gave rise a more Khunian perspective (Kuhn, 1962) where discontinuities in scienteific progress and the socio-cultural context dependency and influence is highlighted. Scientific evaluation and regulatory mechanisms are put in place that take into account the different types of impact (environmental, psychological, institutional, legal, economic, social, etc.), these impact is evaluated (what level of riks can be assumed, etc.)

and expert's advice is call for decision making by the State when dealing with scientific and technological development and funding.

The most recent stage of this quick overview of the evolution of scientific policy making involves the still dominant focus on innovation. There are two defining dimensions of the notion of innovation: its scientific or technological novelty and the benefit of its introduction into the market. Scientific funding, evaluation and regulation agencies appear now centred on maximizing the economic performance and impact of scientific research. Paradoxically, the early agency and regulatory bodies that originated for and from social movements (e.g. to asses and contain the environmental impact of new technologies) appear now aiming, almost exclusively at optimizing the coordination between science, technology, corporate firms and the market. Society, as the target beneficiary of scientific research, almost disappears from perspective. To say it with Dickson "Where new technological projects previously has to be studied for their environmental impact, the regulations subsequently introduced to mitigate this impact now, in reverse, have to be assessed for *their* economic impact." (Dickson, 1988, p. 311).

The last 50 years have witnessed a displacement from a science-push model (where scientific progress was conceived as autonomous) to a market-pull model of scientific funding, regulation and structuring. On top of the quantity and quality of publications, patents and corporate private partnerships are increasingly necessary requirements for scientific funding. Indicators for R&D start developing in the 80s and spread in the 90s. This kind of evaluative mechanisms include interview with entrepeneurs to asses the level of profit that scientific output delivers to the market. A substantial change takes shape: science is constrained or channelled towards economic and market impact. All leading to what has been termed "academic capitalism" (involving the interfacing of science with capitalism and the incorporation of capitalist-economic managerial and relational logic inside academia):

> "[T]he theory of academic capitalism sees groups of actors—faculty, student, administrat ors, and academic professional—as using a variety of state resources to crate new circuits of knowledge that link higher education institutions to the new economy. These actors also use state resources to enable interstitial organizations to emerge that bring corporate sectors inside the university, to develop new networks that intermediate between private and public sector, and to expand managerial capacity to supervise flows of external re sources, investment in research infrastructure for the new economy, and investment in in frastructure to market institutions, products, and services to students." (Slaughter & Rhoades, 2004)

As a result, there is a clear deficit on the social appropriation of science (Cerezo & Hurtado, 2004) outside the form of capitalism and science. Over the last decades we have witnessed a progressive privatization of public scientific knowledge (Jaffe & Lerner, 1999).

2.3. *The corporate capitalist enclosure of scientific production and infrastructure*

Thompson Reuterus[4] is one of the main corporations on the field of strategic information management and intellectual property. It manages the closed platform *Web of Knowledge*[5], the biggest scientific paper and journal database, and the *Journal Citation Index*[6] that defines the official ranking of scientific journals in the world (together with Scopus[7], which provides, at least, a free search and visualization tool for the academic impact of scientific journals[8]). Developed during the pre-internet era, this index has become almost a *de facto* monopoly with which Thompson Reuters exerts its power over scientific management and the impact indexes and measurements over scientific development (Peekhaus, 2012). Moreover, its measurements and rankings lack transparency (Rossner, Van Epps, & Hill, 2007), which directly affect the distribution of symbolic capital (one of the most important motivational drivers for scientists).

One of the main obstacles for the creation of a new scientific or academic journal is to get into the index of Thompson Reuters. The first barrier, on top of having to comply with the standard that the corporation demands, is to break the vicious circle by which publishing a paper in a journal that still doesn't figure on the index does not give credit to the authors, while without good papers the journal cannot increase its impact factor. This provides a considerable advantage to the older scientific publishing companies, whose business model is based on restricting access to scientific production behind a pay-wall of, on average, 25-35 USD per paper. If we consider that a PhD thesis might reference between 200 and 500 such papers, but use around 500-2000 papers, the total cost of PhD in terms of access to knowledge might be averaged out at around 30.000 USD (which is far beyond the average PhD scholarships for researchers in developing countries). PhD students however do not access journal papers on an individual basis, university libraries often provide some of the papers. However, the fees to be paid by public and private educational or scientific institutions to have access to a single package of Reed Elsevier journals can reach over 1.5 million de USD (Simpson, 2012) and, to give an example of the publishing packages or product bundles, "[t]he average cost of an annual subscription to a chemistry journal is $3,792" (Monbiot, 2011). Moreover, scientific books (even on electronic format) have extraordinarily high prices. Just to provide an example, while writing this document, access to a digital copy of "Global Scientific and Technical Publishing 2013-2014" is behind a 2.500 USD pay-wall[9] (which is also a clear symptom of the obstacles to transparency within the sector). As a result of this quasi-monopolistic regime, the net profit margin of companies such as Reed Elsevier (the biggest scientific publisher) is estimated over 38% (The Economist, 2013) with a yearly benefit of 3.2000 million USD, and a total market value of 17.71

4 http://thomsonreuters.com/
5 http://wokinfo.com
6 http://thomsonreuters.com/journal-citation-reports/
7 http://www.scopus.com
8 http://www.scimagojr.com/ para una comparativa entre Scimago y JCR ver: http://www2.warwick.ac.uk/services/library/researchexchange/topics/gd0055/
9 http://www.simbainformation.com/prod-toc/Global-Scientific-Technical-7681199/

Billion USD[10]. Only 6 private publishing companies (Reed Elsevier, Kluwer, Blackwell, Berterlmann, Wiley & Taylor and Francis) hold more than 44% of scientific papers in 1998 (Gooden, Owen, Simon, & Singlehurst, 2002). As a result of this monopoly regime, access to scientific publications rose over 260% between 1986 and 2003 (well above the inflation rate of 68% for that period) giving rise to what is known as "the serials crisis" (Panitch & Machalak, 2005). by which public research and academic institution find themselves incapable to pay for access to scientific literature.

The result is an enclosure of symbolic capitalism of science and academia into a fenced territory, abusively dominated by a few corporate systems (publishing companies and rating agencies). To say it with Monbiot:

> [U]niversities are locked into buying their products. Academic papers are published in only one place, and they have to be read by researchers trying to keep up with their subject. Demand is inelastic and competition non-existent, because different journals can't publish the same material. In many cases the publishers oblige the libraries to buy a large package of journals, whether or not they want them all. (…) What we see here is pure rentier capitalism: monopolising a public resource then charging exorbitant fees to use it. Another term for it is economic parasitism. To obtain the knowledge for which we have already paid, we must surrender our feu to the lairds of learning. (Monbiot, 2011)

Even if *fair use* clauses might arguably apply for many cases of sharing of scientific results, and despite the 27th article of the The Universal Declaration of Human Rights, which states that "everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits" (see Shaver, 2010 for a detailed account of access to science as a universal right) intellectual property protection and expansion in scientific production prevails as a ruling principle in contemporary cognitive capitalist regimes and international IP enforcement treatises.

The disproportionate prosecution of those who attempted to make scientific research results openly available is particularly notorious. The case of Aaron Swartz is revealing. After having systematically downloaded PDF files from JSTOR (a copyright scientific publishing archive) servers using access from MIT, he was sued facing "a prison term of up to 35 years and a fine of up to $1 million" (Sims, 2011). The pressure and stress of the case lead to his suicide a few months latter. Swartz's, albeit the most visible and reported, is not the only case of abusive litigation in science. More recently Diego Gómez, a 26 year old scholar from Costa Rica, has been sued, facing 4-8 years of prison, for allegedly having shared the content of a previously published PhD thesis with colleagues (Peñarredonda, 2014). These cases are common and framed along the strategy of copyright alliances to sue and frighten knowledge and culture sharers (Beckerman, 2008). However, knowing that they won't benefit from harassing knowledge produces, publishing companies try to avoid targeting individual researchers and threaten instead institutions and sharing communities or scientific social networks. This is the case with the recent Academia.org site, where authors were increasingly sharing preprints of their work

10 http://www.forbes.com/companies/reed-elsevier/

until Elsevier issued thousands of takedown notices (Swoger, 2013), giving rise to an international boycott campaign against the company[11].

But more subtle, yet effective, are the lobbying efforts to stop legislation that favour alternatives to the strong IP models of scientific dissemination and to keep obstructing access to science (Peterson, 2013). Only Reed Elsevier (out of all the academic publishing companies) has invested, in an identifiable and documented manner, and exclusively in Washington, over 20 million USD on lobbying, during the last 15 year[12]. The attempts of big publishing companies to stop successful Open Access alternatives to academic cognitive capitalism is well documented (Taylor, 2012). Effective policy making is essential to guarantee open science (David, 2004a) and to avoid anti-commons tragedies in scientific development (Heller & Eisenberg, 1998).

Enclosure of science commons does not only affect publications. A growing concern affects the privatization of databases and datasets and the economic and research burden that it implies (David, 2004a):

> Seeking to apply the rights granted by the EC's Database Directive, and to partition and restructure the "information space" so as to readily extract licensing fees from users, would have the predictable effect of curtailing searches that were not thought to have a high expectation of quickly finding something with high "applications value." In other words, the probabilities of unexpected discoveries would be further reduced by the economically restricted utilization of the facility. (…) The adverse influences of the consequent "lost discoveries" also are likely to ripple outwards. This is so because the development of new and more powerful search devices, and techniques of pattern recognition, statistical analysis, and so forth, are more likely to figure among the discoveries that would be made collectively through the exploratory use of facility by a larger number of searchers. Therefore, some cost of extracting economic rents from this construct today will most likely come in the form of smaller benefits (and the sacrifice of reduced applications- oriented research costs) in the future. (David 2004:17-18)

Beyond data and publications, major publishing companies and IP driven companies are nowadays creating big copyrighted information complexes that enclose researchers and institutions within computer programs, databases, publication lists, indicators and even social relations. So for instance, Thompson Reuteurs and Elsevier, both provide author indexes and publication datasets that demand the use of proprietary software (like Endnote) for researchers to update their profiles. Authors remain often forced to contribute to these databases to keep their profiles updated because funding agencies rely on them to evaluate projects.

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The collective social capital and empowerment of science appears enclosed under the form of intellectual property capitalism, that reproduces the enclosure of cultural capital by artificially rising the prices of knowledge resources and restricting access using technological barries and tracking devices to avoid sharing and free dissemination.

11 http://www.thecostofknowledge.com

12 https://www.opensecrets.org/lobby/clientsum.php?id=D000028557

Moreover scientific funding is channelled towards the production of market oriented private economic assets and devoid of regulatory indicators that boost social benefit. And yet, a full capitalist structuring of academia and science, one in which cultural, symbolic and intellectual property capital appear perfectly aligned, is yet far from complete. This is partly due to intrinsic motivational factors within scientists and the fact that economic capital cannot yet be directly exchanged for symbolic capital (that demands acknowledgement from peers) due to strict (implicit or explicit) anti-plagiarism rules. Equally important is the widespread perception among scientist that it is to the essence of science to be based on public access and universality principles (and many scientist resist public business managerial tendencies inside institutions while favouring open access for dissemination of their work, which is their source of symbolic capital). This fracture (between the forms of capital, scientists motivations and principles) is nowadays deeper and wider due to ICTs and the new opportunities for collaboration and diffusion of scientific knowledge that they make possible. It is within this framework that we find a new revival of scientific commons, sustainable models of scientific publishing and the creation of an open and accessible global infrastructure for scientific progress and dissemination. A direct resource producing commons available to society and to the social economy of knowledge.

3. Alternative models: open, participatory and collaborative science

It is the view of the FLOK Society that the rise of Open Science suggests the possibility of a new mode of scientific discovery that builds upon a capacity for networked innovation. Indeed, it our view that the economy of commons-oriented peer production is leveraging a transformation in the productive capacities of many different research communities with particular implications for scientific research and discovery. Borrowing language and discourse from the Open Source Movement (OSM), for example, Benkler (2006) suggests that the rise of networked environments is making possible a new modality of organizing production through community-driven mass collaboration. Accordingly, the key to understanding mass collaboration is that resources are held in common– that is, they are collectively shared, managed and produced. In contrast to systems of private property, “no single person has exclusive control over the use and disposition of any particular resource in the commons” (Benkler, 2006, p. 61). As he notes:

> Information, knowledge, and culture are central to human freedom and human development. How they are produced and exchanged in our society critically affects the way we see the state of the world as it is and might be; who decides these questions; and how we, as societies and polities, come to understand what can and ought to be done. For more than 150 years, modern complex democracies have depended in large measure on an industrial information economy for these basic functions. In the past decade and a half, we have begun to see a radical change in the organization of information production. Enabled by technological change, we are beginning to see a series of economic, social, and cultural adaptations that make possible a radical transformation of how we make the information environment we

> occupy as autonomous individuals, citizens, and members of cultural and social groups (Benkler, 2006, p. 1)

As opposed to the many ways in with capitalism encloses the social empowering potential and commons oriented productive capacities of science, a new paradigm has been growing during the last decades (Dutton & Jeffreys, 2010), partly captured under the name of *Open Science* (Woelfle, Olliaro, & Todd, 2011) (OS hereafter), *Scientific Commons* (Cook-Deegan, 2007), *e-Science* (Bohle, 2013) or *Science 2.0* (Waldrop, 2008).

The term "open science" now largely refers to a kind of scientific research that includes guaranteed free access to research publications and data, to shared research platforms, and to broader collaboration in scientific discovery including collaboration with non-scientists. Notwithstanding the fact that the concept of open science emerges with academic journals in the 1600s (David, 2004b), the term itself has taken on a new cultural and technopolitic significance in recent decades. With the rise of information and communication technologies (ICTs), the ideal of "openness" has become highly pronounced (Alexander et al., 2012; David, 2004a; Wallerstein, 2011; Willinsky, 2005). Building on common pools of knowledge, code and design, an economy of open knowledge is now beginning to reframe the discussion on scientific practice. The rise of increasingly sophisticated ICT tools, open-source software, and network driven communities-of-practice, are together introducing new modes of scientific research.

It is worth noting that what this new trend on OS is actually doing is not the creation of a new kind of science separated from the already existing system but creating a semi-institutionalized form of liberation of the productive commons of science that are already in place but have been progressively enclosed and privatized (as shown in the previous section). So, for instance, the peer review process, that remains unpaid under the current scientific publication process, has an estimated total cost of £1.9bn [3.2 billion USD] per year, the production cost of the research itself being estimated to be of £116bn [198 billion USD], while more than 80% of the cost is public (CEPA, 2008). Whereas that productive potential became privatized under the cognitive capitalist model what OS does is to remove the enclosures of this productive forces. In doing so it also transforms the productive and organizational landscape of science. Moreover OS also opens the *interfaces* of science, its relationship with society and economy at large: by ensuring access to results and data, platforms and tools, it makes possible a more participatory research where the lack of cultural or symbolic capital is not an obstacle for scientific production.

We can summarize the following features and benefits of the new models of scientific production and dissemination that are taking place (under the names of Open Science, Science 2.0 or Scientific Commons):

Features:

1. Open Access to scientific publications and data without economic, legal or technological barriers, with interoperable formats and meta-data structures that facil-

itate automatic processing or structured systemic constructions (like the semantic-web or linked-data).

2. Open Infrastructure (both digital-electronic and physical) that makes possible the collaboration, re-use, preservation, and improvement of research.
3. Fast publishing of results and openness to collaboration on the early stages of discovery for others to comment, review and contribute.
4. Open, public and transparent organization, self-management or governance.

Benefits:

1. It is more just: in terms of justice OS guarantees access to knowledge as a human right, it avoids private enclosure of publicly funded research, it enhances participation of different social agents and makes possible to monitor and audit public investments in science.
2. It is more efficient and powerful: OS is a research accelerator (Woelfle et al., 2011), it solves the anti-commons tragedy of scientific data and result enclosures making it possible for researchers to search and use knowledge faster and without economic and technological barriers through interoperable protocols and formats. It delivers and builds faster as a system of cognitive production.
3. It is cheaper and sustainable: publishing and managing scientific production with free software and open access has been shown to be more cost-efficient. Economic models exist for the sustainable of Open Access publishing and for an economy based on knowledge services instead of knowledge goods (enclosed under IP regimes).
4. It is more fruitful to society: direct citizen involvement, open access to results and re-usability of infrastructure and resources makes OS contribute to social and community needs more efectively, adapted (or at least adaptable) to their needs, replicated with variation by other communities (e.g. localized) or used as a resource to provide other economic agents with services built upon and through OS projects.

In order to provide data and analytic detail to support the above statements for these FLOK alternative models of science we can split its innovations and procedures into different layers: products, infrastructure and organization.

3.1. Products: Open Access and Open Data as alternative models to the cognitive capitalist enclosure of scientific production

Much as the academic publishing companies enabled wider access to scientific knowledge between communities of scientists and researchers (in an era where they had to invest on paper printing and distribution), so today ICTs are providing a means to generate new repositories for storing and indexing research and new tools enabling global collaboration. The trend across global science is an accelerating focus on open access

(OA) publishing as a way of counteracting the influence of proprietary global science publications. These publications form the foundations of cultural production in the field of science publishing but criticism of this cultural infrastructure is rising. One of the central arguments for public access to scholarly literature is that scientific research is often funded by taxpayers through government grants. For this reason, public access to scientific publication is viewed as a universal right. This includes a particular emphasis on alternative copyright systems for diffusing research results. Unlike proprietary journals, for example, OA journals are predicated on the idea of free public access to science, and the elimination of any financial, legal, or technological barriers to public scrutiny. The economic, social and epistemic benefits are well studied (Suber, 2012). In economic terms a "move towards author-pays open access publishing, on top of the cost reductions arising from a move to electronic publishing, could bring global savings of £556 million [949 million USD]" (Corbyn, 2008)[13]

But what is OA exactly? There are different definitions of OA with different emphasis on aspects of access (technological, legal, economic, etc.) and re-usability of scientific productions and results (Suber, 2012). We here attach to the Budapest Open Access Initiative declaration, that states that:

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

It is important to note that "because OA uses copyright-holder consent or the expiration of copyright, it does not require the reform, abolition, or infringement of copyright law" (Suber, 2010, p. 7). In addition, we shall highlight that, as is the case with any other copyleft work (music, software, literature, etc.), the use of existing copyright laws does not make OA dependent on it. Copyleft and OA instrumentalize copyright laws to reverse the limitations of freedom it was designed to enforce, while they guaranteeing access to the product without violating national or international law. To provide a specific legal framework for these guarantees (that can be understood in terms of contract agreements between producers and consumers), copyright holders and OA publishers often make us of Creative Commons licenses. It is important to emphasize the importance of Copyleft licenses over other licenses that can equally be considered valid for OA. Copyleft licenses, on top of guaranteeing the access, use, copy, modification and distribution of a work, demand that any re-use or copy be distributed under the same licence.

Currently, OA takes two main forms or routes: green and golden (see Figure 1). Both routes or mechanisms are compatible but discussion is often focused on which of the forms should gain policy priority. Gold OA refers to the a model of publishing where authors pay for the publication and dissemination of their article, so publishers

13 Data for Zoe Corbyn's article was taken from (CEPA, 2008).

make their work sustainable and maximize access and diffusion of the publications. Green OA is oriented to the self-archiving of scientific production (often financed and sustained by the institution to which authors belong), the archived version of the paper can be either a pre-prints (the article sent to a journal before it is reviewed, corrected and formatted) or in the form of a delayed publication (between 6 and 12 months) so the publisher has time to exploit the publication to cover for its publication costs but frees the product afterwards.

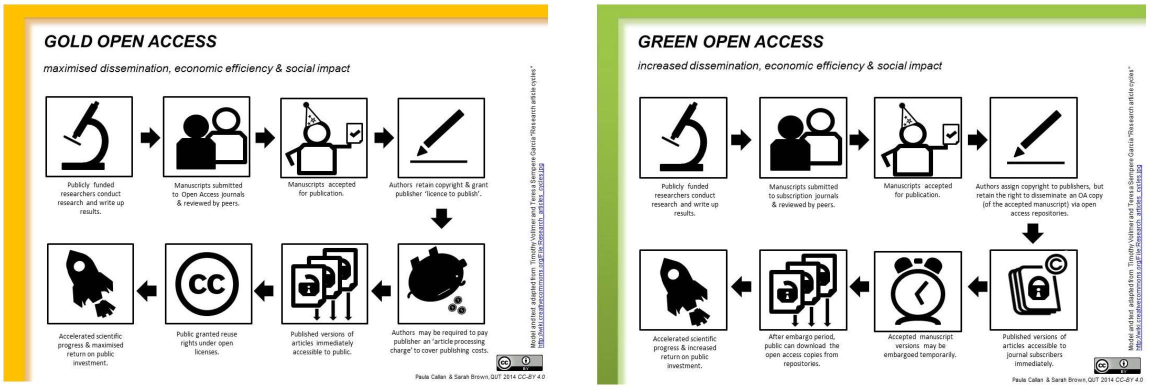

Figure 1: Gold Open Access and Green Open Access.

OA is a fast growing trend in scientific publishing and has been shown to be of hight quality and economically sustainable. In 2008 a study stimated that 19.4 % of the total yearly publications are already under some kind of OA (Björk, Roos, Lauri, Björk, & Roos, 2008). The DOAJ[14] (Directory of Open Access Journals) includes more than 9,919 journals with 1,692,261 articles from 134 different countries and the Open Science Directory[15] includes more than 13,000 journals. The quality and impact of these journals increases fast and among the most important international scientific journals some are already OA journals, among them PubMed Journals[16], PLoS Journals[17] and Frontiersin[18] collection of journals. These are often not just journals but whole scientific ecosystems including author profiles, job offers, etc.

The question often raised against OA journals is that, since they charge fees for publication, they will accept anything. This critique ignores a fundamental aspect of scientific journals, none of the journals would accept low quality article because authors select their journal in terms of quality (often measured by the Impact Factor), so nobody would spend money and resources on publishing a paper in a journal that has low quality papers.

The green route for OA involves public repositories of publications. These repositories often specific of a research field or family of research areas. The registry of OA reposit-

14 http://doaj.org/
15 http://www.opensciencedirectory.net/
16 http://www.nlm.nih.gov/bsd/journals/subjects.html
17 http://www.plos.org/journals/journals.php
18 http://www.frontiersin.org/

ories[19] has catalogued more than 3792 OA repositories with more than 12 million documents. Arxiv[20] is by far the most known and one of the oldes preprint repositories (some authors even skip publishing their work in a journal or deposit their discoveries in the repositories before they submit to a journal), it operates for the fields of fields of physics, mathematics, computer science, quantitative biology, quantitative finance and statistics. Other similar repositories include CogPrints[21] (centered on cognitive science) or CitesserX[22] for computer science. Other repositories are institutional, university-based, national or regional. SciELO[23] initiative was born in Brazil but it is now a latinamerican and international repository and is now part of wider institutional effort to integrate latinamerican repositories (with specific agreements between states) in LaReferencia[24] portal (see section 5 of this document for a more detailed explanation). These repositories are not limited to scientific papers but some also cover the publication of Masters and PhD thesis, like the european DART[25] that provides access to 543273 research theses from 562 Universities in 28 European countries.

International impact and adoption of OA policies: The trend towards OA includes a wide assortment of changes in the way academic scholarship is stored and managed. Indeed, a growing number of universities are providing institutional repositories through which researchers can deposit their published articles and make them available for public consumption. Research organizations and governments around the world are actively promoting open source models for scientific publication, as an alternative to journal clearinghouses, aiming at accelerating innovation, ensure economic growth and fair public investment returns:

> What is at stake is the speed of scientific progress and the return on R&D investment, and in particular publicly-funded investment which has enormous potential for boosting productivity, competitiveness and growth. Wide, affordable and easy access to scientific information is particularly important for innovative small businesses (Small and Medium Enterprises, SMEs). (…) The European Commission emphasises open access as a key tool to bring together people and ideas in a way that catalyses science and innovation. To ensure economic growth and to address the societal challenges of the 21st century, it is essential to optimise the circulation and transfer of scientific knowledge among key stakeholders in European research — universities, funding bodies, libraries, innovative enterprises, governments and policy-makers, non-governmental organisations (NGOs) and society at large. (European Commission, 2012a, pp. 3–4)

In 1998 SPARC[26] (the Scholarly Publishing and Academic Resources Coalition) was founded:

19 http://roar.eprints.org/
20 http://arxiv.org
21 http://cogprints.org/
22 http://citeseerx.ist.psu.edu/index
23 http://www.scielo.org
24 http://www.lareferencia.info
25 http://www.dart-europe.eu
26 http://www.sparc.arl.org

“an international alliance of academic and research libraries working to correct imbalances in the scholarly publishing system. Developed by the Association of Research Libraries, SPARC has become a catalyst for change. Its pragmatic focus is to stimulate the emergence of new scholarly communication models that expand the dissemination of scholarly research and reduce financial pressures on libraries. Action by SPARC in collaboration with stakeholders – including authors, publishers, and libraries – builds on the unprecedented opportunities created by the networked digital environment to advance the conduct of scholarship”.

A number of international declarations followed soon after[27]:

- **The Budapest Open Access Initiative:** the Budapest Open Access Initiative[28] (February 2002), signed by more than 5793 individuals, and 702 organizations (as of August 2014) from around the world, representing researchers, universities, laboratories, libraries, foundations, journals, publishers, learned societies.
- **The Declaration of Principles of the World Summit on the Information Society**: CERN, UNESCO and ICSU (in cooperation with TWAS and ICTP) made a number of comments for the World Summit on the Information Society representing the Scientific Community[29]. This document - compiled on behalf of the international scientific community - suggests amendments to the Draft Declaration of Principles and Draft Plan of Action Plan for the World Summit on the Information Society, the first stage of which was held in Geneva, Switzerland in December 2003. The document underlines the central role of science in the information society, and says that information and communications technologies "provide an historic opportunity to reduce the scientific divide: they improve and increase the transfer of scientific knowledge between developed and developing countries". It specifically urges the Summit to "promote electronic publishing, affordable pricing schemes and appropriate open source initiatives to make scientific information affordable and accessible on an equitable basis in all countries". As a result The Declaration of Principles of the World Summit on the Information Society, (Geneva 12 December 2003) stated: “We strive to promote universal access with equal opportunities for all to scientific knowledge and the creation and dissemination of scientific and technical information, including open access initiatives for scientific publishing”. (Article 288)
- **The Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities[30]** (October 2003), signed by more than 255 organisations including large national research institutions such as France's CNRS and Germany's Max-Planck Institutes, Spanish CSIC; national Academies of Science such as those of China, India and the Netherlands; international research institutions such as

27 For a complete list of declarations for OA see http://oad.simmons.edu/oadwiki/Declarations_in_support_of_OA
28 http://www.soros.org/openaccess/read.shtml
29 http://rsis.web.cern.ch/rsis/Links/Fulldeclaration.pdf
30 http://oa.mpg.de/openaccess-berlin/berlindeclaration.html

CERN; and individual universities and research funding agencies around the world.

- **OECD Declaration on Access to Research Data from Public Funding**[31] (Organisation for economic co-operation and development) constituted by more than 30 nations, recognising that “fostering broader, open access to and wide use of research data will enhance the quality and productivity of science systems worldwide”.

In 2009, faculty members of the Massachusetts Institute of Technology (MIT), for example, voted unanimously to allow their academic work to be published on MIT's open-source website. In January 2013, MIT launched a torrent site that displays not only text articles, but the actual datasets on which articles are based, joining a world-wide trend in providing open access to the public. In fact, a growing number of research funding agencies are making it mandatory for their recipients to publish in open-source platforms. In North America, the Canadian Institute of Health Research and various major U. S. agencies through the Federal Research Public Access Act (FRPAA) have introduced OA policies. In Europe, the European Research Advisory Board (EURAB) ruled that publishers are entitled to an embargo of no more than 6 months before making research articles openly available to the public. And the European Commission has stated that 100% of the research funded under the Horizon 2020 program be OA (European Commission, 2012b). In 2013 the UK Research Council has developed a detailed OA policy[32], including specific funding mechanisms, independent assessment bodies, and an UK Open Access implementation group[33]. In 2013, UNESCO announced that it too was introducing an OA policy (UNESCO, 2013). In Latin America HERRRE (see section 5 for a more detailed explanation).

There is an increasing awareness among scientists and science policy makers that the knowledge society should be built as an open society where scientific research is accessible to anyone, particularly when research is publicly founded. In turn, there is an increasing number of foundations, declarations and studies that support, promote and demonstrate the advantage of this approach and facilitate the creation of open access initiatives. In the words of SPARCeurope:

> There is growing international momentum in favour of self-archiving and open access journals. Increasing numbers of libraries are taking on the role of hosts for institutional repositories, becoming responsible for maintaining the intellectual heritage of their institution. The success of growing numbers of open access journals is proving the feasibility of the new business models. Evidence is accumulating to show the dissemination and impact benefits of open access and as success is proved, more authors, university administrators, librarians, and funding bodies are becoming aware of the limitations of the current system and possibilities of the new models.[34] SPARC-EUROPE

31 http://www.oecd.org/dataoecd/9/61/38500813.pdf
32 http://www.rcuk.ac.uk/research/openaccess/policy/
33 http://open-access.org.uk/
34 http://www.sparceurope.org/resources/hot-topics/open-access

3.2. *Infrastructure: free software and hardware for scientific research, collaboration and dissemination*

At the level of infrastructure there is a growing set of free/libre and open resources for the production (processing of data, collaborative writing, programming, etc.) and publication of science.

a) Free software: tools and platforms.

Free software (at all levels of implementation): personal computers, servers and supercomputers) is by far the most relevant FLOK infrastructural aspect of science with tools covering almost any aspect of scientific production from text editors to massive data processing programs, from journal publishing software to distributed computing. Notwithstanding, except for laboratory equipment (including physical and biological objects) and academic space (offices, seminar-rooms, etc.), software satisfies the rest of the commonly needed contemporary scientific infrastructure: from communication to data processing and visualization (provided that the required hardware is available). Free software has a prominent development in science due to a number of factors: a) it is very often developed within research labs (which are mostly publicly funded), b) the software benefits the whole research field, in which the software is of use, therefore free and open software development is also capable to include improvements and bug reports and patches from other labs, c) reproducibility of results demands that access and modification of the code be required, and, most importantly (Ince, Hatton, & Graham-Cumming, 2012).

Free software packages that are specific for scientific research are well documented and systematically organized (Gough, 2009) and ranges from medical analysis (Loening, Gambhir, & others, 2003)to integrated genetic analysis tools (Nicol, Helt, Blanchard, Raja, & Loraine, 2009), from mathematics (Stein & others, 2008) to robotics (Metta, Sandini, Vernon, Natale, & Nori, 2008). Free software resources are baste and there is no space here to mention a comprehensive list of available software infrastructure. The above examples are but a few of the relevant scientific software research infrastructures that are equivalent to the existing private platforms or resources (Debian, the most comprehensive GNU/Linux software distribution includes a meta-package with hundres of science oriented free software packages organized by disciplines[35]). But there is more to free software than tools for doing science. Some of the most notable free software resources for open science have to do with organizing scientific collaboration and publishing scientific results.

Projects like the Public Knowledge Project[36] provide whole suit of free software infrastructure for scientific publishing and organizing:

- Open Journal Systems: provides the software necessary to run a professional online journal including features such as edition of papers, management of issues, reviewers, etc.

35 https://wiki.debian.org/DebianScience
36 https://pkp.sfu.ca/

- Open Monograph Press: makes possible edit books and publish then with the appropriate catalog meta-data, different user and adminstrative interfaces, etc.,
- Open Conference System: offers a platform to organize conference websites.
- Open Harverster System: provides indexing for journals and conference information.

Other free software tools exist to manage journals[37], conferences (e.g. EasyChair[38]) and scientific collaboration (so for instance mediawiki provides the technological infrastructure to create wikis that have been used for scientific collaboration world-wide—e.g. Scholarpedia[39] is a scientific, peer-reviewed encyclopaedia). Other free software tools, like Zotero[40], help researchers create and share bibliographies, extracting metadata from scientific journals, archives and PDF files.

Apart from specific programs for scientific data manipulation, computation and experimentation, and from tools for academic research and publishing, one of the most relevant aspects of software infrastructure for scientific research has to do with e-science (Besten, David, & Schroeder, 2010; Bohle, 2013) and the development of big software platforms that make possible to assemble, structure, process, edit, audit, compare and display massive amounts of data and models for specific scientific fields. Since some of these platforms are having profound effects on the very organization of scientific research we shall explain then in section 3.3 below.

b) Free hardware and open computational resources

The combination of 3D printers, like RepRap (Jones et al., 2011), and low cost open hardware microcontroller platforms and component, like the Arduino[41] family, with Free Hardware is already triggering a revolution both in manufacturing and scientific laboratory infrastructures (Pearce, 2012, 2014) Universities world-wide are creating their own infrastructure to create prototypes, cheap laboratory equipment, or specific devices for their research needs, at much lower cost than what equipment companies can provide:

> To appreciate the elegance of the open-source hardware design approach, consider the recently developed open-source optics library of customizable printed designs that can be rendered with off-the-shelf parts and Arduino microprocessors[42]. The collection of inexpensive 3D-printable components, from simple fiber-optic cable holders to automated filter-wheel changers, dramatically reduces the cost of optics equipment in labs and classrooms. For example, to outfit an undergraduate teaching lab with 30 optics setups that include 1-meter optical tracks, lenses, adjustable lens holders, ray-optics kits, and viewing screens would cost less than $500 with

37 A full list, with more than a dozen option, of available free and open source solutions for scientific publishing can be found at: http://oad.simmons.edu/oadwiki/Free_and_open-source_journal_management_software

38 https://www.zotero.org/

39 http://www.scholarpedia.org

40 https://www.zotero.org/

41 http://www.arduino.cc/

42 http://www.thingiverse.com/jpearce/collections/open-source-optics

open-source hardware, compared with approximately $15,000 for commercial versions. (Pearce, 2013, p. 8)

An increasing demand of scientific infrastructure is computing power for all kinds of data processing. In this sense the Open Science Grid[43] provides a distributed network of computers for intensive research demands. Similar projects include Open Science Data Cloud[44] or the citizen science computing personal computer clusters (see case study 3).

3.3. Organization: collaborative, networked and participatory science.

Most of the recent transformation on organization of science have to do with the new forms of communication, collaboration and dissemination made possible by the collaborative infrastructure explained above and the sharing and communication culture that emerged from the massive use of ICTs.

Biology is one of the most complex scientific fields nowadays (partly because of the molecular details and the huge amount of data produced by labs, and the very complexity of life). Huge data-sets demand an enormous collaborative effort to produce knowledge out of it, and that demands the establishing of protocols and data-structures and data-query and analysis tools. Big Data commons initiatives like the NIH Big Data to Knowledge[45] (BD2K) or the resources put available by the European Bioinformatics Institute[46] are opening the way to new forms of massively collaborative science including inter-institutional collaboration, specific calls, collaborative platforms and even policy making teams to set up the necessary resources to tackle big scientific problems. The Global Alliance for Genomics and Health[47] with "more than 200 organisations active in more than 40 countries (…) to form an international alliance, including leading funders of research, biomedical research organisations, healthcare providers and disease advocacy organisations". A more interesting example from the point of view of freedom and openness of results is the Open Data Drug Discovery initiative in India (see case study 1 on section 3.4 below).

The WormBase[48] and WormBook[49] are illustrative projects of how medium-size research communities are build around around a specific research subject (in this case an animal model). They both operate like knowledge repositories (of papers, data, models, videos, anatomical maps, etc.) for the study of *C. Elegans* worm (one the most important animal models, the smallest multicellular organism on Earth). Everything is copyleft and open access and there is an active international and collaborative community built around this work and knowledge base. Out of this community other projects have been

43 http://www.opensciencegrid.org
44 https://www.opensciencedatacloud.org
45 http://bd2k.nih.gov
46 http://www.ebi.ac.uk
47 http://genomicsandhealth.org
48 http://www.wormbase.org
49 http://www.wormbook.org

born, like the Open Worm[50] project that tries to simulate the whole life of *C. elegans* with open source software taking the knowledge-base of wormbase.

At a larger scale, the Complex Systems Society[51] is a huge community-platform that provides innumerable services: data, software, wikis, etc. around complex systems studies, all copyleft and participatory, including the research roadmaps, written and discussed online and in conferences to push the research agenda. The very online platform provides a community explorer software tool[52] and it will soon open its MOOC (Massive Open Online Courses) as well with open content and lab applets.

Thanks to the free and open source infrastructure and the open access content, when organizational problems arise scientific production does not get paralysed or trapped under one of the factions of the collaborative network that produced it. Instead a *fork*[53] can be easily created by simply copying all the material and resources and setting up a new server with that material. Despite the (relatively low) cost of replicating the project, forking has been shown on free-software to boost technological innovation, by allowing proliferation of variation and letting the user and developer environment select among the parallel projects (in a manner that mimics biological evolution).

Parallel to the collaborative platforms developed for certain research fields or to tackle specific scientific problems we find a set of foundations, communities and federations that produce software, that launch and connect projects, initiatives and principles of open science. So, for instance, the Center for Open Science[54] that develops the Open Science Framework[55] which makes possible to coordinate the workflow of a scientific project or distributed collaborative interactions. The Open Science Federation[56] is a non-profit alliance that gathers more than 40,000 people "scientists and citizen scientists, writers, journalists, and educators, and makers of and advocates for Open Data, Open Access, and Open Source and Standards". Science Open[57] is a meta-publishing community where OA papers are discussed and working groups created to share information and resources.

But the biggest scientific social network is ResearchGate[58], with more than 3 million users, provides social network features like author profiles and stats, article sharing, Q&A tools, and wide set of services focused on scientific sharing, iterconnection, peer evaluation and collaboration. It is important to note, however, that ResearchGate is a private company that exploits open access (and also copyrighted material) and researcher participation with profit seeking goal in a non-open manner; that is, even if they gather data from open access journals and repositories the information, statistics, connections and content generated inside its network (unlike the other example communities

50 http://www.openworm.org
51 http://cssociety.org/
52 http://communityexplorer.org
53 http://en.wikipedia.org/wiki/Fork_%28software_development%29
54 http://centerforopenscience.org
55 https://osf.io/
56 http://opensciencefederation.com
57 https://www.scienceopen.com
58 http://www.researchgate.net/

and platforms mentioned above) remains private and copyrighted. From their Terms and Conditions page: “The software running the Service, the site design, the logos and other graphics, articles and other texts as well as the database are protected by copyright and property of the Provider.”[59] In this sense, despite it often masks itself as an Open Science iniciative, ResearchGate is a clear example of netarchical capitalism (Bauwens, 2005, 2009) where collective social capital is exploited and enclosed by a private corporation.

Last but not least, are communities, labs and open science initiatives that cross boundaries between academia and society to give rise to participatory and creative scientific research. A number of DIY (do it yourself) biological laboratories are quickly emerging[60] with more than 40 of them developing all around the world out of the hackerspace movement that fosters innovation hubs in self-managed, open and participatory citizen spaces. PublicLab, is perhaps, one of the most success interesting initiative coming out of a hackerspace and spreading internationally.

> The Public Laboratory for Open Technology and Science (Public Lab) is a community -- supported by a 501(c)3 non-profit -- which develops and applies open-source tools to environmental exploration and investigation. By democratizing inexpensive and accessible Do-It-Yourself techniques, Public Lab creates a collaborative network of practitioners who actively re-imagine the human relationship with the environment. The core Public Lab program is focused on "civic science" in which we research open source hardware and software tools and methods to generate knowledge and share data about community environmental health. Our goal is to increase the ability of underserved communities to identify, redress, remediate, and create awareness and accountability around environmental concerns. Public Lab achieves this by providing online and offline training, education and support, and by focusing on locally-relevant outcomes that emphasize human capacity and understanding.

Digital research on social networks or internet data and communication is cheap and accessible to citizens and communities without resources. Social and political research can be directly carried out by communities and collectives with little barriers. Open Data, Open Science, Free Software and collaborative research is essential to projects like OccupyResearch or DatanAnalysis15M.

Among the transformations that have taken place with the wider access to scientific literature, the emergence of scientific social networks and the spirit of free openness and collaboration, some have expanded to the processes of evaluation and measurement of research quality and impact. DORA, the San Francisco Declaration of Research Assessment[61], proposes to improve on the research indicator produced and managed by Thompson Reuters or Elsevier. OS makes possible the measurement and tracking of the use, downloading, copying, modification, social dissemination and economic impact of scientific processes and contributions to the commons. Science evaluation (for career promotion, funding, etc.) should move to include other measuring standards that better

59 http://www.researchgate.net/application.TermsAndConditions.html

60 http://diybio.org/

61 www.ascb.org/dora

capture the benefit produced and reproduced by research institutions, scientists and contributors to scientific commons. Almetrics[62] is a network of alternative metrics that different companies or non-profir agencies are implementing, visualizing and providing as a service to the commons.

3.4. Case studies

a) Case Study 1: Open Source Drug Discovery in India

Open science and collaborative research are often described as research accelerators that promise a new era in science. Beyond open access to scientific research, Web-mediated collaborative platforms are enabling entirely new methods of discovery. The Open Source Drug Discover (OSDD), for example, is a healthcare program sponsored and funded by the government of India and managed by the Council of Scientific and Industrial Research (CSIR). The mission of the project is to foster innovation on infectious diseases in developing countries through the use of open collaboration. Launched in 2008 as a shared partnership between various Indian universities, research institutes, and scientific organizations, the OSDD is designed to accelerate drug development and provide a global platform for healthcare systems in the fight against neglected tropical diseases. Indeed, it main focus is the development of new drugs leading infectious diseases such as tuberculosis and malaria. With 7,900 registered participants from across 130 different countries, OSDD is an example of the varied global platforms now emerging in scientific research that is enabling researchers and scientists together to advance new frontiers in scientific and medical discovery (OSSD, 2014).

Building on the success of open-source practices across a variety of academic and research domains, OSDD views itself as both an incubator and global aggregator of human intelligence under a common OSDD license. Formed as a community-of-practice supporting students, scientists, and researchers and industry practioners, OSDD is explicitly focused on Open Science that supports early stage research through an open and collaborative environment with the aim of developing low-cost medical drugs at highly affordable scale. In order to deliver drugs to market, OSDD relies on a generic industry model so that drugs may be manufactured anywhere in the world without the constraints imposed by intellectual property. Indeed, OSDD sees its mission as a response to market failure:

OSDD understands that the reason for failure to get adequate research investments to the tropical infectious diseases is the absence of a market which ensures return on investment for the industry. These diseases mostly affect the poor. Affordability and Accessibility of drugs to the affected population is at the core of OSDD philosophy. It is the OSDD mission to bring openness and collaborative spirit to the drug discovery process by developing an open source model of innovation for tropical infectious diseases with the objective of keeping medicine cost low and developing a web based platform for collaboration. OSDD aims to bring the best minds to drug discovery through open innovation and best partners with experience of drug development through product de-

62 https://en.wikipedia.org/wiki/Altmetrics and http://altmetrics.org/manifesto/

velopment partnerships. The drug development for tropical diseases carried out in those countries with diseases situs, in collaboration with the best minds of the world will make the research and development less expensive, compared to the traditional approaches followed in the industry (OSDD, 2014).

As an example of Open Science and ICT mediated scientific research, OSDD provides a strong example of the growing potential of collaborative platforms for supporting research and discovery. Perhaps most interestingly, the OSDD project is entirely managed online reducing its fixed costs. All project documents and tracking are done through the OSDD portal Sysborg 2.0 (http//sysborg2.osdd.net).

b) Case study 2: Public Lab and *Citizen Science Alliance*

Perhaps the strongest example of the growth and institutionalization of organizations supporting citizen science in the English-speaking world is the Citizen Science Alliance. A transatlantic collaboration between universities and museums in the United States and Britain, the mission of the organization is to serve as a platform for housing and promoting citizen science projects around the world. The aim of the Citizen Science Alliance is to serve as a collaborator and clearinghouse for scientists, software developers, educators, and the public-at-large in the collection, development and provision of Internet-based citizen science projects. Beyond the utilitarian value of expanding the capacities of science itself, the organization sees itself as an educational institution for public understanding about science and the scientific process (Citizen Science Alliance, 2014).

Beyond its educative function, Citizen Science Alliance provides a platform for linking the exponential rise in scientific data. As the capacities of computers have increased in terms of bandwidth, storage, and computing power, Internet platforms have emerged to facilitate the production and transmission of scientific data. As a platform for citizen science, the project uses crowdsourcing as a means to join a distributed community of citizen scientists together as collaborators in a science commons. In fact, the data collected from the numbers of varied projects has led to the publication of dozens of scientific papers.

As a home for a diversity of citizen science projects across a wide range of scientific disciplines, Citizen Science Alliance provides a common infrastructure for massively distributed citizen science. This includes tools and features for data analysis that can be shared across projects and a space for real-time scientific collaboration. Perhaps most importantly, the Web platform provides a learning ecology for scaffolding the education and development of amateur and volunteer scientists. According to the organization's founders there are several key features of citizen science that makes it's a promising domain for expanding and transforming the practice of science itself (Box 1).

Box 1

- The ability to cope with extremely large data sets – in its first six months Galaxy Zoo provided the same number of classifications as would a graduate student working round the clock for 3.5 years.

- Unlike work by a small number of experts, our ability to gather multiple independent interactions with the data provides quantitative estimates of error. This is an essential part of the ‘wisdom of crowds’, allowing us to understand the accuracy of the data we provide.
- Citizen science data sets naturally provide large and powerful training sets for machine learning approaches to classification problems. This is an essential part of our future; as data sets continue to grow we will need to hand off more and more of the routine tasks to machines; by doing citizen science today we can help train them.
- Serendipitous discovery is a natural consequence of exposing data to large numbers of users, and is something that is very difficult to program into automatic routines. Humans are naturally programmed to keep an eye out for the weird and the odd, even while sorting most objects into more mundane categories.
- While the primary goal of our projects is to produce academic research, by their very nature they are also outreach projects. As it involves our volunteers directly in the process of research, citizen science is a powerful tool for both formal and informal education. Unlike traditional education programs, from the moment users first interact with one of our project, they are not only learning but also contributing to science.

Building on the idea that science should engaged all members of society and not merely professional scientists; Citizen Science Alliance is a strong example of the kinds of resources that can now be marshaled in support of citizen science. Growing out of the success of the “Galaxy Zoo” project, the organization now hosts dozens of projects across astronomy, ecology, and cell biology. Citizen Science Alliance depends upon hundreds of thousands of volunteers to collaboratively participate in scientific research.

c) Case Study 3: *FOLDING@Home*

The power of distributed computing to support peer-to-peer collaboration among scientists and nonscientists is now entering into a new era in which unique projects around the world are able to serve as benchmarks for application in Ecuador. One of the most established projects for leveraging horizontally-scaled computing resources is the Folding@home project at Stanford Univeristy. Folding@home demonstrates both the power of “parallel computing” in support of scientific research and discovery and the new opportunities emerging for engaging citizens and nonscientists in research and discovery. Anchored at the Pande Lab, Folding@home first begam in 2000 on the premise that peer-driven distributed computing could be a substantial infrastructure in support of scientific discovery. The project uses the idle processing resources of Internet-connected personal computers owned by volunteers to study long timescale dynamics and is design with the primary purpose of determining the mechanisms underlying protein folding and the causes of protein misfolding.

Specifically focused on disease research for computational drug design and other types of molecular dynamics, Folding@home offers an intriguing example of growing potential of supercomputing to enhance scientific discovery and medical research into

Alzheimer's disease, Huntington's disease, and many forms of cancer. One of the world's fastest computing systems, Folding@home operates at a speed of approximately 46.0 petaFLOPS (floating point operations per second), making it the world's most powerful computing system. This performance has allowed researchers to develop otherwise costly atomic-level simulations of protein folding thousands of times longer than previously achieved, resulting in hundreds of scientific research papers. What the project demonstrates is that a distributed computational infrastructure rooted in citizen-volunteers can provide a revolutionary opportunity for building a scientific research base. More to the point, it demonstrates the revolutionary capacity to develop leading edge science project without the prohibitive expenses associated with Big Science projects.

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There are two important consideration regarding OS and the development of policies for a social economy. First is the temptation of a passive benefit from global open science, if other will why bother investing in OS?. The second is the reverse of the first: the fear for a national committed investment-on and public endorsement-of open science on the basis of fear to waste resources that could be appropriated by foreign agencies and companies in detriment of local economyt. These fears are, partly, motivated by the well known dilemma of the “tragedy of the commons” (Hardin, 1968): if there is a common pool of resource from which anybody can benefit without private property limit... then what is the short term incentive to contribute and take care of the commons instead of exploiting it indefinitely until exhausting it? It has been largely argued (Hess & Ostrom, 2007) against this tragedy, showing that, even for material scarce resources, commons management outperforms private management. But the arguments are even the more compelling for the case of knowledge—unlike the case of land or material commons, where other constraints and dynamics apply, knowledge is inexhaustible. In fact, the contrary has been shown: that, for the case of scientific knowledge, is actual tragedy is that of the anti-commons (Heller & Eisenberg, 1998).

Yet, there are a number of important reasons that demand specific consideration for the case of Science. Public investment on open science particularly benefits local and national population and economics:

1. OS grows faster and better than capitalist restrictive management of scientific production, if publicly founded research is well connected with national social, economic and political needs (which are often specific to the region/country), OS can significantly contribute to the national economy and the goodliving of communities (moreover, when considering that OS makes possible a more fluid systematic access to scientific results and the social and economic participation on the very processes of research);
2. The impact of OS principles on the very process of scientific production and management increases the quality of scientific results, its impact and social engagement, as a result, the nation benefits from the increase on scientific literacy and quality.

3. A social economy of open knowledge commons, demands the circulation of rent mostly through free/libre knowledge *services*; since the products, as well as the means to produce it, are common goods (cannot be commodified) promoting and investing on OS provides the means to advance human capabilities to deliver such services and attract students, economic agents and initiatives to the country.

4. General principles for policy making in Science

From our analysis of the different forms of capitalism that permeate science, the pressure of market capitalism and the enclosure and privatization of scientific production, and from the principles that have recently emerged to oppose these trends we can abstract a series of policy principles.

4.1. Results

- To maximize open access to scientific production (papers, books, data, textbooks, and otherwise), both national and international
    - To make explicit and expand the scope of fair use of intellectual property for research and educational purposes.
    - To enforce publication in open access journal and/or green open access with specific mandates.
        - To mandate green open access archiving for each university or public research institution (institutes, research centres, etc.)
        - To favour significantly OA publications over non-open access publications in researcher and academic curricula.
        - To assign specific funding for publication in OA journals and for the creation of such journal where no alternatives exist.
    - To enforce OA CC-by-sa licensing for any publicly funded research and publishers, including the publications made by public servants (academic or otherwise).
        - Not doing so should require a special permission with a specific justification of the case in hand, explaining how other alternatives where not available. A public record of such cases should be kept and publicly available.
        - Graduate, Masters and PhD thesis should also be published with copyleft licenses in institutional repositories.
    - To develop platforms for private file sharing among scientists.
    - To create a first tier national journal or repository that re-publishes open access content of the most relevant national research projects, to provide visibility for the highest quality works.

4.2. Infrastructure

- To strengthen, develop and promote the free/libre and open infrastructure required for the development of cooperative and open science.
    - To promote national and international online platforms of open and participatory science either by making funding calls to create new platforms or to join existing ones.
    - To promote the use of open 3D printing and open hardware in maker spaces at universities and other research facilities to make possible the production of research infrastructure such as devices, tools, prototypes, or scientific equipment.
    - To enforce the use of free software in public research institutions (both at the scale of personal computers and service infrastructures) as a basic requirement to provide a genuinely inter-operable, open, modifiable and non-depent technological infrastructure for scientific development.

4.3. Organization

- To open up scientific research to participation and socially valuable interfaces, particularly to the social economy of open and commons knowledge.
    - Within research projects applying for funding, to specify (on the side of applicants) and to assign relevant assessment weight (on the side of evaluator), to the following aspects of the research project to:
        - What the benefits are for the social economy of open and commons knowledge, specifying the research outputs.
        - How research process will be open to participation and results be open access.
        - Specific plans for public dissemination and popular science explanation of the project and results.
    - To allow for citizen communities, public institutions and non-profit organization to propose calls for publicly funded research.
    - To enforce involvement of undergraduate students into open science initiatives.
    - To open up research calls to researchers, projects and teams or collectives (provided they are non for-profit and cooperative on their governance), not necessarily associated with public system of research.
- To enforce transparency, equality of treatment, equity of access, accountability and verifiability for research funding calls and academic merit assessment.

- To make explicit the evaluation criteria for all funding, grants, research positions and academic promotion.
- To publish the results of the evaluation has been public (with open data standardized formats) and to allow for a period of revision of evaluation results.
- To publish the name of evaluators and the evaluation committee they participated in.
- To standardize the application for funding, promotion and access to research and academic positions with a digital CV template that can be updated at any time and generates structured data for the evaluation of the researcher (or institution).
- To develop open and quantifiable or intersubjectively-validable research indicators beyond the impact factor or patents.
- To create specific calls for research projects and initiatives (including research positions) that promote young or inexperienced researchers so as to avoid a winner-takes-all accumulation of symbolic capital in research calls and institutions.
- To publish (with FLOA licenses and open readable format) research proposals, results and final evaluation reports after the completion of the project or funding.
- To promote or enforce mobility between different academic institutions

* To promote and develop open, participatory and commons science practices and institutions and to rise social and academic awareness of its potential and possibilities.
  - To promote research of meta-scientific aspects related to OS and its relationship with a social economy of open and commons knowledge.
  - To set up research training programs (including open educational resources) that explain OS principles, governmental initiatives, success stories, use of programs and platforms, etc. targeting: a) researchers, b) companies and cooperatives that work on the social economy of knowledge and c) students, citizens and communities.
  - To open calls for citizen/public/open science spaces that boost collaboration between scientists, citizens and communities in relation to economic and social services that science can provide.

5. FLOK Science in Ecuador

Although the global research community is often interpreted as monolithic, the truth is that scientific discoveries are routinely introduced from various regions around of the world. Notwithstanding this fact, it remains the case that 60% of scientific publications originate in the United States and the European Union. The dominance of U.S. and European science has made publication in exclusively English-language journals a basic necessity for securing academic promotion. The consequence of this Western hegemony of science, however, has meant that emerging economies like Ecuador have been at a significant disadvantage.

Outside advanced economies, a growing cluster of rapidly industrializing countries is expanding the reach and scope of scientific research. Despite the fact that the large majority of scientific output and academic publication are produced in developed countries, the rate of scientific output is now fastest across emerging economies in East Asia and the Middle East. A 2011 report by the British Royal Society has predicted that Chinese scientific research will in fact take over the United States by 2020 despite the meager impact of China's overall scientific (as determined by citation rate).

One of the central contradictions emerging with the affordances of so-called network societies is that the use of networks makes information easily reproducible. This change in the system of knowledge production has now led to a variety of freedom/control problems relating to IP. While the goal of IP protection is to incentivize creativity and invention by rewarding individuals for their work. However, the rise of peer production regimes has introduced an entirely different set of values and incentives. The truth is that IP is a juridical concept that refers to creations of the mind for which exclusive rights are recognized. Advocates of open source production, for example, argue that knowledge is a public good, linked to other commons-based resources like the natural environment. In their view, IP is in fact preventing innovation by inhibiting the free circulation of information and ideas. Lessig (2004), for example, criticizes the implied analogy between physical property and intellectual property on the grounds that while physical property may be rivalrous, intellectual works were inherently non-rivalrous.

The truth is that Ecuador stands to gain a tremendous amount from OA and related open-source initiatives. Indeed, Ecuador has already made significant inroads in the development of OA policies. In 2010, for example, a higher education law required that graduate and postgraduate theses be deposited in the Higher Education National Information System. In fact, Ecuador maintains 21 digital repositories registered in ROAR (Research Open Access Repository) and/or OpenDOAR (Directory of Open Access Repositories). In Latin America, two thirds of the investments in research and development are funded by State resources and so funding for OA initiatives are linked to public funding (UNESCO, 2010). Despite this, the truth is that scientists, educators, and health care professionals often lack the necessary capital to access scholarly literature. But this is changing. In much of Latin America, OA has become the standard. Ecuador has joined Mexico, Columbia, Argentina, Brazil, Chile, and various other Latin American countries in developing *La Referencia*, a federation of national digital repositories. La Referencia acts as regional harvester and links worldwide with the Confederation of Open Access Repositories (COAR). However, out of the +600.000 documents archived at La Referencia, only 761 are from Ecuador (including PhD and Master thesis, journal articles and scientific reports)[63]. On top of the technical problems to implement OA

63 http://www.lareferencia.info/vufind/Laref/Mapa

archiving in Ecuador, acknowledged by Christian Benalcázar (La Referencia, 2013, p. 13), it seems that specific policy mandates are missing to enforce researchers to update repositories. Moreover, the regional agreements that found La Referencia are weak, they only mention "promotion" of open access not "enforcement"[64], and it has been shown that mere promotion does not produce significant changes on researchers and institutional behaviour regarding OA but that specific mandates need to be in place to ensure both open access publishing and archiving (Gargouri et al., 2010; Swan, 2012).

Beyond OA publishing, Joshua Pearce (2014) argues that open-source hardware offers Ecuador an unprecedented opportunity to reduce the costs associated with experimental research. Building on an argument for commons-based tools and resources, he points out that proprietary scientific tools are exorbitantly priced for the wrong reasons. A widespread dependence on the import of scientific equipment has ensured that access to research and education has been particularly daunting for developing countries. The combination of open-source microcontrollers and 3D printers, for example, now present Ecuador with new opportunities in the fabrication of customized, low-cost scientific equipment. As Pearce explains:

> For example, open-source colorimeters can be built to do COD measurements for under $50 replacing similar hand-held tools that cost over $2000 or single automated devices used in solar energy labs such as a filter wheel can be built in a day for $50 replacing inferior commercial tools that cost $2,500. Even high-end equipment can be built from open-source plans such as an $800 open-source microscope that replaces a $80,000 conventional microscope. This method not only offers the potential to radically reduce the cost of doing science, but also training future scientists. An entire university classroom of physics optics setups can be printed in house for $500 on a $500 open-source 3D printer replacing $15,000 of commercial equipment, which would save over $400,000 if scaled only to the basic physics labs in the 29 public universities in Ecuador.

Beyond open hardware, there are new scientific fields emerging with "open and linked data" that offer significant opportunities for knowledge-based societies. Indeed, OA is only a small part of what amounts to a new era in the field of open science. In the context of "Big Data" and high-performance computing, for example, some researchers are now becoming proficient in data science. Advancements in Big Data analysis present data scientists with new opportunities to improve decision-making across widely varied fields including health care, security, basic research, and resource management. In developing countries, however, the lack of adequate technological infrastructure and skilled human resources has meant that engaging in data science is often out of reach.

The term Big Data itself reflects the application of new and experimental data processing applications to datasets so large and complex that the very idea was unthinkable until very recently. In Latin America, *Cooperación Latino Americana de Redes Avanzadas* (Latin American Advanced Networks Cooperation) or *RedCLARA* is aimed at joining the region's academic and computational networks together and offers a promising platform for advancing data science. In Ecuador, the Ecuadorian Consortium for Devel-

64 http://lareferencia.redclara.net/rfr/acuerdos-regionales

opment of Advanced Internet or CEDIA is tasked with the mission to “promote and coordinate the development of advanced computer and telecommunications networks, focused on scientific, technological, innovative and educational development in Ecuador". The value of platforms like CEDIA is they facilitate national and international e-science projects across numerous fields. By linking various academic and research centers worldwide in the exchange vast amounts of data CEDIA and RedCLARA offer Ecuador a unique opportunity to build on high performance computing and data-driven science.

Combining open data with advanced computing resources promises a new era in scientific research. In order to truly leverage the exponential power of computers, Ecuador must ensure that access to platforms like CEDIA are widely available to both professional scientists and citizen scientists alike. A focus on federal funding to ensure wide access to scientific tools and resources providing a common platform for education and scientific practice is critical to science today. Ensuring that all Ecuadorians have equal access to high performance computing will very likely determine the success or failure of Ecuador’s science base in the 21st century.

6. Public policy recommendations for Ecuador

As the trend towards Open Science continues to grow, the value of developing legal and cultural protocols that promote “openness” in scientific research is now becoming fundamental to global science. This assumes of course that publicly funded scientific research is widely available through to open-access agreements and open-access partnerships with universities and research centers outside of Ecuador. The value of commons-based resources, for example, is that they leverage scale horizontally rather than vertically. Put this way, the key to leveraging the commons to enhance Ecuador’s science base, is the development of policies that ensure the social construction of knowledge.

1. Ecuadorian Open Source Resource Repository

Managing data has largely been subject to proprietary laws which have been used to build large and extensive financial empires around scientific and corporate data worth of billions of dollars. In the context of government, for example, “public” data has often been hidden from public view in the name of security. In the wake of the Internet and an “open data” revolution, however, a new era of government transparency is making government databases widely available to the public through official portals. Creating a national resource repository of vetted and validated free and open-source scientific hardware and software that could provide the materials, digital designs, instructions for assembly, etc. is critical in enabling scaled access to common resources. Many OA initiatives in the region suffer from a lack of substantial Internet access. Additionally, active participation in OA initiatives is needed from key institutions of the region in order to both advance scientific output and coordinate research policy.

2. Open Source Hardware

The use of 3D printing systems could provide Ecuador with the means to digitally replicate scientific devices at scale for a fraction of the cost of purchasing proprietary resources. What this means is that Ecuador could potentially acquire research-grade scientific instruments for education and for research. Additionally, federal funding of the development of open-source scientific hardware could be accomplished through a combination or traditional grants and/or contests to drive creative research.

3. Open Science Task Force

Form an Open Science Task Force to identify and benchmark successful examples of the application of open science initiatives in the region and the world at large. Begin the process of mapping open science projects in Latin America, especially the cost structure associated with these projects in order to determine and potentially reduce the fixed expenses associated with current and future equipment costs.

4. Maker Spaces

To enable distributed access to knowledge and resources supporting open hardware and open science tools, basic “maker spaces” should be funded at public universities including access to open-source 3D printers, machine shop tools, and laser cutters. Makerspaces combine manufacturing equipment with community learning systems in support of the design and creation of collaboratively manufactured goods. Perhaps most importantly, makerspaces can be designed to provide local communities with access to the technologies and resources that they most require.

5. Open Science Scholarship Programs

Scholarship programs have a long history of providing opportunities for young scholars to develop and mature in their chosen fields. Through the use of government-supported research scholarships, Ecuador can both promote new and innovative approaches to open science discovery and build out its science base and expand the numbers of skilled scientists and researchers in the country. This could also include travel abroad programs for young Ecuadorian researchers, as well as internationally collaborative programs for hosting researchers from abroad.

6. High Performance Computing Resources

Ecuadorian public policy has focused on promoting a "social knowledge economy" that aids in sustaining a healthy democracy and a prosperous society. Part of the challenge in advancing a social knowledge economy is the use of tools and resources that push the boundaries of data science and facilitate wider access to data-driven scientific practice. Ensuring democratic access to high performance computing platforms will be key to both advancing science literacy and pushing the barriers of science in the 21st century.

7. Conclusion

Building on Ecuador’s Good Living Plan (SENPLADES, 2013), this paper has advocated the importance of Open Science to expanding the country’s science base and enhancing its human capabilities. Beyond conventional approaches to research and practice that often depend upon proprietary scientific tools and resources, the FLOK Society emphasizes the value of commons-based scientific practice in the context of expanding public engagement with science. It is our view that openness in the field of scientific research is critical to both ensuring transparency and advancing human capabilities. More than this, we believe that the rise of Open Science portends a new mode of scientific discovery that feeds on user-driven collaboration in the context of open data, open hardware and a rising capacity for scaled networks. Put simply, it our view that the economy of commons-oriented peer production is leveraging a transformation in the productive capacities of communities, offering a unique opportunity for Ecuador to expand and transform its science system.

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