Open Innovation and the Triple Helix: The Case of Neglected Tropical Diseases

Key words: Open Innovation, non-commercial research, neglected tropical diseases, Triple Helix, global public health

Samantha Vanderslott is a PhD candidate in Science and Technology Studies at University College London. She is interested in the adoption of Open Innovation approaches in BRICS countries with a focus on global public health. Previously Samantha studied Economics and then Global Politics at the University of Bath and University of Oxford. She also worked for three years as a senior policy advisor on enterprise and venture capital policy at the UK government Department for Business, Innovation and Skills.

Contact: s.vanderslott.12@ucl.ac.uk

Abstract
The Triple Helix has proved to be a useful tool in which to view the changing and interchanging roles, responsibilities and relationships of key innovation actors. This study looks at the adoption of the 'Open Innovation' concept and explores the challenge to our understanding the Triple Helix of government, industry and university relations. Through the case study of neglected tropical diseases (NTDs), the argument is presented of Open Innovation being reflective of the new ways that innovation actors operate. The involvement of various innovation actors in tackling NTDs and their individual rationales shows that innovation models and paradigms are lacking in their consideration of public and social objectives, which invites a re-conception of the meaning of innovation.

Introduction - Openness in innovation

Openness has become a popular concern when thinking about innovation. Dahlander and Gann chart the "rising interest in using the openness construct" (2010, p. 700). As a term that holds many positive connotations it is not surprising that they find the associated literature concentrates mainly on the potential benefits of openness. In particular 'Open Innovation' has found fame as a management concept and buzzword, with "widespread acceptance in different lines of research, and it had a major impact on both research and practice" (Lichtenthaler, 2011, p.138). There has been a strong following within industry, as noted by the Big Innovation Centre: "Unilever and GlaxoSmithKline now have Open Innovation elements in over 50% of their R&D projects" (Golightly et al, 2012, p. 3). Similar sentiments can be found in other reports.

Henry Chesbrough is often dubbed the father of Open Innovation (Sloane, 2011; Pascu, and van Lieshout, 2009)[1]. He described a new paradigm for how the knowledge landscape has changed through the availability of different sources and uses of ideas (2003, p. 43-45). What Chesbrough was conveying is a systemic change in the way that innovation happens. Open Innovation is the move from an economy where large corporations dominate the innovation landscape to a more entrepreneurial system, which encourages the flow of ideas to and from firms. Today's economy is characterised by the equally powerful force of start-up companies, along with the venture capitalists that fund them. There is more of an abundance of knowledge, aided by the Internet and large companies are no longer the knowledge monopolies typical of the 1970s, needing to look outside their firm boundaries for ideas. Chesbrough uses the case study of photocopier company Xerox, as an example of 'closed innovation' through the creation of the Palo Alto Research Centre (PARC) in 1970.

PARC became birthplace for many technological innovations but Xerox was unable to appropriate this value effectively. He explains: "The majority of technologies that left PARC, however, did so via newly formed, independent start-up companies, which were staffed by departing PARC researchers and funded by venture capitalists" (2003, p. 5). This is closed innovation because the company did not make use of external sources of innovation - even

[1] Chesbrough confirmed this status in an interview with Forbes, saying: "I really am the father of open innovation" (2011).

though these ideas were initiated internally, they needed to be spun out to be further developed. With closed innovation, internal ideas that fit within existing business plans are privileged.

Underling the new system of Open Innovation is the observation of the changing and sometimes interchanging roles of key innovation actors. Chesbrough shows that there is a challenge to industry posed by young entrepreneurial firms and to survive large companies must utilize these firms as well as universities. Government must in turn keep up with such developments by supplying the necessary intellectual property (IP) frameworks and investment in basic research. Featured here are universities, industry, and government, a three-way interaction, which Henry Etzkowitz calls the 'Triple Helix' (2003). Etzkowitz recognized each sphere as being an equal a source of innovation but there is also a move outside of traditional functions, where each sphere "take the role of the other" (ibid). Both Chesbrough and Etzkowitz are thus interested in the sources of innovation on the macro level of institutions and organizational structures.

Chesbrough places more emphasis on start-up companies and venture capitalists, making a further differentiation of industrial actors, while Etzkowitz elevates the status of the university. Often innovation models and paradigms will differ in the emphasis placed on innovation actors. Models such as 'National Systems of Innovation' emphasize the firm as a key component of innovation, while Sábato's 'Triangle Model' emphasizes government (Etzkowitz and Leydesdorff, 2010). This paper is interested in innovation actors: their roles, relationships and responsibilities. The Triple Helix offers a starting point through a relatively equal treatment of actors, however the Open Innovation concept poses alternative arrangements, explored through the case study about neglected tropical diseases (NTDs). Here the adoption of Open Innovation approaches are being used outside of the original remit, for social and public objectives rather than following the interests of the firm. This shows how innovation actors can behave in a ways that does not adhere to Triple Helix relations.

The paper is structured as follows: Section 1 outlines the state-of-the-art; how Open Innovation relates to the Triple Helix. Section 2 introduces the case study of NTDs as an example of adoption of Open Innovation approaches, setting out the methodology of how the research was conducted. Section 3 explores the key findings and provides an interpretation of the campaign and adoption of Open Innovation approaches to NTDs. Section 4 concludes through a discussion about meanings of innovation and considers policy implications. This paper aims to show that Open Innovation whilst a complementary idea to the Triple Helix, presents a more distributed view of innovation amongst individual actors in addition to the main institutions of innovation. This is the viewpoint with the central concern for efficiency and competitive benefits to the firm over other actors. Also highlighted what may be missing in these models through concern about agency of actors as well as innovation objectives and outcomes.

1. State-of-The-Art - The relation with the Triple Helix

Open innovation can bring a new understanding to the changing roles of the Triple Helix, exemplified through the practical adoption of the concept in its application to diverse fields. Presented here is the example of Open Innovation for non-commercial research. Chesbrough identifies basic research as a social concern in the adoption of Open Innovation and sees it threatened by the changing Triple Helix relationships. He states: "The new division of labor between industry, government and academia will witness less basic research inquiry being conducted inside corporate research laboratories. The strength of the diffusion mechanisms, and the resulting breakdown in the virtuous circle, mean that industry can no longer be expected to underwrite the bulk costs of early stage research" (2003, p. 191). This leads Chesbrough to call for greater public funding and increased availability of basic research through a number of channels to provide a 'seed corn' for future scientific discovery (ibid). A similar argument has been made by Slaughter and Leslie (1997, 2001) as they highlight firms using universities as a source of R&D in effect relocate the cost to government as the main funders of university research. However, this debate goes further than a call for investment.

Basic research does not neatly fit into the Triple Helix relations for allocation of responsibility, not least as it is a contestable term (Calvert, 2006). The debate that Etzkowitz (2003) provokes is whether universities should continue concentrating on basic research or developing closer links to industry, through more applied research activity and increasing industry involvement in the basic research realm of university research. Some like Chesborough may see basic research as ultimately the responsibility of government, putting it in the camp of 'knowledge for knowledge sake'. However, as first argued by Donald Stokes (1997) scientific research often has components of basic and applied research. Stokes first challenged the dichotomy between basic and applied research while drawing on the work of microbiologist Pasteur who was doing both in establishing the germ theory of disease. He provides differentiation by also identifying 'use-inspired basic research' where basic research on fundamental scientific problems is conducted with a use for society in mind (1997). If we cannot distinguish easily between what is basic and what is applied research it is not clear who the funder should be either. Furthermore, exploring earlier theoretical contributions to this topic highlights why nominating government as the funder of basic research may not be so clear-cut in any case. Economist Kenneth Arrow argued, it is not only a role for government to supply funding for basic research, as historically private individuals have also been responsible and it is important for these agents to have non monetary incentives (1958, p.20).

In considering non-commercial research, there are similarities with the attributes of basic research, which has received due attention in the literature (of Science Technology and Innovation studies) because of its status as the lifeblood of science, technology and innovation (Pavitt, 1991; Salter and Martin, 2001). It is specifically of interest for a number of reasons. Like basic research there is no private funder as a public good function is being performed and may include basic research. However, it differs in that it may also include applied research. Again this reflects the messy borders between basic and applied, and indeed non-commercial research may become commercial or contain elements of commerciality but the lack of direct commercial viability causes different treatment. Others have also noted this difference. Glenna et al describe the public funding of R&D after World War II: "(u)niversities received public funding to do basic and other research not easily converted into commercial products" (2007, p.142). What is significant about non-commercial research that it introduces a political and social dimension because the question arises to whom it is not a commercial proposition and why. This might be poorer, disadvantaged, disenfranchised and powerless groups; as we see with the communities affected by NTDs.

2. Methodology - Case of Neglected Tropical Diseases

Neglected tropical diseases or NTDs are a collection of 17 tropical infections afflicting the poorest people in Africa, Asia and Latin America[2]. Despite constituting a high proportion of the world disease burden they receive a disproportionally low amount of funding towards research and development (see Harris and Masum, 2011). These are ancient diseases of poverty that require new or improved products for treatment but there lacks a sufficient commercial market within private industry. For pharmaceutical companies it has not been a profitable revenue stream and for governments and NGOs attention has been directed at the 'big three' diseases (Malaria, Tuberculosis and HIV/AIDs). However, in recent years the issue has been raised in status, followed by marked policy response. Research for NTDs has also seen a rise in initiatives adopting open approaches (Hunter and Stephens, 2010; Maurer et al, 2004; Årdal and Røttingen 2012).

[2] The WHO lists these as: Buruli Ulcer (Mycobacterium ulcerans infection), Chagas disease, Dengue/Severe dengue, Dracunculiasis (guinea-worm disease), Echinococcosis, Foodborne trematodiases, Human African trypanosomiasis (Sleeping sickness), Leishmaniasis, Leprosy, Lymphatic filariasis, Onchocerciasis (River blindness), Rabies, Schistosomiasis, Soil transmitted helminthiases, Taeniasis/Cysticercosis, Trachoma, Yaws (Endemic treponematoses) – (WHO Website).

There are a number of routes to address NTDs, which include improving sanitation conditions and healthcare infrastructure. This is no doubt important but the purpose of this paper is to explore the adoption of Open Innovation approaches, which is why drug development or discovery (also including vaccine development) is the central focus[3]. It is also not within scope to concentrate on interrogating the conceptual foundation of Open Innovation, as others have done, (Huizingh, 2011; Mowery, 2009; Trott and Hartmann, 2009), although exploring the adoption of the concept informs the discussion on conceptual foundations. The questions that arise are: Is this anything new or has it been seen before? Why classify these observations as Open Innovation and not something else (e.g. technology transfer)?

Mowery has questioned Open Innovation on the basis of historical underpinnings. He argues that Open Innovation is not new when you look at the pre-1940s as in the 19th and 20th century closed innovation in industrial research was the exception. More broadly, Trott and Hartmann (2009) also appraise what they see as a constructed false dichotomy between old and new. Closed innovation principles[4] have existed in the past but few firms follow these today. Thus the old and new systems are not mutually exclusive in that firms follow one or the other. Other critiques concentrate on the reach and breadth, claiming that the Open Innovation only applies to high tech industries and goods rather than service firms and Chesbrough has sought to respond (see 2006; 2010). These challenges must be kept in mind when exploring the adoption of the Open Innovation concept. The concept may be accepted as 'new' and separation between 'closed' and 'open' through use by practitioners. Looking forward we can ask: Can the claims of Open Innovation be justified through the use of the concept? Will it be self-fulfilling? Does the evidence hold up? The combination of descriptive and normative aspects of the concept makes it more difficult to address these questions.

It is clear that there has been enthusiastic adoption of the idea despite the conceptual challenges and this research is concerned with how the Open Innovation concept has been adopted by practitioners. Comparative perspectives of adoption are shown through the case study, exploring the views within firms, NGOs and research institutes. Twenty-two semi-structured qualitative interviews were employed with scientists, managers and policy officers. This included seven interviews with scientists at the Institute for Parasitic Diseases in China, senior research managers at 'pharma' companies Novo Nordisk and Novartis, academics at the University of Sydney and the Norwegian Knowledge Center for Health, as well as scientists in policy roles within NGOs or international institutions such as the 'Drugs for Neglected Diseases Initiative' (DNDi), Cambia and the World Health Organisation (WHO).

Qualitative interviews allowed for a detailed understanding of views and anecdotal evidence to address the following questions: In what ways are Open Innovation approaches being adopted in the pursuit of non-commercial research? And what are the implications for the Triple Helix relationships? NTDs have long sat outside of the scope of concern for governments, universities and industry. The obvious place for responsibility might be thought to be with NGOs, but historically NTDs have not attracted concern from the NGO sector in comparison to the other big diseases. The next section discusses the evolving responsibilities through the campaign for NTDs, how Open Innovation has been introduced and with what effect.

[3] See McGoeya et al (2011) who present the emerging literature on this topic. Also Scudellari shows a discussion about how scientists are divided on the best route to take in an article in the 'The Scientist' magazine (2010).

3. Findings – Campaign and Adoption

To build a picture of the interest from various actors we can turn to the Global Funding of Innovation for Neglected Diseases Survey or 'G-FINDER survey', which has been tracking funding patterns for investment in R&D for NTDs (Moran et al, 2012, p.11). The survey puts public investment top followed by the private sector and philanthropic organisations. The public sector provides 64% of global funding ($1.9bn) for NTD R&D, mostly from high-income countries. The philanthropic sector and industry make up the rest at 19% and 17% respectively. However, the survey also found that "(b)oth public and philanthropic funding have dropped away since the global financial crisis, but industry funding has increased dramatically over the survey period, predominantly due to increased multinational pharmaceutical company (MNC) investments" (ibid). This reflects how over the past decade the pharmaceutical industry has made concerted efforts to engage with global public health issues.

Firms have been drawn to NTDs in recent years. On January 12 2012, some of the worlds' largest pharma companies signed the 'London Declaration' pledging to eliminate or control NTDs by the end of the decade (Uniting to Combat NTDs, 2012). From Lakoff's description of tackling diseases affecting poorer nations, as a problem of "alleviating the suffering of individuals, regardless of national boundaries or social groupings" (2010, p.60), we can begin to see why Open innovation is a complementary approach in supporting the breaking down of barriers. Furthermore seeking new solutions is embraced because, as Bailey notes: "(i)n many ways, NTDs call for greater innovation because of the challenges of treating chronic endemic diseases often concentrated in rural areas of very poor countries" (2012). Thus the adoption of Open Innovation concept is not unexpected.

In Chesborough's book it is apparent that Open Innovation can manifest in a number of forms for firms undertaking R&D outside of their organisational boundaries. For the case of NTDs my interpretation is that this is principally through:

a. Research collaboration and funding
b. Intellectual Property (IP) sharing

The established actors who may be seen as the 'recipient' of Open Innovation action on the part of firms in this context include:

c. Research institutes
d. NGOs

Also in addition to these innovation structures, the role of individual actors is seen to be prominent through:

e. Activist scientists

The Triple Helix actors of industry, universities and government are represented here to some extent. Research collaboration and funding and IP are Open Innovation approaches for industry. The research institutes fall under the government or university spheres but see themselves as independent bodies. NGOs lie outside of the Triple Helix and the activist scientists can be aligned with institutions such as universities but their action is distinct from the normal activities of those institutions. By looking at the adoption of Open Innovation by these various actors we can begin to see the dispersed and agency-orientated nature of innovation.

a. Research collaboration and funding

Pharma companies see the appeal of Open Innovation approaches for research collaboration in area such as NTDs because they lack the dedicated research teams and are limited in the resources they are able to commit. Open Innovation approaches have be adopted to overcome such difficulties. Dr Paul Herrling describes this evolving situation. As the head of corporate research at the Swiss-based pharmaceutical company Novartis and the chairman of the Novartis Institute for Tropical Diseases, he has seen changing attitudes within the industry. Novartis set up the $122 million for Tropical Diseases Institute in 2002 Singapore, as a public-private partnership with the Singapore Economic Development Board. At the time there were few people working in the field and Novartis did not have a lot of experience in

tropical medicine. The institute was established for small-molecule drug discovery research, as well as the training scientists and technical staff from developing countries in diagnostic lab procedures (WHO website). When Novartis decided to establish the institute they needed to work closely with NGOs with established expertise - DNDi and the TB Alliance. Today there are many pharma companies involved so it is more efficient to work together. As Herrling sees it, these activities are "not to carve out a market so there is no reason not to share" and he believes the collaborative approach is working well with "a solid purpose to neglected disease" (Interview, February 2013).

This is not to say that big pharma had no historical involvement in NTDs. The American pharmaceutical company Merck developed ivermectin in 1987 (marketed as Mectizan) to prevent the NTD onchocerciasis or 'river blindness' and the drug was donated for public treatment (Gill, 2012). Ivermectin had been developed internally for veterinary use until it was found to have potential for humans and the company embarked on a joint research programme with the WHO (Collins, 2004), Merck went on to engage in a number of partnerships for distribution, including enlisting the help of former president Jimmy Carter to act as marketer with high level officials in endemic countries (Saporta, 2012). Still, such activities targeting NTDs had been isolated until then. When Merck decided the drug would be produced for free and made available for patients as long as it was required, this was an almost unprecedented undertaking. Merck had first pursued pricing the drug commercially before seeing this would not work for poor patients and had "turned to national and international organizations—such as the WHO, the U.S. Agency for International Development, the U.S. Department of State, European and African governments, and private foundations—but to no avail" (Collins, 2004). The senior management at Merck, particularly CEO Dr. Roy Vagelos, had been supportive throughout and the scientists involved suggested the possibility of drug donation. From the view of those in the company:

"Abandoning the drug was unattractive both in terms of health benefits denied to suffering people in Africa, and in terms of characteristics of Merck and its situation: its corporate culture, its already-existing donation programs, and also its image now that many knew of the existence of this breakthrough… Reportedly Merck paid little attention to the financial implications of this donation program at the time of taking its basic decision… Its view at the time apparently was that the company's financial performance had been and was good, and it could afford the donation program." (Coyne and Berk, 2001, p. 10-11).

Other factors that may have influenced the decision were the fact that ivermectin had been extremely successful as a veterinary medicine representing the company's second most profitable drug and the tax benefits of donation, although there is no substantial evidence that this was considered (Collins, 2004). Today the campaign represents the "largest on-going medical donation program in history" (Merck Website, Mectizan Factsheet). The impact has been huge and more than 60 million people with the parasitic disease still being treated annually[5].

The donation of ivermectin did not begin as a dedicated research project but since then other pharma companies followed suit with their own drug donation programs, although many also began as an offshoot of a commercial drug for another disease or when no commercially viable market had been found (Coyne and Berk, 2001). Establishing research partnerships specifically for NTD drugs is a more recent development involving a wide network of innovation actors as shown through the Novartis Institute for Tropical Diseases. There are also drawbacks in the establishment of institutions, as activity is subsumed in a selected package with commercial activities will be undertaken within this banner, but in general it represents a broader and longer-term commitment to R&D for NTDs. Still, while there has been a proliferation of dedicated pharma company involvement, Mary Moran explains this actually means: "(i)nstead of conducting a limited number of more expensive late-stage drug development projects (the pre-2000 model), companies have moved upstream to the less

[5] Now there is also inclusion of ivermectin for the treatment of lymphatic filariasis another NTD (Merck Website).

expensive and more innovative drug discovery stages" (2005, p. 0829). This is explored in the next section through the example of compound library donation.

b. IP sharing

Other companies rather than engaging in collaborative research concentrate on sharing IP. Many of the large pharma companies have engaged in this sort of activity in support of NTD research[6]. One specific example is Danish global healthcare firm Novo Nordisk, which donated its small compound library in 2008 to the National Center for Drug Screening (NCDS), China. Novo Nordisk, whose drug development activities centre on diabetes haemophilia and autoimmune diseases, had developed the library in relation to diabetes small molecule research. In 2007 the company changed their strategy to bio-pharma and no longer needed to use the library. As Palle Høy Jakobsen, who ran the project for Novo Nordisk explained, "the project was very much about Open Innovation" (Interview, December 2012). For Novo Nordisk the library still held commercial value and they could have sold to another company. Instead donation is a way of not giving away information to competitors while also engaging in philanthropic activities. As a result Novo Nordisk found a way to contribute towards treatment of NTDs after realising they were not doing work in that area.

The collaboration was intended to both benefit Chinese pharmaceutical developments and the WHO in their efforts to combat NTDs, as described by Jakobsen: "so the announcement at the time of a scientific collaboration… was a strategic decision to foster strong R&D ties with China's Academy of Sciences and commercial market. The Novo Nordisk small molecules compound library donation was made to ensure the library will primarily benefit society" (Interview, December 2012). This also aided related capacity building through the WHO[7], which acted as the independent party evaluating applications for using the library and the day-to-day running. The administration of the compound library through the WHO allowed global access to researchers interested in the library's contents for research in NTDs and the WHO viewed the donation as a welcome action: "Big pharma donated a small molecule library for the first time and had a partnership in the South for screening and capacity building" (Bernadette Ramirez, Interview, February 2013).

Novo Nordisk was keen to support research in China. As stated by Jakobsen: "Novo Nordisk had and continue to have a long-standing scientific collaboration with the Chinese research community and this donation was one way to deepen that collaboration even further while also contributing to research in neglected diseases of developing countries…hence fulfilling key strategic business and a philanthropic goals of our company" (Interview, December 2012). This offers explanation as to what companies might gain in return for sharing IP, beyond the more straightforward corporate social responsibility and public image.

The benefits from the library donation are now beginning to be seen. In 2012 an international team of researchers announced that they discovered a new compound that inhibits and kills Mycobacterium tuberculosis. They had used the compound library for the basis of high throughput screening initiative (Kumar et al). Still, recipient countries are often keen to

[6] The 'Pool for Open Innovation', established in 2009 and originally populated with 800 patents from GlaxoSmithKline (GSK) and Alnylam Pharmaceuticals (GSK website). In 2010 South Africa's Technology Innovation Agency (TIA) became the first government agency to join the pool and make use of the patent filings. Andrew Witty, the CEO of GSK describes, "The key objective of the pool is to make it easier for researchers across the world to access intellectual property that may be useful in the search for new medicines to treat neglected tropical diseases" (GSK website). This has now evolved into the WIPO Re:Search run by WIPO - the World Intellectual Property Organization.

[7] By training young scientists through 'The Special Programme for Research and Development in Tropical Diseases' known as the WHO-TDR, established in 1975 (WHO Website).

establish long term and sustained involvement. Government research institutes devoted to working on NTDs welcome contributions such as donations but have a range of requirements and expectations of what the private sector can offer. With donors such as the WHO no longer pursuing drug discovery as a major activity and others cutting their funding (e.g. The Bill and Melinda Gates Foundation), there may be more emphasis on private companies for involvement in developing drugs for NTDs. The views of established innovation actors, which include the government research institutes and NGOs who have been driving research, put firm involvement in perspective.

c. Research institutes

Research institutes based in disease endemic countries are dedicated day-to-day to develop drugs for diseases seen as a priority by their governments. In innovative developing countries (Brazil, India and China), there is an advancing R&D base that can allow these countries to take action on NTDs (Hotez, 2010). As Prof. Xiao-Nong Zhou, National Institute of Parasitic Diseases notes, in China "NTDs are one of the most prevalent infectious diseases, with more than 100 pathogens recorded to infect humans" but this situation is changing: "(d)ue to great efforts by government leadership, professional guidance and community involvement, NTDs have declined significantly with the increase in economic development in China" (2013, China Health Policy Report). For example, in 2007 lymphatic filariasis was eliminated in China.

The institute where Prof. Zhou works was established in 1951. A team of seven scientists is currently working on pharmacology drug screening and they are focusing on drug development for the NTD schistosomiasis (a parasitic infection caused by worms) and malaria. They have developed new drugs for both diseases as well as the identifying new indicators, including for the anti-malarial medicine Methoquin. However, underfunding is a major inhibitor to their work, as one of the scientists describes when I visited the institute: "we have good drugs but not money to introduce into the market… we should be supported by government or international governance" (Research Director). At the institute despite having invested in more than 20 drug products in last 20 years, few are used in field and the scientists are frustrated they are "just sitting there" (Senior Researcher).

Declan Butler has written about this 'translational gap', making the point that academic scientists doing disease research have their role restricted to the early stage - and it is for pharma companies pick up subsequent drug development - but this does not happen and promising research is left on the shelf (2007, p.158). Two drugs were developed and deployed 30 years ago with support from the government but now government intervention is less. The limited funding also has an impact upon the ability evaluate the drugs produced, causing delays to the patent life span, as a drug will be patented but then it takes time to pass through testing and be approved. The scientists explained, this means: "when a company buys a patent it only has five to six years left – so it is too short to get interest" (Senior Researcher). In addition the adoption of new drugs requires more capacity to produce the papers and research to show that they are safe and effective. Doctors are afraid to try new drugs and tend to use the older, already proven drugs even if they are less effective.

In dealing with these problems there is a feeling that the private sector could do more, as companies are looking for cooperation but often not on equal terms. Small companies can be useful in getting new drugs to the market and occasionally if they are doing a pharmacology study they will come to the institute for research assistance. Multinationals have less of an interest, as the scientists describe, "they concentrate on heart disease and diabetes" (Senior Researcher) but do hold expertise to develop anti-parasitics. Their usage of drugs is also seen as too narrow, with patents only for a small number when the actual application for different diseases could be greater. Overall, the scientists at the institute note that companies do investigate collaboration and acquire information but once a company has invested they tend to lose interest. Research institutes want long-term support and assistance, from the private sector, government or international institutions. For them, the meaning of Open Innovation is the willingness to cooperate with international community and international networks. It is not efficient if they are only connected with developed countries and not developing countries or the other BRICS. This shows how the scientists at the institute are

putting their own meanings onto Open Innovation in the context of their specific objectives and priorities.

d. NGOs

Playing a central part in organizing international networks has been The Bill and Melinda Gates Foundation. According to the G-FINDER Survey (Moran et al, 2012) they are the largest philanthropic funder and have been behind much of the rallying of pharma companies. The London Declaration, which they led on, has been the largest coordinated effort aimed at tackling NTDs. Bill Gates believes this to be a new way of organisation: "This innovative approach must serve as a model for solving other global development challenges and will help millions of people build self-sufficiency and overcome the need for aid" (Bill and Melinda Gates Foundation, 2012). It has represented a series of target-setting commitments similar to what was seen for malaria, HIV/AIDs and TB through the United Nations Millennium Development Goals. The Declaration built upon the WHOs' 2020 Roadmap on NTDs, a new strategy launched in 2012.

Many NGOs are willing to embrace Open Innovation approaches but can hold some skepticism for what can be achieved. While NGOs come in different shapes and sizes[8], a commonality is their positioning at the intercept between pharma companies and governments, so that they can see the potential of Open Innovation approaches but challenge their practical benefits. One of the well-established NGOs that signed the declaration was the 'Drugs for Neglected Disease Initiative' (DNDi). DNDi has a history of working NTDs, often collaboratively with pharma companies. Dr Robert Don is Director for Discovery & Preclinical Program Drugs at DNDi. He believes "Open innovation can be effective for drug discovery but it can also be open chaos" (Interview, February 2013). For example public databases can be overplayed and turn out to be a data dump. To get best value, tools are needed to utilize data effectively. He points out: "open access can be misguided as in its simplest form it is difficult to accept – more exciting are approaches to use information more effectively" (Interview, February 2013). There are levels to Open Innovation because it comes under different guises and names, which can mean it is confusing to companies. Even if they have been working collaboratively for a long time they still might respond better if Don uses the term 'pre-competitive research' as they are "familiar and comfortable with the concept" (Interview, February 2013).

Don is also currently pursuing Open Innovation projects such as forming a drug accelerator for NTDs, which goes a bit further than compound library donation in terms of sharing IP. Here more information and more diversity around particular compounds with drug potential are provided before a decision is needed on the annotation around a chemical structure, saving time and money. He has been surprised by the take-up of the idea, as for pharma companies it is a non-competitive way of putting investing money with an in-kind research contribution, also from a technical perspective the scientists are very interested. This shows how scientists who are working in industry can be drawn to projects that are not-for-profit because of intellectual challenge presented. Such enthusiasm of scientists, including those working in industry where NTDs is not their priority, can be very influential.

e. Activist scientists

Many scientists have had a prominent role to play in raising the profile of NTDs. They have framed the approach to tackle NTDs, including in terms of openness, which is why they can be seen as activist scientists. When scientists enter the political arena there may be resistance to the adoption of a role that is viewed to be outside of their remit, going against a more one-dimensional image of scientists as being neutral and objective (e.g. this idea can be seen debates about climate change or geo-engineering). In other cases the viewpoints of scientists may champion an issue that was previously under-acknowledged or not well understood. This could be said for NTDs. The precursor is seen in the scientists who pushed for ivermectin to be developed for use in humans and then to be donated for free and

[8] NGOs are defined broadly as not having government affiliation and acts independently.

indefinitely. Collins stresses the part that they played: "pharmaceutical company employees were often vilified as the industry came under fire for its astronomical profit margins and the rising costs of pharmaceuticals, these employees, like many of us, saw themselves as moral agents working within an ethical framework" (2004, p.104-5).

Open Innovation approaches have been often supported by scientists working in pharma companies, as shown by an article published in Nature. Andrew Hopkins and Michael Witty who work for Pfizer, alongside Solomon Nwaka at the WHO wrote: "Our capacity to combat neglected tropical diseases must now be mobilized to include a pan-industry effort using an open innovation approach to drug discovery. All of the tools needed to create a sustainable and scalable model of drug innovation for many of these devastating scourges are within our reach. The challenge now is for industry, governments and philanthropists to unite in undertaking this mission" (2007). On the other side of the coin scientists working in the public sphere can also be forthcoming in their involvement with pharma companies. Alice Lam shows that scientists working in academic are "active agents seeking to shape the boundary between science and business" (2010, p.309). In her study of 770 academic scientists in UK universities, Lam draws focus on the agency of scientists in the context of "the growing power of the marketplace and the ethos of commercial science" (2010, p.335).

Scientists were later to have a central role in the campaign for NTDs. It had been highlighted by the Wellcome Trust, that scientists originally 'coined' the phrase 'Neglected Tropical Diseases' with the first use of the term in a paper in 2005 (Regnier, 2012). They became aware that the policy focus on Millennium Development Goals in 2000 drew attention to malaria, TB and HIV/AIDs but other endemic diseases were left out of the spotlight. This led to the construction of NTDs as a worthy cause, as Dr Peter Hotez one of the early activist scientists based in the US explains: "The phrase was part of a drive to think about these diseases in a fresh light… I think as scientists we are taught not to be advocates… That's something I'm trying to correct" (ibid). Scientists have also played a part in developing possible solutions, their position 'on the ground' making them well placed to consider whether Open Innovation is the right direction forward or not. Two prominent examples of this are found in Australia, with Dr Richard Jefferson who set up the NGO Cambia and Dr Matt Todd at the University of Sydney.

Todd is a scientist working in the Chemistry department at the University of Sydney and is concerned with how Open Source innovation can assist in drug development. Scientists have not only embraced Open Innovation approaches - Open Source has similarly generated excitement about its potential for NTD drug discovery. As Christine Årdal and John-Arne Røttingen document, there has been a great deal of theoretical discussion and a number of initial projects based on this idea. Open Source for drug discovery is a concept that "borrows two principle aspects from open source computing (i.e., collaboration and open access) and applies them to pharmaceutical innovation" (Årdal and Røttingen 2012). Of those interviewed for the case study, many were keen to embrace both Open Innovation and Open Source approaches. For example DNDi expressed an interest in becoming involved with Open Source projects[9] and said they would also like to have a public Open Source portal. Similarly Cambia has established a Biological Open Source (BiOS) Initiative, launched in 2005, which offers licensing and agreement tools to enable sharing of biological technologies (Cambia Website). However there are others, like Dr Matthew Todd have reason to prefer Open Source approaches above Open Innovation.

Todd originally became interested in the NTD schistosomiasis as a post-doctoral researcher, drawn to making molecules that are difficult to make and hold practical applications. The appeal of Open Source innovation came later: "it mimics the software development term… the aim is clear that the way to gain benefit is to share everything" (Interview, April 2013). For Todd Open Source is a way to share research in a complete state so that others can then take it and make changes that they see fit. While Open Source is sometimes confused with

[9] Such as Open Source Drug Discovery (OSDD) and Synaptic Leap

citizen science or crowd sourcing[10] the advantage of Open Source is that there is no exclusive ownership or control. Based on this rationale, Todd began a project on a website known as the Synaptic Leap in 2006.

The Synaptic Leap originally consists of a group of online research communities for malaria, schistosomiasis, toxoplasma and TB. A lab notebook was made visible along with the aims of the project, all to be available in the public domain mimicking Open Source in software development. Many other online platforms run in parallel to the Synaptic Leap for the most active current project in malaria, including a wiki, Github and Twitter pages. The project on schistosomiasis was completed in 2011, resulting in significant improvements to the production of the most common drug used to treat the disease called Praziquantel, and this work was published in peer-reviewed journals. Open Source appears to have been a successful approach in this project but Todd sees problems in the usage of the 'open' term in other projects claiming to be Open Source when they are not: "People can have laudable aims, but Open Source is something specific that requires everything to be shared, not just the intention to be more collaborative than normal" (Interview, April 2013). A distinct use of 'open' in his view is Open Innovation by companies who put out a request for a solution to a problem, pool ideas and then give a prize for the best idea to be developed. To him this does not change the way people are researching as they still work in teams in secret. The secrecy also applies to companies opening up data to provide a seed for new projects. The problem being data may be filtered or not up-to-date - for example they will provide 3,000 active compounds from a two million compound library. Likewise in academia there are also struggles to adopt more of an Open Source approach. As Todd observes, academics and scientists are expected to publish papers so that they are known for something, but they keep ideas secret in the meantime.

A greater dialogue would be beneficial. Although Todd also thinks there might be more activist scientists working on NTDs today because "They are on the ground so see the weaknesses. Scientists are afraid of doing work that is unnecessary… and can be frustrated getting hold of data or when data is incomplete" (Interview, April 2013). When work is published only a fraction of all the data is visible, the rest is not released. This is a lost opportunity, although changing to an Open Source mentality could be a struggle: "Some colleagues are interested, and some are not. Some simply find the terms confusing, and do not distinguish between concepts such as Open Access and Open Source" (Interview, April 2013). In considering why there might be adoption of Open Innovation or Open Source approaches, Todd noted that wide interest in open approaches in Europe and US may be economics-driven: 'research communities that are financially squeezed so want research to be quicker and more efficient" (Interview, April 2013). Although this also fits with the idea of scientists being urged within their universities to be more entrepreneurial (the academic 'third mission' for socio-economic development according to Etzkowitz, 2003), so the connection with trends such as Open Source may be part of a pressure to seek new ways of working.

Other scientists have also taken on a larger entrepreneurial role to establish their own NGOs. Jefferson founded Cambia in 1992 and it is ranked as one of the world's top NGOs (The Global Journal, 2013). It aims to challenge the status quo and has been receptive to adopting open approaches to innovation. Cambia was very much the brainchild of Jefferson. A molecular biologist by training, he was critical of multinationals such as Monsanto for controlling critical technologies through patents and access to capital, while also envisioning the public sector as more orientated to producing social value. For him the blockbuster mentality and rent-seeking model in biotech is not working and inhibits innovation: "In that model, you invent a new process, find a drug target, or discover a new gene, then wrap it up in intellectual property protection and try to sell it to the highest bidder. That bidder then has to try to assemble the puzzle into something actually useful. It's a slow, expensive, and

[10] According to the Webster Dictionary of English, Citizen Science is scientific research conducted by amateurs or non-professionals often by crowd sourcing. Crowd sourcing is obtaining services, ideas or content from a large group of people, including online. Todd gives the example of the FoldIt project, which is "built on great science but not open source".

cumbersome process" (Jefferson, 2006). As an alternative to this model he has sought to create accessible tools and technologies that enable equitable innovation.

Jefferson in describing Open Innovation sees many people using the term and meaning something different: "No one who's actually doing it appreciates the enormous complexities of making products and services happen" (Interview, May 2013). This again reflects the issue of conceptual ambiguity that others have grappled with. To Jefferson this is reason not to use the term and Open Innovation as a descriptor for projects is not helpful. As an early pioneer he spent a lot of years involved in the dialogue of openness. He sees concepts like Open Innovation as only useful in what can be achieved as a result and if that approach is not working it is time to try something else: "you have to push it to failure and push it beyond. All these systems fail… few of the practitioners take it on the chin and say well I learnt from that and better do other things" (Interview, May 2013).

Jefferson identifies some of the problems facing the community who have adopted open approaches being that it can become a comfort zone and failure is not accepted in policy intervention (unlike in entrepreneurship rhetoric where failure is often celebrated). He does not see openness as particularly the bottleneck either; openness in research is focused on but it is only a modest part. Therefore for him openness is to create the open infrastructure to make innovation equitable and transparent by allowing people to see their self-interests and align self-interests between disparate groups. In tackling NTDs Cambia provides the Patent Lens as a tool. There is not a direct initiative for NTDs because the focus is on "making it possible for people to be active in problems and their own solution-set" including different groups in problem-solving and poor people especially (Interview, May 2013). Jefferson's definition of innovation follows this thinking, with innovation being for economic or social impact and here "the social market is a perfectly viable form of a market" (Interview, May 2013).

4. Conclusion

The case study has shown that scientists have become more pertinent as innovation actors and more questioning of Open Innovation approaches than others. Responsibility has been taken on for raising the profile and finding ways of addressing non-commercial research with NTDs, especially seen through the role of activist scientists. Therefore societal actors outside of the Triple Helix are able to move into action but Etzkowitz has discounted public as a fourth helix (a number of authors have taken this idea further, see Cooper 2009; Carayannis and Campbell, 2011). For Etzkowitz public actors such as international donors can play an innovation organizer role when there is something lacking in the three spheres but, "to view the public as a fourth helix is to narrow the public to a private sphere, rather than seeing it as the underpinning of the entire enterprise of innovation" (2003, p.312).

Indeed Etzkowitz makes the valid point that the Triple helix is not a 'rigid framework', however Open Innovation does appear to challenge the way that it is understood to operate. What becomes difficult to ignore is the collective agency of actors outside of the Triple Helix in a social or public capacity, when they can be joined up with other actors under the Open Innovation banner. The micro level of innovation becomes more apparent as these types of actors step in when innovation is for social and public objectives. On the other hand it is the pharma companies and international institutions (e.g. the WHO) that are working on a larger scale so will espouse ideas of Open Innovation for multiple organisations to collaborate. This compares with the scientists working in the public sector may be more concerned with practical ways of working, more connected with ideas such as Open Source or whichever approaches work pragmatically. Thus this paper has shown that Open Innovation adoption is a way of mobilizing activity[11] and is able to serve a different purpose to the original rationale, in promoting the pooling of resources, sharing of information and knowledge and working across organisational and geographical boundaries. Through this understanding, Open Innovation is useful vehicle in order to describe emerging roles and interests of innovation

[11] See Mortara and Minshall (2011) who document Open Innovation practices in firms before and after the release of Chesbrough's seminal book in 2003 and record the resulting impact.

actors who come together under a common banner but are still able to maintain individual interests.

What then comes under consideration is a more fundamental question: Should concerns about public and social involvement matter (especially for models of innovation)? And are we only concerned with innovation that is seeking purely economic outcomes? This paper argues that it should matter as we begin to care more about what innovation is for. Schumpeter (1938) defined five types of innovation in products, processes, markets, source and organisational change. This can be termed as 'Innovation in'. A next level could be innovation in terms of impact bringing in a political and sociological dimension. Here the emphasis is less on the commercialisation of ideas but the actualization. Our definition of innovation does not need to involve entrance into the market or profitability criteria, which is how innovation is introduced at the beginning of Chesbrough's book: "invention implemented and taken to market" (2003, pg ix).

Alternatively, drawing on a definition by Kanter, innovation can be referred to "bringing any new, problemsolving idea into use" (1983, p. 20). 'Innovation for' is concerned with the wider environment – the economy, society, public and development, to consider which groups benefit and who is sidelined. While governance of innovation has been well covered (Irwin, 1995; Owen et al, 2003; Collins and Evans 2002)[12], public and social concerns do not commonly enter at the stage of innovation models and paradigms. This urges a reconsideration of the remit and scope of these conceptual frameworks, including the Triple Helix and Open Innovation. For example Carlota Perez (2012) addresses the question of innovation for whom in her paper 'Innovation systems and policy: not only for the rich?' and this is innovation for development or equity. Likewise, innovation for sustainability is a topic that gained some popularity in the 1990s drawing on the Science and Technology Studies (STS) literature and is "beginning to have a significant impact" (Martin, 2012). There has also been a growing, although smaller, focus on innovation for global public health as shown by the creation of international institutional structures such as the WHO Commission on Intellectual Property, Innovation and Public Health and dedicated university research teams such as the Institute of Global Health Innovation at Imperial College London and Center for Innovation in Global Health at Stanford.

These developments show a movement toward innovation being considered in light of desirable social and public outcomes, instead of a more straightforward economic growth case. The policy implications of such thinking applies to the framework and incentives set by government, in setting direction on what are our desired innovation outcomes looking beyond economic arguments. Further case study examples would help build a more detailed picture of how the Open Innovation model can be harnessed for social benefit. In particular, the role of scientists influencing the NGO sector and in development work appears to be under-researched, which is surprising as science and technology underlies many issues relevant to the development world, as demonstrated by NTDs.

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[12] "Responsible Innovation" is more recent concept that considers the implications of innovation and what policy makers should be considering in how to manage risks. It brings the consideration of ethics by asking the question of who is responsible for the multitude of possible effects when innovations are released into society. This relates to how innovation is governed, particularly for emerging technologies whose effects are unknown.

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