Open Innovation in Development

Integrating Theory and Practice Across Open Science, Open Education, and Open Data

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Abstract

This article integrates the concepts of open innovation and open development. It extends the theory of open development beyond the field of information communications technology to address aspects of innovation systems more generally. It applies the concept of openness to innovation in practice across the domains of open science, open education, and open data. Creating a framework that is more integrated in theory and cross-cutting in practice creates new possibilities for interdisciplinary research and policy-relevant insights.

Keywords

open innovation, open development, innovation systems, development theory, intellectual property, access to knowledge, open science, open education, open data

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Introduction

We know that innovation – the implementation and diffusion of new products, processes, business methods or organizational strategies (OECD 2005, 46) – drives development. Over 75 years of solid research proves that innovation creates jobs, generates wealth and produces benefits for society as a whole (Arrow 1962; Marshall 1920; Rostow 1960; Schumpeter 1934; Schumpeter 1942). Innovation also has the potential to enhance individual freedom and improve people's capability to lead longer, healthier and happier lives. However, ensuring that the socio-economic benefits of innovation are not concentrated among society's elites, but are shared inclusively by all people, is a significant challenge.

Distributive justice is also among the key concerns of "open development", a theoretical conceptualization emerging from the field of information communications technologies (ICTs) for development (ICT4D). "There is no guarantee that the benefits flowing from open models will be more positive or more evenly distributed than those of less-open models", explain Reilly and Smith (2013, 33). This issue must be addressed.

Can "open innovation" help unlock access to knowledge or contribute to more just, equitable and inclusive societies? Perhaps. But much work is needed to align definitions, especially around the central concept of openness applied to the phenomena of both innovation and development.

This article exposes and critiques the failure of most existing research on information technologies and open development to integrate the theories and practices of open innovation. It uses the method of meta-analysis to challenge assumptions and build understanding of innovation in practice across the domains of open science, open access, and open data. It brings critical insights from the disciplines of law, economics, management, and public policy to bear on this problem. And it considers the strengths and limitations of using the theoretical lens of open innovation to shed light on open development.

Among those interested in development, open innovation is often misunderstood. It is conflated with concepts like open source, copyleft or crowdsourcing. While such concepts may be found in some examples of open innovation practices, the core principles of open development and open innovation are not necessarily aligned. This ambiguity and misinterpretation is emblematic of broader problems with overuse of the word "open", which a recent review showed is associated with dozens of different terms (Pomerantz and Peek 2016).

Better understanding the relationship between open innovation and development will help grow open development beyond its roots in ICTs, in theory and practice. In its two-part

analysis, this paper offers insights on both theoretical and practical aspects of open innovation and open development.

First, in theory, anchoring the concept of open development in ICTs specifically, as opposed to innovation systems more broadly, limits its potential to explain models of openness driven by socio-economic as well as (or instead of) technological factors. A more integrated theory, such as presented in this paper, has wider explanatory potential and creates greater possibilities for impact.

Second, in practice, our understanding of what "open" means for development is fragmented across science, education, software, data and other domains, despite the fact that innovation happens in all those contexts. Moreover, the focus on legal and economic formality in much existing research on these topics ignores the informality of innovation practices throughout the developing world. The more cross-cutting analysis in this paper – covering open science, open access, and open data practices – offers technologically agnostic, universally applicable and sector-neutral insights into the concept of open development.

Extending Open Development Theory

1. (Open) Innovation for Development

This section of the article extends the theoretical framework for open development beyond its roots in ICT, framing openness within the broader context of innovation management strategies and policy systems. After pushing the theory of open development beyond ICT4D to innovation systems, it may be possible to take the concept much further. Open development could, for example, critically influence fields such as information systems (Myers and Klein 2011). Once untethered from the sole domain of ICTs, open development might even shape mainstream development discourse, in the way of other recent breakthroughs such as Sen (1999), Nussbaum (2011) and others. Theoretical growth may start, however, with the far more modest move from ICTs to innovation.

An early article framing open development introduces the concept as a set of possibilities to catalyze change through ICTs (M. L. Smith, Elder, and Emdon 2011). Field leaders Smith and Reilly (2013, 4) suggest the idea behind open development is: "harnessing the increased penetration of information and communications technologies to create new organizational forms that improve the lives of people." In their foundational chapter defining open models of development, they position open development as an outgrowth of literature on the information society and the subsequent work on ICTs as a tool for development, so-called ICT4D (Reilly and Smith 2013). Then, in explaining the history of open models, they begin with open source software and trace the evolution of openness from that starting point.

Reilly and McMahon (2015, 74) suggest that there is consensus emerging from open development research about what "open" means: "Open resources are defined as those which are accessible, digital, affordable, locatable, timely, sharable, and appropriately licensed. In addition, they need to be presented in a format that allows for their reuse and modification." The temptation to characterize "open development" as being a theory formulated for ICTs, or a phenomenon driven necessarily by ICTs, (for example, defining open resources as necessarily "digital") creates limitations.

We know that digital resources are not accessible to many people, so conditioning "open" on being both accessible and digital doesn't work. The loose, emerging definition of open resources is problematic for that paradox. The potential contradiction between digitization and accessibility can only be resolved if the openness conceived is confined to the digital environment, so accessibility means at least but also more than mere connectivity. Indeed, that seems to be common understanding of the idea in existing open development literature.

Smith (2015) points out two other problems facing those interested in understanding openness, both of which this paper confronts. One is that there is no common theory with which to learn and compare openness across a multiplicity of connotations, applications, and interpretations. This problem is not new. From the outset of its adoption in international development, "open" has been described as a fuzzy, trendy term susceptible to cooption; "a better marketing term than analytic concept" (M. L. Smith, Elder, and Emdon 2011, iii).

Davies (2012) sheds light on one reason the idea of openness is so malleable. "There is an important distinction to observe between openness focused on artifacts such as data, source code, or academic articles, and openness of processes, such as democracy and development", he explains. "Formal definitions of the former may tend to be concerned more with the legal or technical status of the artifact, whereas definitions of the latter may focus on questions of who is participating, how they are allowed to participate." Davies is also among numerous researchers who suggests that openness is often defined in oppositional terms. In the legal context, for example, open is the opposite of proprietary (Reilly and Smith 2013, 31). A question, therefore, to answer using a more integrated theoretical framework is: how might the relationship between open, proprietary and blended models of innovation enlighten us on open development or its antipode?

Another challenge Smith identifies is that openness is typically defined in universal legal and technical terms that are not sufficient for understanding the reality of openness in a development context. While the inclusion of some legal criteria is apparently universal across the openness discourse in various domains (M. L. Smith 2015, sec. 2.2), just saying open resources are those that are "appropriately" licensed is too vague to be meaningful. Indeed, there are valid concerns about whether any kind of legal licensing requirement must be part of a definition of open. "[S]coping the concept of openness as legal permissions is an arbitrary boundary that doesn't reflect reality," explains Smith (2016, 6-7). That is because, as explained later in this chapter, in many developing countries legal rules may be less influential than social norms governing appropriation of and access to knowledge. Smith's point about the arbitrariness of scoping openness through legal permissions mirrors my point above about the limitations of a technologically determined definition.

One possible direction to go from here is to focus on "ICT-enabled open practices" and ground theory-building in those practices (M. L. Smith 2015). It is also, possible, however, to invert the analytical framework. ICTs may be less the tool driving social and economic reorganization than a vehicle through which social and economic changes are easily visible to community outsiders. On this view, the foundational social elements, rather than technological elements, are the true drivers of information networking for innovation (de Beer and Armstrong 2015, 62).

This inverted perspective would more explicitly recognize that "an ICT ecosystem is … more than just a technological system; rather, it is a social system within which ICTs are

embedded." (M. L. Smith and Elder 2010, 65). Moreover, contrary to popular belief, many or perhaps most (based on Google scholar citations) recent uses of the term "open" do not depend on the existence of ICTs. Digitization isn't a prerequisite for openness. Offline resources and processes can be open too. Of course ICTs may be a factor facilitating social and economic change, but ICTs are neither sufficient nor necessary for a robust and holistic theory of open development.

This paper argues that there is significant value in exploring openness outside of ICT-enabled contexts. Indeed, this analytical shift (from ICTs to open innovation as the organizing principle?) is crucial to understand how openness impacts development through innovation generally, beyond ICT4D. Doing so allows us to see that open models are everywhere, not just online. Without disconnecting openness from ICTs, it cannot be holistically conceived, implemented, tested and improved as a model for development. A broader, cross-cutting analysis also shows that the starting point for understanding openness isn't the legal terms and conditions that govern access to software, but the social norms that inspired a community to seek out the appropriate legal tools to govern co-created knowledge.

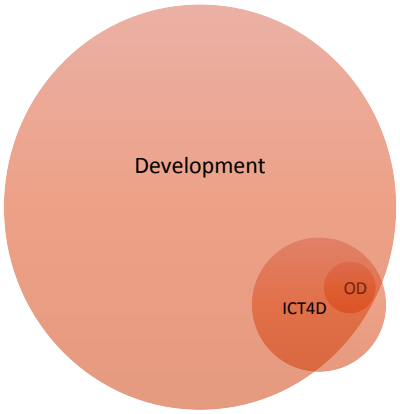

Figure 1: Open development (OD) conceived within the field of ICT for development (ICT4D)

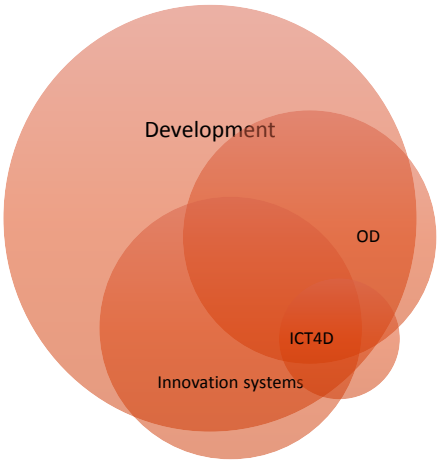

Figure 2: Open development (OD) conceived as covering aspects of ICT for development (ICT4D) and innovation systems

Figures 1 and 2 demonstrate the expanded potential of reconceiving open development to cover aspects of ICTs and innovation systems, instead of a subfield or outgrowth of ICT4D research. Of course, open development might cover much more than innovation, just like innovation covers issues falling outside the concept of open development. But enlarging the domain of open development beyond ICTs creates the possibilities of pushing the boundaries of development theory itself, as innovation systems thinking has done. Indeed, studying open development in connection with innovation systems, not just ICTs, has the

added benefit of connecting the concept with a much richer body of knowledge on development generally (B. Lundvall 1992; Muchie, Lundvall, and Gammeltoft 2003; Kraemer-Mbula and Wamae 2010).

For example, integrating open development and open innovation can help researchers tap into new insights on "inclusive innovation". The crucial importance of research on inclusive innovation has been recognized, although much work remains to be done (IDRC 2011b). While the leader on this topic in recent years has been the OECD (OECD 2015), a number of scholars have begun to build the field (Altenburg 2009; Heeks, Foster, and Nugroho 2014).

Another key aspect of innovation strategy and policy that could be tapped to inform open development is knowledge governance. Indeed, the tension between control over and access to knowledge is a – perhaps the – unifying thread in open development. One of the most important legal tools for governing knowledge is IP. Laws, policies and practices related to IP ownership can ultimately determine who benefits from open innovation. The potential of knowledge, in particular, to contribute to development has been well theorized and documented (Aghion, David, and Foray 2009; Benkler 2006; Juma and Yee-Cheong 2005).

In the broader context of innovation systems, "the link between openness and innovation is not necessarily straightforward; openness may support some types of innovation, but there can be a dynamic and productive tension between open and enclosed systems. Closed technological innovations can often emerge from open systems, while open initiatives can take advantage of closed technologies or systems." (Reilly and Smith 2013, 35). Researchers have investigated whether open innovation might change innovation policymaking in catch-up economies (Karo and Kattel 2011), but have not situated open innovation in the context of development policy more generally.

Significant uncertainty stems from the fact that many development scholars' understanding of openness is inconsistent with the literature on open innovation, especially in respect of knowledge governance systems. It is to open innovation literature that this chapter turns now.

2. Innovation through Openness

The open innovation literature is vast and very well established in comparison to the literature on open development. Numerous thorough reviews and syntheses of key sources among the thousands of works on this topic have already been published (Chesbrough and Bogers 2014; Dahlander and Gann 2010; Elmquist, Fredberg, and Ollila 2009; Fredberg et al. 2010; Huizingh 2011; Lichtenthaler 2011; Vanhaverbeke et al. 2010; West et al. 2014).

If another open anything movement is to move forward with credibility in the fields of innovation studies, management science or law and economics, then a serious conceptual gap must be acknowledged and bridged. This is especially true in respect of open business

models, where the focus is squarely on firm strategy, but the leading research is neglected (compare Lemos and Mizukami 2010 with Chesbrough 2006; Teece 2010).

While there may be observable differences between developed and developing countries, such work should not continue in silos. It is impossible to be taken seriously by the business leaders or economic policymakers whom development researchers aim to influence without understanding their perceived connotation of terms like openness and innovation. The research gap is not just North/South or developed/developing country issue; it is also cross-disciplinary and cross-sector. This subsection of the article summarizes the most relevant insights for open development.

"Open, user, collaborative and related innovation concepts imply strategies and systems where ideas and knowledge flow across firm boundaries" (de Beer 2015, 11). That is the common thread in the literature on openness related to innovation. Beyond that point of convergence, however, a recent review by leading researchers identifies a "fault line" over the importance of appropriation (West et al. 2014, 808). The key divergence is over how and why knowledge spillovers happen.

Research on "user innovation", grounded in the work of Eric von Hippel, tends to view appropriation through IP rights as a drag on innovation, especially sequential or cumulative innovation, thus diminishing social welfare (von Hippel 2005). In this context, the word "open" is adopted as part of the phrase "open collaborative innovation" to mean: "all information related to the innovation is a public good – nonrivalrous and nonexcludable" (Baldwin and von Hippel 2011, 1400). The non-proprietary innovation is open.

Research on "open innovation," a term associated with Henry Chesbrough's seminal book by that title, sees the appropriation enabled by IP as a tool facilitating in- and out-flows of knowledge between businesses (Chesbrough 2003). Recent work on open innovation by (West et al. 2014, 806) has defined the phenomenon as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms." Chesbrough's first book has been cited almost 12,000 times, with subsequent related works receiving thousands more.

It may surprise open development researchers to realize that within the most widely known and cited paradigm of "open" innovation, strong IP protection is a key facilitator of openness. That is because the openness Chesbrough identifies is the firm's. In the process of innovation, the knowledge-exchanging firm is open.

There is a parallel between the systems/firm views of openness in innovation and the artifact/process distinctions of openness in development. Research following von Hippel's work on "open and collaborative innovation" centres on the open nature of the artifacts circulating within an innovation system. Research following Chesbrough's work on "open innovation" and "open business models" centres on the open nature of processes through which firms innovate.

From the firm-centric perspective, clearly delineated IP rights that can be purchased into or sold out from the business are among the important market institutions that explain the rise of open innovation during the second half of the twentieth century. The existing research on open innovation highlights several major trends driving the phenomenon: market institutions, labour mobility, product complexity and technology platforms (de Beer 2015, 20).

Market institutions other than IP that promote open innovation include venture capital, securities exchanges and other financing systems, as well as industry standards that require interoperability. Labour mobility is a crucial factor, as people no longer spend entire careers with one organization. As people move, so does knowledge. Increasing product complexity is also associated with open innovation, since no single firm is able to produce all components working in isolation. Finally, technology platforms – ICTs in particular – make asynchronous collaboration across geographic boundaries possible. Technology is one, but not the only, factor responsible for open innovation, which is noteworthy for open development and ICT4D researchers.

Existing open development research has seized upon only part of the literature on openness and innovation. Benkler's concept of "peer production" – decentralized, collaborative, non-proprietary production by widely distributed and loosely connected individuals (Benkler 2006) – has been the most influential (see International Development Research Centre 2011; M. L. Smith and Elder 2010; M. L. Smith, Elder, and Emdon 2011; Katherine M. A. Reilly and Smith 2013). Regarding appropriation, or rather non-proprietary approaches to knowledge management, Benkler's conceptual framework is more closely aligned with von Hippel's work on user innovation and "open and collaborative innovation" systems than with work on "open innovation" in the firm-centric paradigm (de Beer 2015, 28). A key question that this article raises is whether widely distributed and loosely connected peer production aptly characterizes much innovation that happens the informal sector that dominates economic activity throughout developing countries.

3. A "Source" of Openness to Interpretation

Other influential concepts imported into the open development research include crowdsourcing and open sourcing, terms that offer insights into the root causes of misunderstandings. Despite using the common word "source", these terms cover very different ideas.

Crowdsourcing is a term coined by Jeff Howe, first in an article for Wired magazine and then in a book by that title (Howe 2006; Howe 2008). It can refer either to decentralized peer production, in the sense imagined by Benkler, such as Wikipedia. But it is more commonly understood by management researchers as a firm-centric open innovation strategy within Chesbrough's open innovation framework.

A recent cross-disciplinary review of research integrated 40 original definitions from over 200 sources to propose this integrated definition of crowdsourcing: "Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. …" (Estelles-Arolas and Gonzalez-Ladron-de-Guevara 2012, 197). With their integrated definition, Estelles-Arolas and Gonzalez-Ladron-de-Guevara (2012, 197) offer eight criteria to determine whether an activity is crowdsourcing or not:

> "(a) there is a clearly defined crowd;
> (b) there exists a task with a clear goal;
> (c) the recompense received by the crowd is clear;
> (d) the crowdsourcer is clearly identified;
> (e) the compensation to be received by the crowdsourcer is clearly defined;
> (f) it is an online assigned process of participative type;
> (g) it uses an open call of variable extent;
> (h) it uses the internet."

Two things are especially notable about this integrated definition of and criteria for crowdsourcing. First, Wikipedia, which is often cited as a paradigmatic example of peer production by open development researchers, meets barely more than half of the eight criteria defining crowdsourcing. This demonstrates key differences between peer production and crowdsourcing, and thus raises questions about how well aligned open development and crowdsourcing research really is. Second, several of the eight elements that define crowdsourcing seem very difficult to apply in the context of informal economic activities in the developing world. Is crowdsourcing a misnomer in open development, or is international development missing in the crowdsourcing research?

Open source is often understood as the inspiration for open development through ICTs. Open source software is also a better example of peer production than crowdsourcing, although many firms practicing crowdsourcing may turn to open source solutions. The original and still-leading research explains that open source refers to software licensed on particular terms. The licence must meet criteria for free redistribution, source code availability, derivative works and more (de Beer 2015; Perens 1999; Raymond 1999).

One key point is that open source in the context of software is defined primarily in reference to legal criteria. But another key point is that open source software is not, legally speaking, non-proprietary. It is legally protected by copyright and/or patents, but creatively licensed to require instead of restrict sharing (de Beer 2015, 32). A framework is also emerging to understand open source hardware, in addition to software, based on similar legal principles and practices.

While software is the most dominant model for understanding openness in ICT4D, looking across other domains is appropriate to frame open development in the broader context of science, technology and innovation policy. That is only possible by looking out how open innovation plays out in practice across different applications. So, the next section of this chapter considers the relationships among innovation, appropriation, and development in the realm of open science, open access, and open data.

A Cross-cutting Concept of Openness Through Innovation in Practice

> "A key finding of early open development research is that the qualities of openness are highly contextualized; that is, they are embedded in different technical, political, economic, social, cultural and institutional environments." (Reilly and McMahon 2015, 60). Both scholarly literature and practical experience belie the premise of classifying the study of innovation and/or business models into a silo distinct from the domains of science, education or data. Therefore, this section of the chapter moves the theory-based discussion in the previous part into practical application. It does so by considering innovation-related aspects of knowledge governance—across a range of domains from science to education to data. It takes up the challenge to move "beyond studying the qualities of openness within specific localized projects, and focus its energies on crosscutting studies that identify the factors driving quality openness" (Reilly and McMahon 2015, 48, 77).

The core argument in this section is that open innovation is inseparable from open science, open education, or open data. Through access to and exchanges of knowledge, innovation is intractably embedded into, and also transcends, each of these fields. Put another way, when open science, open education, and open data principles are applied in practice, they are examples of open innovation. The implementation and diffusion of new products, processes, organizational and marketing methods, i.e. innovation as commonly understood, is the phenomena that makes science, education, and data drive development in a knowledge society. Figure 3 depicts these relationships.

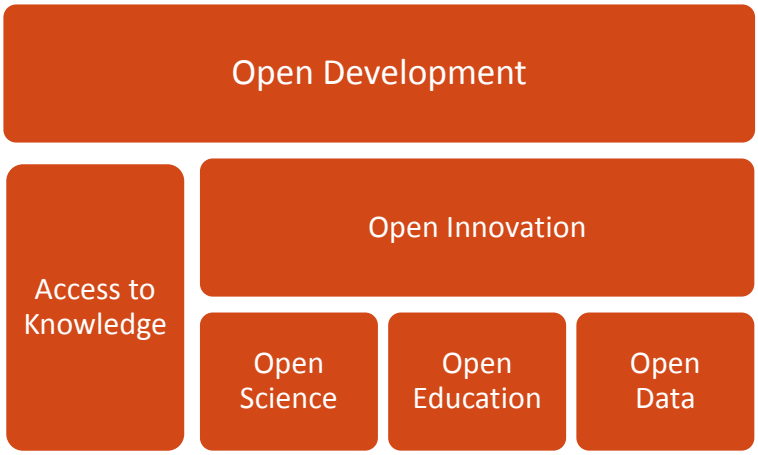

Figure 3: A framework for analysing openness, situating knowledge and innovation (not ICTs) between science, education, data and development outcomes.

1. Open Science

Science is perhaps the broadest domain for open development research, since science both produces and depends on scholarly literature and data. In a way, open science subsumes and transcends many aspects of open access publishing and open data.

In 1994, Dasgupta and David (1994, 487) explained the "new economics of science" as a synthesis of "the classic approach of Arrow and Nelson in examining the implications of the characteristics of information for allocative efficiency in research activities, on the one hand, with the functionalist analysis of institutional structures, reward systems and behavioral norms of 'open science' communities – associated with the sociology of science in the tradition of Merton – on the other." The stylized term inspired by Merton (1973), "Open Science," is now understood as an institution with a self-reinforcing code of conduct. The scientific priority of original discovery is rewarded with monetary and social benefits, which create incentives for full disclosure and diffusion of scientific knowledge.

The Open Science model contrasts with one where exclusivity of property rights is the key incentive for investments in science. The tension over openness was described by Paul David and Bronywn Hall (2006, 767) this way, in the introduction to a special issue of Research Policy on intellectual property issues affecting science:

> "[W]e have two distinctive regimes or environments for the conduct of research: the actors in the realm of 'open science research' expect reciprocal sharing of discoveries among themselves and the rest of the world, while those in the world of private profit-oriented and proprietary R&D expect to receive payment for the right to use their inventions (and to pay others for the use of theirs)."

This and other seminal literature on "open" science defines openness at least partly by reference to its opposite, proprietary science (see also David 2004).

The incentives produced by open and proprietary approaches have different impacts depending on the system in which science operates. Indeed, it has been shown that Open Science is responsible for scientific and economic inequalities in developed and developing countries, with "Big" or "Little" science capacity respectively (Carillo and Papagni 2014). That is because the larger the scientific system in which one operates, the greater the social and professional rewards for openness tend to be. There are fewer rewards in smaller systems. Consequently, economic modelling shows a world with two stable equilibria, which "may explain the huge differences existing between scientific sectors of less developed and more developed countries (Carillo and Papagni 2014, 52)."

Distinctions between open and proprietary models of science had tracked roughly the divide between university- and industry-led processes. But this line is becoming increasingly blurry as universities face pressure to commercialize scientific research and industry experiments with new appropriation strategies that support more open models of innovation. Intellectual property rights play a central role here. One of the key conclusions flowing from leading research on academic science and entrepreneurship is that intellectual property rights such as patents are "changing the "rules of the game" for scientific exchange, scientific credit, and the commercialization opportunities arising from scientific discovery (Jaffe et al. 2007, 575)."

The most significant shift in academic entrepreneurship during the last century occurred as a result of legislation in the United States, the Bayh-Dole Act, which permitted recipients of public funding to obtain private intellectual property rights over research outputs. While the legislation may not have fundamentally changed processes at the few American universities that were already actively exploiting intellectual property (Mowery et al. 2001), for most institutions Bayh-Dole was "a major impetus towards increased university involvement in patenting and licensing" (Sampat 2006; see also Popp Berman 2008). Indeed, Bayh-Dole is associated not just with increased intellectual property awareness and acquisition, but with academic entrepreneurship more generally (Aldridge and Audretsch 2011; Grimaldi et al. 2011).

> "[T]he intellectual foundations for this sea-change in federal patent policy were weak," explains Sampat (2006, 773),"based on a lack of understanding of the roles of universities in the innovation system." Nevertheless, in the early twenty-first century the impacts of Bayh-Dole, combined with the World Trade Organization's Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS), have been rippling throughout the developing world. In a must-read review of economic evidence pertaining to intellectual property's impact on science and technology in developing countries, Forero-Pineda (2006, 810) summarizes: "Scientific communities in developing countries are particularly vulnerable to limitations of cooperation and access to information, resulting from stronger intellectual property rights protection, as their efforts to obtain normal science results must be considerable."

There are basically two ways in which intellectual property threatens open science: access costs and transaction costs (David 2004). Institutional innovations that privatize and commodify knowledge "have a potential to do serious damage in the field of scientific and technological research, with all the adverse implications that this may carry for the long-term course of innovation and economic welfare growth in the advanced, "knowledge-driven" economies and the developing economies alike" (David 2004, 10). Empirical studies, using methods such as difference-in-differences estimators, show substantial benefits of academic openness for innovation (Murray et al. 2016). Economic modelling

also shows that under the right conditions Open Science is associated with higher social welfare than secrecy (Mukherjee and Stern 2009).

In developed countries, a possible "tragedy of the anti-commons" is among the biggest concerns around the push to propertize and commercialize scientific research (Heller and Eisenberg 1998). Empirical research is scarce, but some evidence shows that patents do have a "modest anti-commons effect" hindering the free flow of scientific knowledge (Murray and Stern 2007). A core challenge is developing an empirical methodological framework to test anti-commons and open science theories. This is very difficult in developed countries with data about patents and publications (Murray and Stern 2007, 656-61). It is even more difficult to conduct quantitative or statistical analysis in developing countries, where new concepts and metrics to measure informal innovation are just beginning to emerge (De Beer, Fu, and Wunsch-Vincent 2013).

Numerous researchers have called for reform of the Bayh-Dole system in the United States (Kenney and Patton 2009; Rai and Eisenberg 2003). There is also significant debate whether the Bayh-Dole approach is appropriate for other developed countries. The most credible research suggests not: "efforts at 'emulation' of the Bayh-Dole policy elsewhere in the OECD are likely to have modest success at best without greater attention to the underlying structural differences among the higher education systems of these nations" (Mowery and Sampat 2005, 117). The problem is even worse when transplanting Bayh-Dole to developing countries (So et al. 2008, 262).

It is not surprising, therefore, that the emerging research on open science in development characterizes the issues very differently. Development-related research on open science frames the issues less in economic terms than as about "the ways in which colonial legacies, capitalist forces and political repression continue to limit access to knowledge around the world" (OCSDNet 2016).

While it is justifiably argued that "Open Science addresses development by expanding opportunities to create, share and use knowledge" (OCSDNet 2016), these are unfortunately not the terms on which policy debates are unfolding in real time in developing countries. New research by the Open African Innovation Research network, Open AIR, demonstrates that open science is under threat as a result of Bayh-Dole-like initiatives in numerous African countries. The conclusion from Open AIR's work in three countries thus far is as follows (de Beer et al. 2014, 391):

> "It remains to be seen whether such an orientation, fashioned more than three decades ago in the world's strongest economy, will be helpful in contemporary or future African contexts. The evidence provided in this book suggests that the IP commercialisation orientation for public research outputs will have a relatively benign impact in South Africa; potentially damaging consequences in the context of Ethiopia (with its moribund university–

> industry linkages); and highly uncertain results in Botswana (where the policy-making is very recent and awareness among public researchers very low)."

The main reason such a dramatic policy shift away from Open Science may not have serious unintended consequences in South Africa is that relatively sophisticated stakeholders are crafting workarounds to avoid the worst outcomes (Ncube, Abrahams, and Akinsanmi 2013). Not all researchers are optimistic problems can be avoided, however (Barratt 2010). And regardless, the South African approach sets a dangerous precedent for the rest of the continent, and the developing world more generally. Concerns have been expressed about the threats from the propertization of science in research focusing on other developing countries and regions, including India (Sampat 2009) and Latin America (Forero-Pineda 2006). Future open development-related research on Open Science cannot ignore this crucial issue.

"The case for open scientific knowledge clearly needs to be reconstructed," argues at least one leading innovation economist, to acknowledge that "the scientific commons is in danger, the costs of having it erode further are likely to be high, and that we ought to move to protect it" (Nelson 2004, 456, 470). Much work remains to be done to understand when and where an open or proprietary approach makes more sense, and time is of the essence.

Interestingly for the conceptual framing of this chapter, ICTs factor very little in the leading research on Open Science. There are two possible inferences to draw from its absence. Either there is a major gap in the research, with open science scholars failing to recognize the central role of ICTs and give them due analytical attention. Or, ICTs may not be the definitive driver of open science. If the latter explanation is true, or even possible, open development researchers would do well to study the broader social and economic forces at play when building grounded theories about openness in science, technology and innovation policies for development.

Another interesting contrast exists between research on open science and open innovation regarding the direction of the shift toward openness. In the realm of science, openness is being supplanted by appropriation through intellectual property rights as part of the push toward commercialization of publicly funded research. The best efforts of granting councils are helping to push back against this pressure, but science is under threat of becoming less open. In contrast, in the realm of innovation more broadly, industry is becoming more open. Old models of closed innovation premised on isolation and secrecy are being replaced by more collaborative models based on the flow of knowledge across firm boundaries.

Is the trend similar in respect of other areas of open development, such as education and data? The following sections of this chapter explore that question.

2. Open Access

Most definitions of openness include accessibility as a core feature. “Open access” is related to but not synonymous with the concepts of open science, open data, or other applications of openness. The term generally refers to published content that is digital, online, free of charge, and free of most copyright restrictions (Suber 2012). These freedoms address two separate barriers to accessibility. Making works available gratis removes financial barriers to access while making works available libre removes permission barriers to access.

Both of these freedoms were emphasized in three formal declarations on open access publishing: the Budapest Open Access Initiative (2002), the Bethesda Statement on Open Access Publishing (2003), and the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities (2003). A common theme is the understanding that “[f]or a work to be OA, the copyright holder must consent in advance to let users "copy, use, distribute, transmit and display the work publicly and to make and distribute derivative works, in any digital medium for any responsible purpose, subject to proper attribution of authorship..." (Suber 2012).

More so than open science or open data, the term open access has long been associated with intellectual property licensing, particularly copyright. Imbued with this legal connotation, open access has since evolved in three related but distinct directions. First, the original issue of access to published scholarly literature continues to generate debate. Second, recent innovations have led to an increased use of open access to publish other types content. Third, open access is moving to educational resources, both the artefacts and processes of learning.

In the first area, open access to scholarly literature, one of the strongest arguments for open access to literature is its potential to increase the impact of scholarly publications (Hess and Ostrom 2003). Early research suggested that journal articles received more citations when openly published (Antelman 2004; Eysenbach 2006). These findings generated significant interest within academia, leading to the “green and golden roads to open access” (Harnad et al. 2004). By 2004, 90% of academic journals surveyed in one study were “green”, that is they allowed authors to self-archive while 5% of academic journals were “gold”, publishing under open access licenses (Harnad et al. 2004, 313). More critical reviews call these impact effects into question, pointing to variability in findings and identifying various biases (Craig et al. 2007). However, a strong consensus remains, open access increases academic impact (Tennant et al. 2016).

The demand for open access to literature has never been higher. Elsevier’s recent legal victory drew attention to the academic piracy site Sci-Hub, whose users downloaded 28 million papers between September 2015 and March 2016 (Bohannon 2016). However, little research examines the economic impacts of open access to literature. A report to the UK’s Open Access Implementation Group estimated that open access saves the UK’s public

sector £26 million in access fees and £2.6 million in time (Look and Marsh 2012). Recognizing the economic and social value of open access literature, the Obama Administration announced in 2013 that federally funded research would be freely available within one year of publication (Stebbins 2013).

Second, as Internet bandwidth has increased so has "remix culture" and the demand for freely available content (Lessig 2004). The Creative Commons suite of copyright licenses has helped to meet this demand, allowing creators to publish their works gratis while selecting a range of libre-based requirements for attribution and use ("Choose a License" 2016). Over 1 billion works are openly accessible under Creative Commons licenses (Merkley 2015). Major Internet services offer options to publish under Creative Commons, including content on Wikipedia, video on YouTube, music on Soundcloud, and images on Flickr. To date, Creative Commons textbooks have saved students $174 million (Merkley 2015).

Third, open access to educational resources has moved beyond textbooks and other content-based artefacts of education, to the process of learning. Educational resources are made open with the understanding that "access to the world's knowledge is a public good" (M. S. Smith and Casserly 2006, 10). Research in the field explores how open educational resources are produced and delivered (Wiley, Bliss, and McEwen 2014). Open education resources include open courses and learning materials, software for learning (e.g. learning management platforms), and repositories of learning materials (Downes 2007). Of particular interest are Massive Open Online Courses (MOOC) (Haggard et al. 2013). These online courses are open for anyone to enroll and access reading lists, lectures, and participate in various learning experiences. Examples include edX run by a consortium of universities including Harvard, UC Berkley, and the University of Adelaide; Coursera run by Stanford, Princeton, and Arizona State University; and Udemy a non-academic skills training site that allows experts to create and administer courses.

MOOCs have struggled to find sustainable business models (Wiley, Bliss, and McEwen 2014). Development and maintenance of online materials is costly. For example, each course published on MIT's Open Courseware takes a minimum of 100 hours of effort to produce, at an annual cost of $3.5 million USD ("Why Donate?" 2016). These costs highlight the challenges providers face in covering their costs while maintaining free access to course materials.

Downes (2007) highlights a number of business models being used to provide open educational resources. Models include: an endowment model, where funding comes from interest generated from large typically donations (e.g. Stanford's Encyclopedia of Philosophy); an institutional model, where funding is part of the organization's operational budget (e.g. MIT's Open Courseware); and a conversion model, where for-profit organizations offer 'freemium' options, with the goal of converting free consumers into paying customers (e.g. Coursera) (Downes 2007). Some governments have shifted spending from proprietary to open resources.

A number of challenges exist for MOOCs and open educational resources. Although free, as in gratis, remains a common theme across MOOCs, now many courses are not offered free, as in libre. The debate about whether these courses are "massive, open, and online", or just "massive and online" demonstrates ambiguity and controversy about what "open" really means. Courses are often published under contractual licenses that limit users ability to copy the course or make derivatives. As a result, providers are moving to proprietary models. For example, during a platform update in July 2016, Coursera removed their gratis-free track from a number of courses (Inside Higher Ed 2016). These developments have led some commentators to speculate whether massive online courses can remain 'free' and sustainable (Tirthali 2016; Gee 2016).

Open Access is especially important for developing countries. In the knowledge economy access to information drives innovation and growth. Limited financial resources within developing countries constrain access to proprietary journals and other creative resources that are necessary for innovation. Education for innovation requires access to both materials pedagogical tools for learning. As emerging concepts that require innovation in their implementation, open access and open educational resources will also create opportunities for education in the process of innovation.

Moving forward, a leading thinker on open educational resources forcefully argued that there is no longer debate about the meaning of "open" in the context of open educational resources: "As far as I can tell, the only people actively engaged in a debate about the meaning of the word "open" in the educational context are (1) those who genuinely misunderstand it because they haven't become part of the community yet, and (2) those whose business models would collapse if the public had free access to and open licenses for their products." (Wiley 2016). The key phrase in Wiley's comment is "in the educational context."

Cutting across sectors – looking at innovation in education, science, data and more – there is significant debate about what "open" really means. When organizations around the world say they practice open innovation, it is not just naivety or "openwashing", as Wiley suggests (Wiley 2016). These organizations may be adopting a bona fide understanding of openness based on renowned work by authors such as Henry Chesbrough. Work in the realm of open data helps to further highlight the conceptual challenges that still plague open development across domains.

3. Open Data

Data has become a valuable resource with the rise of the digital era. It performs a number of functions: driving scientific discovery, underpinning business models, informing evidence-based policy, and helping farmers plant their crops. Developments in linked data provide incentives for firms to open their data for collaboration.

The Open Data Handbook (2016) defines "data" as datasets, as opposed to a single data point, which it defines as "content". Data is considered to be "open" when it can be accessed, used, modified or shared by anyone (The Open Data Handbook 2016). Within the open innovation literature there is some consensus that open data requires ICT: the data must be machine readable and accessible online (C. M. L. Chan 2013; Gurstein 2011). In contrast, open development scholars acknowledge that data takes many qualitative forms, including maps, pictures, and paintings, and need not be machine readable or accessible online to be open (Hossain, Dwivedi, and Rana 2015; Schalkwyk et al. 2014).

As an intangible resource, IP governs the ownership of data. By default, owners hold a proprietary right to their data. This is a result of a combination of legal mechanisms governing ownership of data, including copyright, sui generis database rights, technological protection measures (TPMs), trade secrets, and privacy (de Beer 2016). Copyright (the most commonly discussed mechanism) automatically protects original compilations of data in databases, but not fact-based contents like statistics or formulas. More than one of these legal mechanisms may apply to a given dataset, increasing the ambiguity of data ownership. Therefore, data is only considered "open" when it is published under an open license.

Proprietary ownership of data poses several challenges for open data artefacts. In practice, proprietary data hinders the growth of the linked data commons, making it impossible to apply open licenses to linked datasets containing proprietary data. The ambiguous nature of ownership rights in data means licensing open data may not be as straightforward as other content. Conversely, clearer ownership rights could facilitate open data by enabling owners to apply open licenses to their data. Open data licenses transfer these rights, allowing anyone to access and use the data with attribution and other optional conditions ("Licenses" 2016; Creative Commons 2013).

Despite challenges, firms are practicing open innovation by releasing their private data, recognizing the economic benefits and potential of open data systems (Dodds et al. 2014; Hammell et al. 2012; Open Data Institute 2016). Depending on the particular model adopted to share open data, these practices could reflect either the firm-centric version of "open innovation" by using IP licenses to exchange data into and out of the organization, or a more systemic approach where data is put into the public domain without any IP protection at all. In either case, the economic impacts of open data are substantial.

Not counting the private sector, the market impact of public sector information across the European Union in 2008 was €28 Billion (Vickery 2011). An independent review of the United Kingdom estimated benefits of public sector information at £6.8 billion in 2013 ("Shakespeare Review of Public Sector Information" 2013). Looking globally, across public and private sector information, the McKinsey Institute estimates the widespread use of open data will globally unlock $3.2 trillion USD in economic value per year (Manyika et al. 2013). It is difficult to assess the reliability of these figures, since little or no empirical work has been conducted on the macro-economic impacts of open data.

Using business case studies, the Open Data Institute (Open Data Institute 2016) described how three firms, Thomson Reuters, Arup, and Syngenta have adopted an open data approach to gain an economic and competitive advantage. Thomson Reuters opened access to "Permanent Identification" (PermID), its key entities identifier system, to improve the richness and accuracy of their data (Dodds et al. 2014). They enjoy a reciprocal benefit when outside users link their open data to the PermID system, gaining access to outside data with little additional effort (Dodds et al. 2014). Arup, a design and engineering consultant, use open data to enable nimble responses to new ideas inside and outside of the firm. It allows Arup to "create IP without having to have complex legal agreements, lawyers, and background discussion that slows everything down" (Open Data Institute 2016). Syngenta, a global agricultural firm, has published six open datasets as part of its Good Growth Plan for sustainably growing its business by improving global food security (Ag 2015; Open Data Institute 2016). Beginning as strategy to engage stakeholders and build trust in their Plan through transparency, Syngenta views open data as part of a shift towards a more collaborative business model.

There is considerable optimism for open data among the development community. The World Bank sees its potential to level the playing field for the communication of knowledge (Walji 2011). Such inclusivity is expected to generate more effective outcomes (Davies and Edwards 2012). For example, increased access to information allows policy makers and aid funding agencies to make evidence based decisions (Linders 2013). But scholars warn, "openness must serve the interests of marginalised and poor people" (Davies and Edwards 2012).

Several challenges must be overcome before these opportunities are realized. Unequal access to ICT and open data creates a digital divide, excluding marginalized users from the benefits of open data while empowering users who already have expertise and access (Gurstein 2011). Developing countries and businesses often lack the capacity to digitize their data (Davies 2014).

When open data is available, it is often published in aggregate (for a variety of reasons including privacy). But the developing world needs disaggregated data to make evidence-based policy decisions (CTA 2016; C. M. L. Chan 2013). Data intermediaries are recognized as a one part of the solution to these challenges (Schalkwyk et al. 2014), but more work is needed to increase ICT penetration and address the context of developing countries.

Summary and Next Steps

This article has highlighted theoretical gaps between the fields of open development and open innovation. It has suggested strategies to better integrate these two concepts, thus extending the potential of open development beyond its origins in ICT4D. This article has also shown how the concept of open innovation enables cross-cutting analysis of commonalities among applications including open science, open education, and open data.

Significant discussion of the meaning of openness was contained in both major sections of this article. That discussion reveals that critics of "openwashing" may misunderstand the reason that companies call practices "open" despite not meeting the criteria that domains one particular application of openness or another. The reason is that particular practices may be labelled "open" according to the widely accepted meaning of openness in the management and innovation literature. This isn't always a disingenuous or nefarious marketing ploy; it is an innovation strategy taught in introductory-level business school courses.

A new theoretically integrated and practically cross-cutting framework can facilitate more interdisciplinary and policy-relevant research. As a final remark, there are two matters that stand out as priorities for future researchers who might use these insights to advance open development research. One relates to informality; the other to governance.

Regarding the informality of openness, it is critical to note the size and importance of the informal economy in many developing countries. The latest figures show that the informal economy contributes nearly two-thirds of GDP in the region of Sub-Saharan Africa, and in some Southeast Asian countries, such as India, informal economic contributions constitute half of GDP. Groundwork has recently been done to prove that (a) extensive innovation happens in the informal economy (de Beer, Fu, and Wunsch-Vincent 2016), and (b) informal sector innovators openly collaborate or appropriate differently from counterparts in the formal sector (de Beer and Wunsch-Vincent 2016). An agenda to better measure and value these contributions has been proposed, but the hardest work of developing and implementing new metrics remains to be done.

Despite the importance of the informal economy in developing countries, little or no research has been published that explores open science, open education, or open data in this specific context. Perhaps because of its current focus on information technologies and legal formalities, open development research has not so far delved deeply into innovation related to science, education, or data in the informal sector. An opportunity exists for researchers to take up this challenge by situating those topics in a framework integrating open innovation and development. Without more explicit and systematic coverage of the informal sector, open development cannot fulfil its explanatory potential or have the impact it otherwise might.

On the issue of governance, further research is needed to understand the best approaches to mediate tensions amongst openness, access and the appropriation of knowledge. Knowledge flows throughout innovation systems influence the degree to which the benefits of science, education and data lead to positive development outcomes for all of society. Access to knowledge was identified as a central concept animating the last decade of work on ICT4D (de Beer and Bannerman 2013). Now the time is ripe to take an analogous step in the emerging field of open development.

One conceptual tool to better understand how knowledge governance impacts innovation across science, education, data, and other domains is "the commons". Numerous scholars have been inspired by the work of Nobel laureate Elinor Ostrom on governing the commons (Ostrom 1990). Her insights have been adapted to create a framework for research on governing the "knowledge commons" (Hess and Ostrom 2006; Frischmann, Madison, and Strandburg 2014). Interesting scholarship using this framework has been published on commons-driven initiatives in genomics, medical research, and astronomy, aviation, journalism, military technology, roller-derby and much more. But the knowledge commons framework for governing open innovation in developing countries has not been well studied.

Informal innovation and knowledge governance are just two specific priorities that might be possible to explore once the concepts of open innovation and open development become better integrated. A theory constrained of open development to the specific domain of ICT4D cannot adequately address these or other key questions around open science, open education, or open data. ICT4D researchers should be proud of the open development theory they have spawned. The next step is to let it loose.

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