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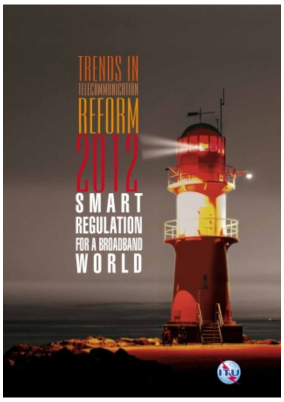
Discussion Paper

Broadband Enabled Innovation



Work in progress, for discussion purposes

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Authors: Michael L. Best, Associate Professor, Sam Nunn School of International Affairs and the School of Interactive Computing at Georgia Institute of Technology
M. Zak Taylor

1.1 Introduction

This paper examines the relationship between broadband networks and innovation. Innovations are inventions that have some sort of (economic) impact, e.g., raising productivity and competitiveness. This chapter considers a particular category of innovations, namely *broadband enabled innovation.* An innovation is broadband enabled if it, at some core level, requires, uses, and perhaps enhances broadband internet. So, for example, cloud computing is a class of broadband enabled innovation – first off, many aspects of cloud computing are inventions that are having a market impact, and clearly without high-capacity internet connectivity most cloud computing services will falter. Similarly, social media and online video streaming are a class of broadband enabled innovations for the same reasons. And so forth. A special class of these innovations is those that are inventions of the broadband network technologies itself – for instance impactful engineering enhancements in high-speed data networking. New high-speed wireless network technologies, for instance, would fall into this category. These are direct *broadband innovations* on top of being broadband enabled innovations.

This paper will first give a more complete picture as to exactly why innovation matters to a nation and how broadband can be an important enabler of innovation. Then a few cases of broadband enabled innovation are studied. Finally a set of critical innovation enabling policy positions is enumerated where policy makers and telecom regulators may have an important role to play in creating an enabling environment.

1.2 Innovation = Invention + Impact

In order to understand the relationship between innovation and broadband networks – and policies that support both – we need to gain an understanding of some basic terminology and to develop some foundational arguments around innovation and information and communication technologies (ICT's) more broadly.

Innovations are inventions with impact. Sharpening this definition, innovations are generally specific forms of invention (technological or organizational) with a specific type of impact (namely economic)[1]. Often these concepts are traced back to Joseph Schumpeter's early insights into "creative destruction", where new ideas and companies result in the demise of old ones.[2] Eminent Professor Chris Freeman, advanced this definition in his seminal work establishing the systematic study of systems of innovation asserting that "innovation is used to describe the introduction and spread of new and improved products and processes in the economy."[3] Today with the rise of popularized "innovation gurus" [4] broader and certainly more colorful definitions have emerged, for example that innovations are "the ability of individuals, companies, and entire nations to continuously create their desired future."[5]

If innovations are organizational or technical inventions that create economic impact, then without question the computer and communications sectors over the last decades have been stunningly innovative. According to an Organization of Economic Cooperation and Development (OECD) analysis in the late 1990's ICT's accounted for 30% of all patents granted worldwide while from 2002-2004 this jumped to fully 35% of all patents. Figure 1, below, shows the percentage of ICT patents granted in these time periods for the most active countries globally. If patents granted are used as a surrogate measure of a nation's innovation intensity, then fully one-third of all innovation, based on this measure, are from the ICT sector.

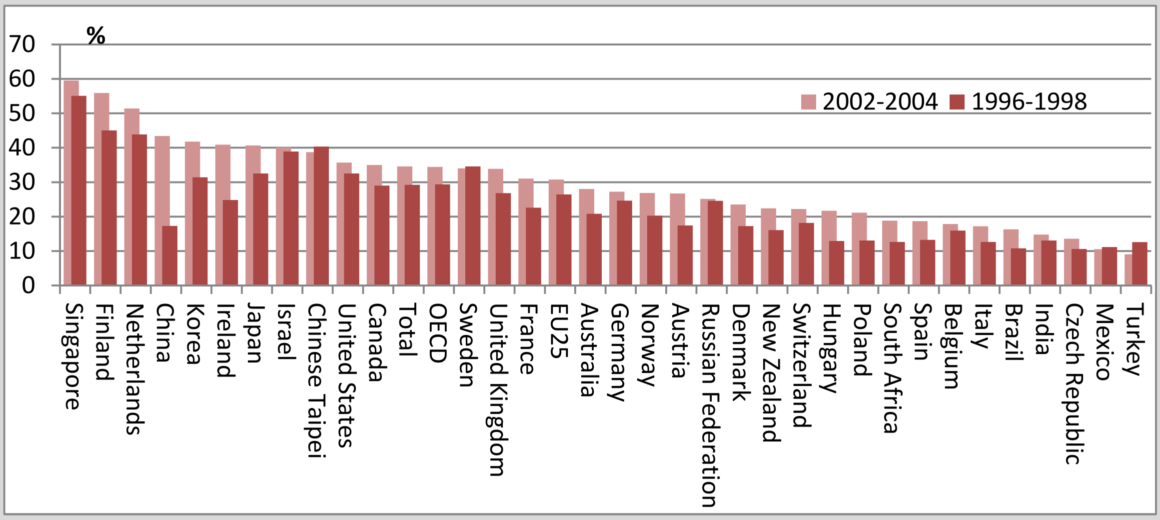
Before going further down this line of argument, let's probe more intensively the putative link between patents and innovation. If a patent system is doing its job then patents are granted only for truly novel inventions. And a company or individual would, in most cases, only bother to patent an invention that they believed had some sort of economic value. After all, it is expensive to get a patent. Therefore one would only bother with that expense if it seemed probable that exploitation of the invention would bring economic returns and, furthermore, that competitors would be similarly inclined towards exploiting this invention and thus monopoly access to it would confer a competitive advantage.

Based on this argument, patents are given to novel inventions that have a fair chance of an economic impact and would seem to be a good proxy for technological innovation. But in point of fact this is not always true. First, some patents are filed for "defensive" purposes. In these cases, a company files a patent without having an interest in exploiting the invention directly but to *prohibit* a competitor from making use of the invention (or more nefariously to threaten competitors with a civil suit regardless of their actual intentions). In a very real sense, a defensive patent is a means of diminishing the ability of a competitor to innovate through exploitation of an invention. These defensive and innovation-stifling uses of the patent system are, regrettably, common enough especially in high-income countries.[6] The intellectual property policy section below treats the particular concerns as associated with software patents.

A second concern with using patent data as a surrogate measure of a state's level of innovation stems from the *type* of invention privileged by the major patent systems. Important innovations, especially in countries outside of the OECD, are often based on attempts to master and adapt imported technologies, to diffuse and re-use these foreign technologies, and to do so in a way that leverages and modifies indigenous knowledge systems. These cases of innovative appropriation are broadly ignored by the major patent systems and therefore are not present in national patent data. Furthermore, innovation is not just technological but can be organizational and increasingly can "thrive in second-generation, production and process innovation".[7] Major patent systems tend to ignore all of these forms of innovation.

Notwithstanding these two concerns with using patents as a measure of innovation – the innovation-killing defensive use of patents and the types of invention ignored by patent systems – we will nevertheless spend some time studying patent data because, regrettably, it is the best cross-national, quantitative data on invention currently available.

Figure 1: ICT-related patents filed under Patent Co-operation Treaty (PCT) as a percentage of national totals for those countries with 250 or more PCTs in 2002-2004.



Source: OECD Patent Database, 2007.

Figure 1 above shows the degree to which ICTs dominate patents globally; from as much as 60% of all patents in Singapore to a still significant 10% in Turkey. Figure 2, below, presents data on the economic impact of ICTs. Again using OECD data, Figure 2 shows the percentage of business value-addition that can be attributed to ICTs for various major economies. If value-addition is the difference between some product's or service's selling price and its production price, then Figure 2 shows what share of that percentage can be attributed to ICT inputs. For most of the economies examined, that share is a formidable 5-10% and has been on the rise between 1995 and 2008.

In summary, this data shows that ICTs account for roughly a third of all patents (inventions) and a tenth of all value-addition (impact) by businesses in today's major economies. Based on this argument, ICTs constitute the very cornerstone of our equation:

innovation = invention + impact.

Departing from the hard numbers above, surveys of people's impressions have also provides evidence for how innovative ICTs are. In one such study, the ICT sector was viewed as the world's single most innovative industry by respondents, followed in second by the pharmaceutical industry. Furthermore, the internet itself was viewed by respondents as the most innovative technology over the last century.[8]

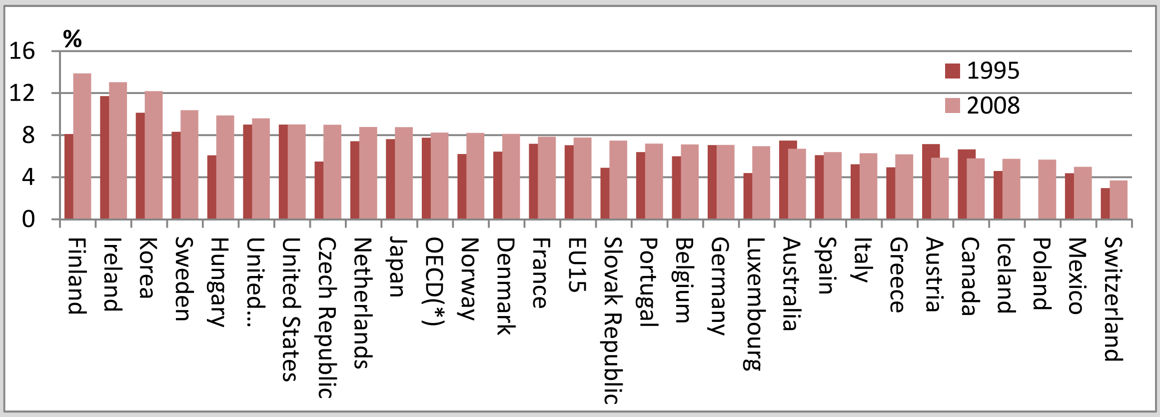
Therefore, from patent and industrial data, to self-reported impressions, the ICT sector has proven to be remarkably innovative.

Broadband Enabled Innovation

Broadband enabled innovations (BEI) are those specific cases where broadband plays a central role in some innovation. For example Youtube is an innovative company having invented new processes of user-contributed video sharing resulting in an impactful web presence. But without broadband there would be no Youtube. This makes Youtube a classic BEI. Similarly, many social media platforms require – or are greatly enhanced – by broadband networks. For instance the always-on component of broadband internet supports the constant update communication styles of some people on the Twitter social media system.

The previous section established the cornerstone role that ICTs play in a nation's level of innovation. But can this be narrowed down to a particular role for *broadband internet*, specific among all the varied information and communication technologies available? If so then the particular importance of broadband enabled innovation, as opposed to just ICT enabled innovation broadly, will be supported. The number of patents granted a nation in a given year will again serve as a surrogate measure for innovation.

Figure 2: Share of business value-addition that can be attributed to ICTs in 1995 and 2008 (Iceland and Switzerland are 1997 instead of 1995;Canada and Portugal 2006 instead of 2008). *OECD aggregate based on estimates for 28 countries; New Zealand and Turkey data are not available.



Source: Information Technology Outlook 2010.

If broadband is innovation enhancing then there should be a link between levels of broadband penetration and this patent variable.

The simplest regression[9] would examine the correlation between a single ICT penetration variable, for instance broadband penetration, and the patent figure. Such minimalism is preferred whenever possible, but in this case would likely result in a strong positive correlation due to exogenous factors, that is factors that are external to these two variables. Primary among these exogenous variables would be how wealthy a country is. It is well known that ICT penetration figures and patent fillings both follow very closely the size of a nation's economy. Holding GDP constant, or controlling for it, should isolate the correlation between patents and ICTs free from variation in GDP. Just controlling for GDP offers the simplest model that should account for a fair degree of exogeneity (though one can validly criticize these models for not controlling on additional exogenous factors).

The point is to see if broadband penetration correlates with the patent variable and in addition how that correlation stacks up against other ICTs. Two other principle ICT variables suggest themselves – internet penetration (including but not limited to broadband) and phone penetration (mobile and fixed lines both). If broadband is related to a state's patent numbers than the analysis should show a positive correlation between broadband penetration levels and patent numbers and this correlation should rise to statistical significance. If broadband is particularly important even when compared to other ICTs than for these other variables there should be a weaker correlation or indeed even a lack of significance (in which case we would traditionally ignore the correlation numbers all together).

The multivariate regressions of these three ICT variables with patent data per capita, controlling for GDP, is detailed in Table 1 in the annex. These regressions are based on 2007 World Development Indicator data. The results indicate a positive and reasonably large correlation between broadband penetration and patent numbers and this correlation is statistically significant. Indeed, the model suggests that the addition of one percentage point in a nation's broadband penetration correlates with seven additional patents for that nation in that year, or roughly a 5% jump. And the chance that this relation is purely by chance is less than one in ten thousand. However, when a similar regression on the phone penetration and patent data is performed, again controlling for GDP, the relation between phones and patents is not of statistical significance at all. When a regression on the penetration for all forms of internet is performed the correlation is about half as strong as that for broadband specifically and almost rises to our significance threshold. Indeed, the probability that this relationship is established just by chance is 6% while a 5% probability is required in order to accept the relationship as statistically significant.

Note that these correlations do not fix an arrow of causation. So one might wonder whether patents cause an increase in broadband penetration or the reverse. Certainly, more patents might cause higher broadband penetration – for instance the activity of writing and filing patent applications drives demand for broadband. But this seems unlikely. Alternatively, the presence of broadband might drive the number of patents – for instance by increasing the capacity to invent. This seems more likely.

In any case, and put simply: *more broadband correlates with more patents; more phones do not significantly correlate with more patents; and more internet users do not significantly correlate with more patents, though they come close.* This suggests that today much of the impact ICTs have on a nations level of innovation, as described in the previous section, may be due to broadband as opposed to other computer and communication technologies.

1.3 Systems of Innovation

Innovations do not happen in a vacuum. Nor do people and firms innovate alone but instead do so within a reciprocal system of interactions and relationships with customers, vendors, external research and development organizations, even sometimes with competitors.[10] These networks create and move the knowledge and skills associated with new technologies and organizations.[11] Freeman defines innovation systems at the national level as "the network of institutions in the pubic and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies."[12] Importantly, Freeman recognizes that a national innovation system is not just the network of economic agents involved, but it is those agents acting together under the aegis of national institutions and policies that influence innovative behavior and output.

Studies of national innovation systems have sometimes put too much focus on formal research and development and high technology science-based innovation. In this framing, innovation only happens at the bleeding edge of invention. But such a narrow focus is not always the best way to think about national innovation systems, especially in the developing world. While every country has some form of innovation system, rarely do they behave the same or innovate in the same ways. In order to ensure that innovation system policy is relevant to the developing world, the concept needs to be broadened to include:

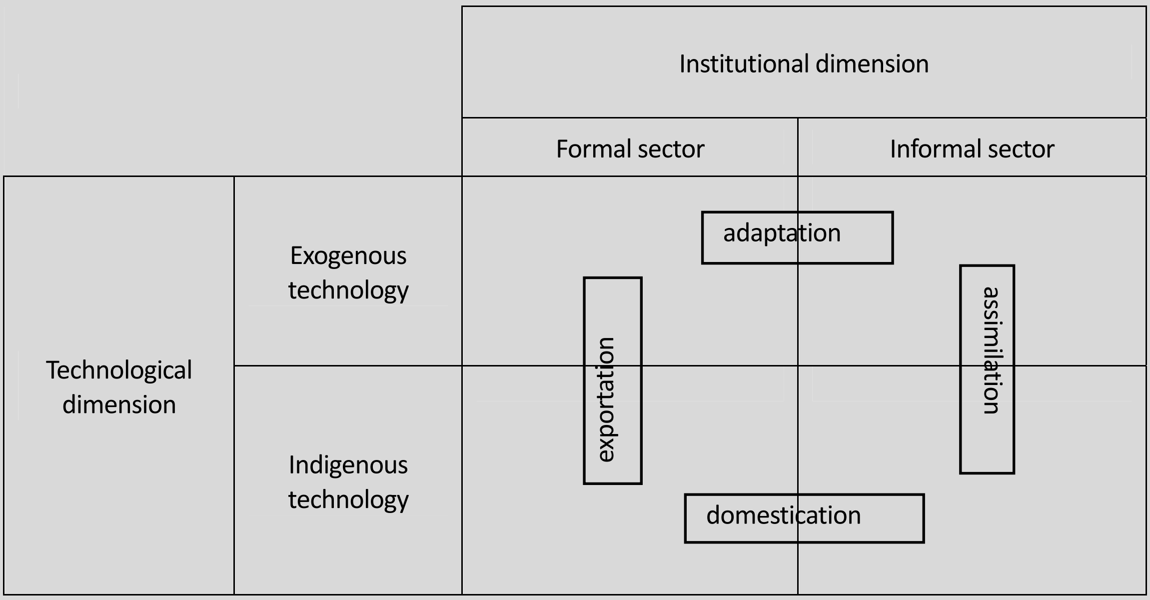
- All sectors (for instance agriculture, service sectors, as well as manufacturing);
- All aspects of innovation (including diffusion, imitation, and appropriation);
- Both indigenous knowledge and the mastery of imported technologies and knowledge;
- All forms of learning (including on-the-job and informal training, learning by doing, using, and interacting);
- Not just the reproduction and refinement of a national innovation system, but also its construction in places that have little extent systems;
- Wider living circumstances and how they affect learning and innovation and ensure that innovation corresponds to local conditions and needs.[13,14]

Newer research has attempted to "change our outlook" on national innovation systems to better accommodate the forms of adaptation, assimilation, and domestication often found in the developing world. If indigenous technology is that which is largely of local origin and exists within a local system of production and use, than exogenous technology is that which comes from without. Our common conceptualization of a national system of innovation within, say, an African country is one where the informal sector and local small-scale industries thrive in their use of indigenous technologies, while the formal sector and large-scale industries exist thanks to the application of exogenous technologies of foreign origin.

Figure 3 proposes a new *national innovation system for the developing world.*[15]

It shows how innovation systems within the developing world cycle exogenous and indigenous technologies between formal and informal sectors through processes of adaptation, assimilation and domestication. That is, a foreign technology arrives and is applied within some formal sector. Slowly through processes of innovation it is adapted into the informal sectors. These adapted technologies are then fully assimilated such that they are no longer of primarily foreign origin, and they are then domesticated back from the informal sectors into the formal sectors.

Figure 3: National systems of innovation processes of adaptation, assimilation, domestication and exportation.



Adapted from Bertelsen, P., & Müller, J. (2003). Changing the Outlook: Explicating the Indigenous Systems of Innovation in Tanzania. In M. Muchie, P. Gammeltoft, & B.-Å. Lundvall (Eds.), Putting Africa First: The Making of African Innovation Systems (pp. 123-138). Aalborg, Denmark: Aalborg University Press.

A specific example may help make this developing world innovation cycle clearer. Consider the case of the mobile phone, a foreign technology arriving some time ago to an African nation. It is used initially within the formal sectors and among urban elites. But as penetration increases and competition brings down prices the mobile phone is *adapted* to the informal sectors in a way that is locally contextualized, for instance a small-scale market person starts using a mobile phone to keep in touch with suppliers and family members around financial matters. These informal sector uses are then *assimilated*, for instance as local entrepreneurs find that they can serve as "human teller machines" by allowing this market person to send money to his or her home village by transferring phone credit to the entrepreneur situated in the village who then dispenses the phone credit as cash.[16] Finally, this indigenous innovation (the human teller machine) is *domesticated* as the formal banking sector begins to offer official m-banking cash transfer services. And this local innovation is then *exported* as mobile operators in other nations copy and learn from these mobile banking innovations.

While this innovation cycle is particularly useful for the developing world, clearly it applies to all nations in today's globalized system of innovation. When considering policy and regulatory responses to encourage broadband enabled innovations it will be important to keep in mind this broader concept of national innovation systems and cycles .

1.4 Broadband Enabled Innovation Case Studies

A few case studies will demonstrate technological, process and policy broadband enabled innovations globally.

1.4.1 The *iHub_ and Broadband Enabled Innovation Incubation

Broadband enabled innovation incubators have been identified as an important tool in the creation and commercialization of inventions globally, including in the developing world. These facilities, sometimes called ICT incubators, generally combine broadband networks with other business infrastructure, training and mentoring, introductions to venture funding, and a rich positive network of entrepreneurs and innovators. The World Bank, through its *info*Dev program, has supported over 150 ICT incubators in 70 countries. According to an evaluation of their programs, the mission of these ICT incubators is to:

- "Provide a safe, stable and secure place to start and grow companies that can offer needed services, support and equipment to the ICT community within the country and the region.
- Create employment in both ICT and the larger business community.
- Promote development of a free market system through training and education, making use of entrepreneurial talent to improve the community's economic well being.
- Enable access to equipment and services required by the new companies.
- Be a focal point of entrepreneurial activity, networking between tenant companies, the business community and potential partners."[17]

Broadband enabled innovation incubators offer an environment where people can come together to invent ICT products and services in a supportive and rich environment. The results of these incubators have been generally positive – and innovation enhancing.

1.4.2 Leveraging local businesses and innovations from international Internet access in Kenya[18]

The *iHub_ is a broadband enabled innovation incubator. It is an ICT focused "open innovation space" with a 20mb broadband internet connection.[19] Located in Nairobi, Kenya the iHub was founded in early 2010 by Erik Hershman who also co-founded Ushahidi, the crises mapping software that emerged out of electoral violence in Kenya. The physical facility consists of an open-plan architecture of tables and workspaces, foosball, and a small coffee bar. As an innovation ecosystem, iHub clearly focuses on building the connections and relationship described above as instrumental to an innovation system. While donors have subsidized many of the center's fixed expenses some members pay dues to use the facility.

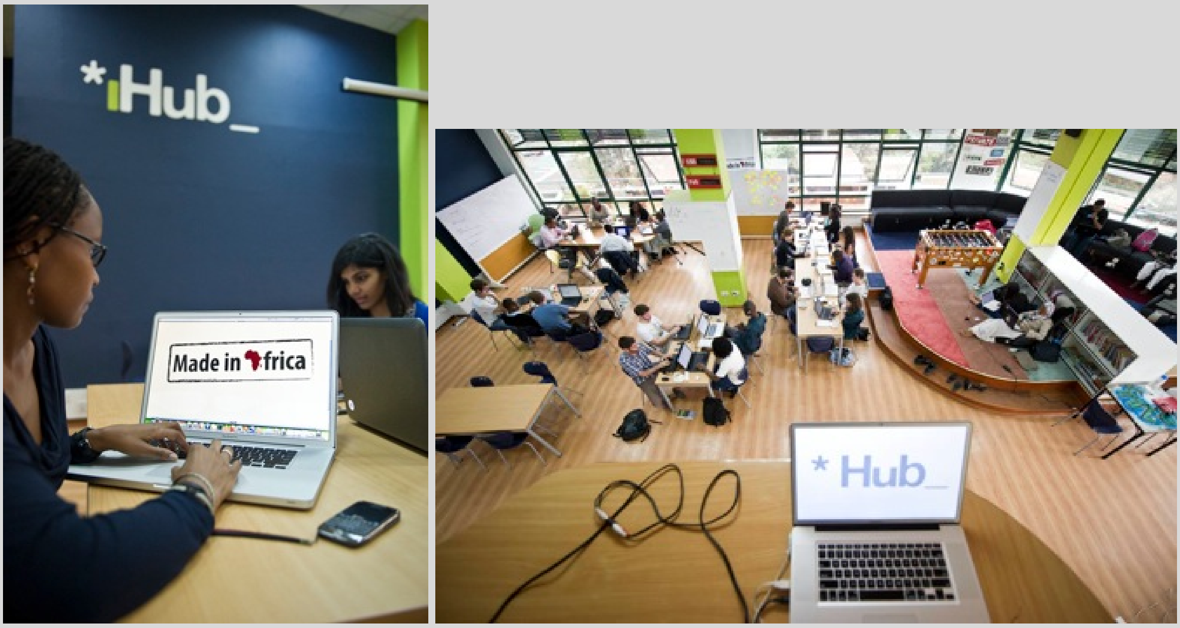
After just a single year of operation, the iHub has attracted over 3,000 members including over 1,000 developers.[20] Recently the iHub opened a mobile application incubation center to compliment its general innovation center.[21] According to reports, in the first year 12 companies have been created based upon work and relationships emerging from the iHub.[22] These companies are all premised on specific technical inventions with strong economic promise. These companies are innovative outcomes of the iHub incubator.

Critical to the iHub's existence is its fast internet connection which, across all of the country (and increasingly the region), has been made possible by the substantial undersea fiber connectivity recently landed in Kenya. Kenya has a natural geographic advantage being strategically located on the East Coast of Africa and well-positioned vis-à-vis the Arab Gulf States. Its government-led "build it and they will come" approach to broadband development has leveraged the country's geographic location and played a major role in dramatically increasing fiber optic backbone capacity. Many of Kenya's milestones have been realized in less than five years. Connections were made to three fiber optic submarine cables by the end of 2010, changing the face of the broadband market. The country has gone from relying on satellite for international capacity at the beginning of 2009, to by the end of 2010 having access to almost four terabits of capacity over fiber[23].

Although the landing of the cables is merely a first step, it has already resulted in an 80 percent decrease in wholesale bandwidth costs (although reliability is sometimes a problem). Lower prices and greater availability are expected to increase access to the internet, as well as to promote the continued spread of sophisticated mobile applications and services, and consequently improve opportunities for the creation of and access to information and knowledge. Affordable broadband is expected to increase Kenya's competitiveness, particularly in the business process outsourcing industry, and to encourage entrepreneurship and innovation. Kenya is also emerging as something of a mobile broadband hub. This builds on its success with the M-PESA mobile money platform. Mobile broadband, launched in 2008, now far outnumbers wireline subscriptions[24].

However, with an estimated wireline and mobile broadband penetration rate of two subscriptions per 100 people in 2010[25], Kenya still has significant progress to make with respect to broadband uptake. Stimulating demand and usage by citizens and the public and private sector remains a challenge. Kenya, largely through the government, has taken an innovative and pro-active approach to putting the user at the center and addressing the other elements of the broadband ecosystem, such as education, literacy, applications and content. This has been done through progressive regulation, the promotion of polices relating to ICT in education, the subsidization of relevant content and application projects, and facilitating creative public private partnerships.

Figure 4: People working at the iHub (right) and a portion of the open-plan work-space.



Source: Images copyright and courtesy of Sven Torfinn.

Much of Kenya's success seems to come from four important factors: (1) a clear national approach to how broadband fits into its *Vision 2030* development goals; (2) strong leadership and direction; (3) a credible regulatory, policy and institutional framework; and (4) leveraging the strength of the public and private sectors through public-private-partnerships The networks demonstrate clear business model innovations and adaptation of network technologies.

Kenya's growing international connectivity demonstrates a broadband lead innovation strategy through developing infrastructure that is innovation enhancing (as demonstrated in our analysis above) while simultaneously leveraging local business and technical innovations along the way.

Piraí Municipal Network

Municipal networks have been a source of broadband innovation both in terms of use of technologies (including WiFi mesh, WiMAX, and 3G cellular[26]) as well as process, business model, and policy innovations.[27] However, these projects have not always succeeded and indeed some have engendered considerable controversy.[28]

One generally well-regarded project is based in Piraí, a moderate sized Brazilian city in the state of Rio de Janeiro. The Digital Piraí project was inaugurated in 2002 with the stated objective of providing broad access to ICTs as tools for economic and social development.[29] Specifically, the project aimed to enhance the city government's services, provide greater transparency, and improve trust in the municipal government.[30]

This municipal network has been lauded for a number of its innovations. These include the use of a hybrid low-cost set of transport technologies and open-source software, both of which have been noted as success factors. Furthermore, the project was implemented using an innovative cooperative consortium of private, civil, university, and public actors.[31] This broad innovative coalition allowed the program to leverage expertise, contributions, and build support among many stakeholders.[32] This project demonstrates local invention in process and organization along with innovations through adaptation and assimilation.

1.4.3 Innovation Nation and Innovation Unions: Policies for Innovation Enhancement

A number of countries have adopted national broadband policies that should have innovation enchaining properties. For instance, Chile was the first Latin American country to announce a national broadband strategy, a clear policy innovation for the region.[33] The strategy identifies ICT as a priority for economic development. Chile has also planned and implemented ICT policies from both the supply and demand sides. On the supply side, the government has authorized four WiMAX operators as regional providers, and the regulator plans to award additional spectrum for a new 3G network. As shown above, supply side diffusion of broadband can enable innovation. The demand-side strategy has included programs for e-literacy, e-government, and ICT diffusion. For example, almost all taxes are filed electronically, and government e-procurement more than doubled the volume of transactions processed between 2005 and 2008. The government has also promoted broadband use by municipalities. By 2008, almost all municipalities had Internet access, and 80 percent had websites[34]. Enhanced national and municipal government use of broadband can enable innovation both by driving demand as well as providing opportunities for broader sensitization and awareness.

Beyond just a single nation, the European Commission, as part of its Europe 2020 policy, has taken directly on both the development of a European digital agenda and the creation of an "Innovation Union" as two of its flagship initiatives.[35] And what they have come to realize is the significant "cross fertilization between [the] flagship initiatives of Digital Agenda for Europe and Innovation Union".[36] As part of this recognition, the Council of the European Union has stressed, for instance, the need for:

- "recognizing the contribution of digital technologies as one of the main drivers to improve Europe's productivity and growth capacity, the ability to innovate in all sectors, and to respond to the challenges facing our society;
- "stimulating innovation in ICT to meet pressing challenges such as fast and ultra-fast internet supply, coverage and use, online trust and security, turning growing internet usages into value creation for EU companies;
- and "reinforcing the digital literacy and skills (e-Skills) in particular in enterprises and the public

sector but also in all other areas in view of strengthening an ICT-enabled inclusive society, reducing as much as possible the digital divide as well as the innovation divide; this may require partnerships with stakeholders based on supply and demand, quality assurance mechanisms for industry-based training, awareness-raising and digital inclusive activities"[37].

1.5 Policies That Support Broadband Enabled Innovation

What public policies might help encourage the broadband enabled innovations suggested by these case studies? Public policies that enhance a nation's capacity to innovate have attracted considerable attention from social scientists and policymakers. Indeed, it is widely believed that the right set of public policies are required in order to ensure that a nation will be innovative. Freeman has noted that in particular, "a more explicit policy for science and technical innovation is increasingly necessary" and that this should be in contrast to just an implicit policy or, even worse in his estimation, "*laissez-innover*".[38]

Many of these policies are designed to address some of the specific challenges associated with innovation. One challenge, for instance, is that some aspects of invention are non-rival and non-excludable and thus cast innovation as a public goods problem. Here innovation requires policy protections to ensure that inventors are able to exploit the fruits of their labors. In addition, innovation can have high levels of uncertainty, risk, high transactions costs, and occur around incomplete information. Policy interventions might attempt to address these challenges through direct investments that share costs or systems of information sharing that reduce risk. Finally, some innovations result in "winners" and "losers" and can cause interest groups to emerge to influence government policy or even inhibit the innovation. In response, public policies can either mitigate the harm to the losers or spread the benefit more widely beyond the immediate winners. All of these challenges have resulted in a tight collection of innovation policy "pillars" that have been utilized across many nations, most centrally:

- Research and development (R&D) investments
- Intellectual property right protections
- Education and demand development
- Universities and public research institutes
- Trade and financing

These five pillars of innovation policy are found across all areas of invention – from manufacturing to service sectors and beyond. But some innovation supporting policies are of special relevance to ICTs and broadband and these include, notably:

- Openness
- Neutrality

The following sections will consider all seven of these policy areas and detail how they can assist in creating an environment conducive to broadband enabled innovation.

1.5.1 Investing in Research & Development

Economists have long noted that markets systematically under-invest in research and development, and that this systematically reduces invention and thus innovation.[39] R&D suffers from externalities and problems associated with public goods. Specifically, the useful results of R&D usually take the form of new knowledge, ideas, and technologies, which are often easily copied and acquired by competitors. Under these conditions the actors who bear the enormous risks and costs involved in invention are not always able to capture enough benefits to justify their initial investment. This can be true even independent of strong intellectual property protections. Therefore some scholars have recommended public sector investments into R&D as an effective way for a nation to spur innovation while avoiding this natural under-investment of the private sector.

Monopolies are a second market failure which helps to justify state support of R&D. A monopoly permits firms to escape the pressures to innovate because monopolies benefit less from innovation, and are punished less for stagnation, than are firms in competitive markets. One economist referred to this as the "replacement effect": In a competitive market innovative firms drive out and replace their competitors; but when a monopolist innovates, they have no competition and therefore nobody to replace them and hence the incentives for monopolies to innovate are muted.

A third problem which tends to reduce private investment in R&D is the unpredictability of the results. Where results are unpredictable, neither investors nor innovators can properly evaluate how many resources to dedicate to a particular research or development program. Worse yet, the products of a particular R&D project may turn out not to be applicable to a firm's existing business model, hence a waste of investment.

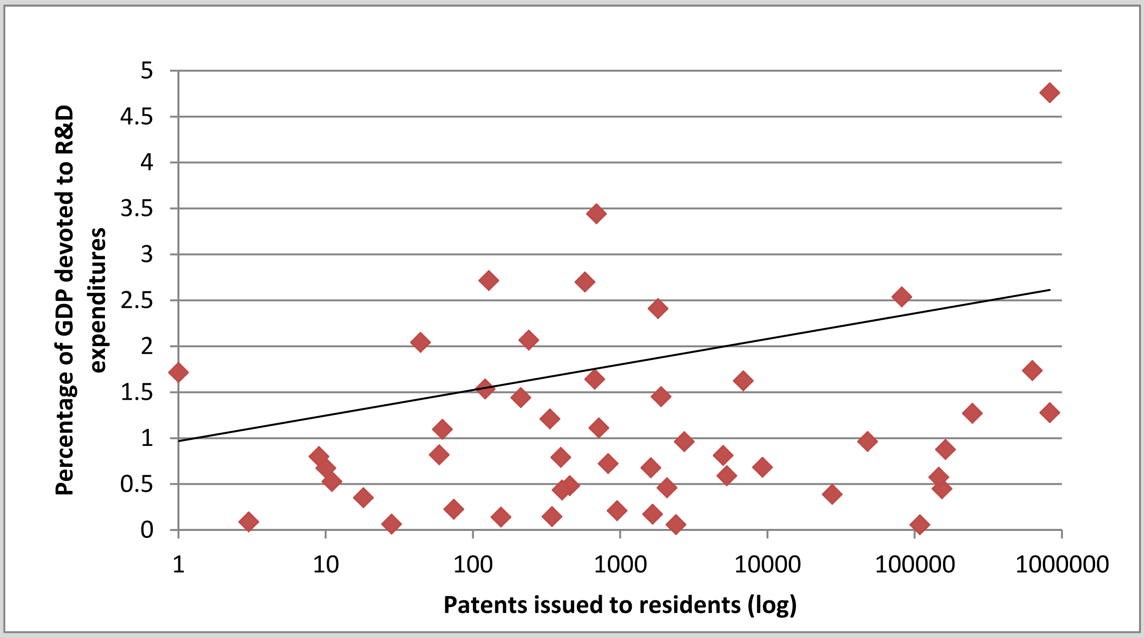
If public R&D investment is a good general policy response for encouraging innovation, then are there any implications specific to *broadband enabled innovations*? Quite famously, the internet (the basis of all broadband networks) is itself largely the product of US government R&D investments. What began as a state investment blossomed into a platform that has become an ongoing engine for private innovation. Indeed this fairly substantial state R&D investment has created a situation where modest private R&D investments can result in highly successful innovations. For instance consider Facebook, famously started with little capital in a Harvard student's apartment.[40] So in the case of the internet, an initial public investment resulted in an innovation that, in turn, has resulted in lower barriers for subsequent inventions spurring an incredible degree of innovation.

High- and middle-income countries routinely use public R&D investments in broadband enabled innovations that, in turn, can enhance their overall capacities for innovation. But not all countries have the surplus resources to allow significant public R&D investments. In all countries, however, the government can encourage private R&D investments. The telecommunications regulator has been shown to play an important role in encouraging ICT investment by the private sector, including innovation spurring investment in R&D. Scholars argue that the regulator's ability to encourage such network investment from the private sector is particularly contingent on reducing regulatory risk by:

- Ensuring regulatory independence and reducing undo political interference;
- Creating and executing clear and consistent policies and ensuring clarity as to policy directions;
- Working in a transparent, accountable, and efficient manner;
- And paying close attention to demand development and consumer affairs while avoiding regulatory capture by operators.[41]

Figure 5 shows the relationship between a country's private and public investment into R&D projects as a percentage of GDP and that nation's patent rates, our innovation surrogate. The relationship, approximated by the trend line, is clearly an upward slope indicating a higher percentage of R&D expenditures correspond to a higher number of patents issued (shown as its logarithmic measure so as to visually compress the index).

Figure 5 Relationship of nation's R&D expenditures as a percentage of GDP against the log of that nation's number of patents issued. Trend line shows correlation (r = .45, p < .0001, n = 113).



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1.5.2 Intellectual Property Rights

Intellectual property rights (IPRs), such as patent protections, are widely considered to be essential for sustained innovation, and in particular science and technology focused innovation. Patent protections offer their holder a temporary monopoly on the use of an innovation. Without intellectual property protections, the economic incentives for innovation often disappear, since any discovery can be copied and sold by parties in competition with the inventor. However, where IPR protections exist, innovators are guaranteed limited-time monopoly use of whatever technology they invent and therefore a competitive advantage. This monopoly power is designed to enable innovators to earn profits from their discoveries, which in turn encourages the very innovation itself.

Patent systems should balance between the *ex post* monopoly powers they grant to an inventor while also enriching the public domain by allowing that this same invention, in some time, becomes available for general use. Both of these steps are critical to the capacity for a nation to innovate: The limited-time monopoly incentivizies the initial creative process (by rewarding the inventor) but ultimately the end of this exclusivity opens the innovation up to broad use and helps to build a rich public domain of invention that can be exploited, improved, and extended upon by a larger community. This public domain inspires innovation by offering free or low-cost access to past work, and by liberating "orphaned" work – intellectual property that is abandoned or not exploited by its license holder. The public domain becomes the "raw material" for future innovation. The public domain provides building blocks for new knowledge and enables competitive imitation and follow-on innovation.[42]

IPRs and ICTs, and in particular broadband, have had a complicated and at times tumultuous relationship [Theresa: please add a reference to the GSR 11 paper on IPRs]. In this context, what most immediately comes to mind are not patent protections but copyrights. For instance, broadband internet is an effective tool for music file sharing, including those cases where such file sharing infringes on copyright. New music is not considered as an innovation because this particular form of artistic work is not an "invention" per se (though the file sharing technologies, such as torrents, certainly are innovations). So while the relationship between copyright regimes and broadband is deep and difficult, these tensions are outside the scope of this chapter.

Restricting ourselves just to patents and their relationship to broadband ICTs, then one area of particular confluence is in the specific area of software patents. While songs are not innovations, software often is. So infringing uses of software programs may run afoul of patent protections. Overall software patent law and practice has been an area of particular contestation.[43,44] What is clear is that a state's IPR regime needs to successfully incentivize software innovation while encouraging the special forms of interoperability required among ICTs and avoiding frivolous or overly defensive patents.[45,46] The section below on openness discusses a range of responses to specific IPR challenges as it relates to software and other computer and communication technologies.

Generally, the telecommunications regulator has not set IPR policy. However, the regulator is in a particularly good position to advise relevant policymakers on the particularities of the ICT industry. This is especially true in regard to patent protections and, more critically, whenever the regulator is able to play a technical, enforcement, and convening role in setting standards for adoption and interoperability – some of which have IPR ramifications.

1.5.3 Education and Demand Development

Education fosters innovation in many ways, three of which are highlighted here.[47] First, formally trained scientists and engineers are a direct input to innovative activity. Certainly this was not always the case and indeed skilled workers with little or no formal education acted as key innovators during the first industrial revolution. However, since the rise of the research university and the corporate laboratory, formally educated science and engineering workers have become an essential input to national innovative activity. Even on the shop floor, skilled manufacturing workers have been shown to consistently contribute to process innovations and product improvements. These workers generally have at least a decade of formal education, often followed by extensive in-house training by their employer.

Second, even if workers are not responsible for creating new innovations, educated workers require technology and process innovations to perform their jobs. Such innovations complement educated workers; therefore an increase in one can drive demand for the other. During the 17th and 18th century, this generally meant technology replacing expensive skilled labor. But during the 20th century, technological change increased demand for skilled workers to use it. As skilled workers enter the market, they create a reciprocal demand for more and higher levels of complementary technology for them to perform their labor. Hence as higher levels of education create more skilled workers, it translates into demand for more and better technology.

Third, educated consumers tend to promote technological change and thus develop demand. For example, It was shown that in many fields users, not producers, drive innovation.[48] He documents how, in industries from scientific equipment to software to sporting goods, consumers are responsible for a considerable amount of technological change. How much is unclear, but studies suggest, "many users—from 10 percent to nearly 40 percent—engage in developing or modifying products."[49] But even when they are not innovating, educated consumers tend to demand ever-improving technologies. Often radical innovations succeed in part due to their ability to penetrate highly educated consumer markets. Automobiles, radios, aircraft, televisions, personal computers, cell phones each made their first appearance as activities for technically savvy hobbyists and then as luxury items for highly educated, wealthy consumers – before often then adapting, assimilating, and diffusing into more generalized use. Finally, schools are often the venue where young consumers are first introduced to new technologies and taught their applications to work and daily life.

The view that education constitutes a cornerstone of a nation's capacity to innovate is even more fitting for *broadband enabled innovations*. ICT policymakers and even regulators have long understood the importance of education, and in particular the importance of direct ICT-related education and its connection to innovation. A number of policymakers and regulators have worked directly on the development of ICT training programs. In some states, telecommunication regulators and ICT policymakers have been called upon by education ministries to assist in the development of ICT education and training goals and materials.

In some cases, the regulator has even gotten directly into the ICT "education business". Consider the case of the Nigerian Communications Commission and its Digital Bridge Institute (DBI). The DBI was established in 2004 by the regulator with a number of goals including to, "offer a comprehensive portfolio of hands-on engineering and technical training programmes…. [and] focus on educating and training manpower in all spheres of telecommunications and information technology."[50] Today the institute has three campuses, in the political capital Abuja, and the commercial and cultural hubs of Lagos and Kano. Current programs include professional short courses and certification programs, and academic degree and diploma programs joint with other universities. To date DBI has offered professional programs to over 11,000 learners and jointly offered 164 academic diplomas.[51] In this case the regulator has moved directly into providing educational programs with clear impacts on innovation capacity.

1.5.4 Universities and Public Research Institutions

Research universities and other public research facilities have long been fundamental to innovation. Universities, and institutions like them, have acted as bastions of advanced research since the first philosophical schools of ancient Greece and the Library of Alexandria.

Universities and public research institutions (PRI's) affect innovation capacity in several ways. Most obviously, university and PRI laboratories are where much scientific research and technological innovation gets done. The artificial heart, the internet, DNA sequencing, nuclear power, and countless other major discoveries and inventions were a direct result of university and PRI research. Universities also provide the highest levels of training for a nation's science and technology workers through degree granting programs, another vital input to innovation.

Universities and PRI's also foster technological change indirectly, via their links with industry and government forming an important element to a national innovation system. For example, a survey of 1,267 corporate R&D managers ranked ten types of linkages by which universities and PRI's contribute indirectly to industrial innovation[52]: research publications (41% of industry respondents found these important), informal exchanges of information (36%), meetings and conferences (35%), university consulting (32%) and contract research (21%), hiring of graduates (20%), joint R&D projects (18%), the use of university patents (18%) and licenses (9.5%), and mutual exchanges of personnel (5.8%).[53] These results highlight, as mentioned above, the importance of relationships and interactions in systems of innovation.

For these reasons, governments around the world have supported an expansion of universities and PRI's.

In China, universities are not only expanding at historic rates, but there is also an attempt to rival the world's best research schools at select places like Peking University, Tsinghua University, and Fudan University. India has likewise tried to emulate top British and American science and engineering universities with its fifteen Indian Institutes of Technology, over half of which were established in 2008-2009. Meanwhile, universities in the US and Europe are putting ever greater emphasis on research, for both faculty and students alike. Increasingly some Middle Eastern economies, such as Dubai, now view universities as a bridge from an oil-based economy to a globally competitive high-tech economy.

However, universities and PRI's only take us so far in explaining national S&T performance. For example, there are relatively few high ranked universities in Japan, the Republic of Korea, or Taiwan, China, but this has not prevented these countries from producing globally competitive R&D. Meanwhile the United Kingdom ranks quite high, second only to the United States, in respected research institutions, but remains a mid-level innovator by some measures.

What about ICT policy and telecommunications regulation and its relationship with universities and PRIs? At the time of this writing the Digital Bridge Institute, noted above as an ICT training facility, is moving to be licensed as a full degree-granting university able to issue stand-alone diplomas. Furthermore, DBI is expanding its research position with the creation of several R&D focused centers of excellence including studies in software development, cybercrime and cyber security, and multimedia research. Clearly, the Nigerian regulator, the Nigerian Communication Commission, is looking to spin off this facility into a full-fledged university and public research institution. DBI also continues to leverage substantial international research linkages; this approach can help countries that do not have resource constraints maintain R&D capacity.

1.5.5 Trade and Investment

Enhancing trade and facilitating foreign investment can also foster innovation, especially in broadband and ICTs. First off, trade itself creates surplus wealth necessary for investment. Often this occurs through the co-development of large banking and insurance industries alongside major trading operations. Trade brings into contact people with diverse ideas about new markets, as well as science, technology and innovation itself. Trade creates competition between businesses and the states that house them, demanding ever greater efficiency via investment in technological change. Trade allows specialization, and therefore an intense focus on particular areas of innovation, such as Taiwan, China in computer hardware, Singapore's recent focus on biotechnology, etc.[54] Trade creates demand for security, for the protection and stability of consumer markets, distribution chains, and production facilities. This translates into military research and development. Trade also creates economies of scale, making profitable large science and technology investments that might not be rewarded in smaller national markets. In sum, to understand the innovation benefits of trade, one need only ask whether a small state, say Switzerland or Sweden, would be as technologically advanced today if it were not part of a trade network with the rest of the world.

Considering the ICT sector specifically, initially many states tried to protect their ICT industries through trade barriers. But after the 1970s, enthusiasm for ICT protectionism has been mostly replaced by export-led growth strategies. The main idea behind the export-led strategy is for a growing economy to use its comparative advantage in labor to become a base for manufacturing, or more recently IT and knowledge services. This requires that they open their economies to imports of all inputs in which the country does not have a comparative advantage. Then domestic firms or government can either setup increasingly high-tech industries themselves (e.g. Japan), or allow foreign companies to do so through foreign direct investment (e.g China during the 21st century). These industries usually produce for export, while providing the host country with factories, jobs, higher wages, and massive transfers of technology and know-how. Slowly, host-country workers, managers, and engineers should learn enough to start up their own domestic firms and compete, thereby moving up the value chain. And this is very much what occurred in Korea, Taiwan, and is beginning to happen in China and India.

A particular complement to trade liberalization is foreign direct investment (FDI), which has played a critical role in ICT sector development worldwide. While many countries historically placed strict controls over foreign investment in ICT's, more recently, countries pursuing trade liberalization have progressively opened themselves up to foreign direct investment in ICTs. As reported in the ITU/*info*Dev ICT Regulation Toolkit, "foreign investment has facilitated the growth and development of the telecommunications sector in many countries, increasing access to capital for network development and modernization, and allowing for the transfer of technology and know-how."[55] And indeed regulators have played a critical role in creating the necessary climate for investment.

1.5.6 Openness

The five policy pillars described above are found throughout the innovation literature and are believed to have broad sector applicability – from manufacturing to service to high-technology fields. However, the policy area of openness has unique relevance to *broadband enabled innovation*. In many ways, openness is a policy issue that is itself broadband enabled, and has emerged directly out of the ICT sector.

Openness is a concept that has two principal components – the openness associated with content (such as open source software or copyright waivers on artistic works) and the openness associated with the networks themselves (such as means to share physical infrastructure among multiple service providers).[56] Beyond content and networks being open, openness can provide a model within a sector or industry, for instance open government, open education, open science, or open business. The impacts and policy implications of these forms of openness on *broadband enabled innovation* is significant. This section will touch on a few forms of broadband enabled openness – open content, open source, open spectrum, and open access – all which have considerable impact on the capacity to innovate.

Consider first that in Brazil musicians are giving away their music: Under their "tecnobrega" open content model, artists freely distribute their music and then charge for concerts and dance parties.[57] Some artists have taken to describing this open model as a "gift economy" where creative works are shared freely, with many parties re-purposing and innovating on the material, and other methods are used to develop economic value.[58] This clearly has business and IPR policy implications and policy initiatives have been emerging to support these open content movements. Creative Commons, for instance, is an organization that has developed legal and technical infrastructure to allow creators (artists, educators, scientists, and government) to customize the copyright restrictions they place on their creative works – moving from "all rights reserved" to "some rights reserved". Their goal is for "universal access to research, education, full participation in culture, and driving a new era of development, growth, and productivity."[59] The implications of these open content (copyright) models – often driven by broadband – on innovation are significant. In the same way that the public domain offers building blocks for invention and improvement, so too can open content. (See the GSR discussion paper on Intellectual Property Rights in a Digital Economy for a more thorough treatment of these issues.)

Beyond copyright, openness has still other IPR implications. The intellectual property section above noted that some scholars have responded negatively to software patents. Indeed, for them the software patent is positioned against openness and as a constraint on innovation. A prominent intellectual property scholar writes, "Software development is a highly incremental process. This means that patents tend to impose a burden on a substantial amount of future innovation."[60] In particular, software patents are a challenge or in opposition to the open source software movement, which also has been innovation spurring. This author goes on to describe free/open-source software as "the quintessential instance of commons-based peer production" which is "radically decentralized, collaborative, and non proprietary; based on sharing resources and outputs among widely distributed, loosely connected individuals who cooperate with each other without relying on either market signals or managerial commands".[61]

In a recent investigation, journalists in the USA further document the innovation-damaging role that software patents have played in that country.[62] A series of cases are described where companies use software patents, often for trivial or widely accepted practice, only for the purpose of extracting rents from others and without any plan to use the invention directly. In some cases this process kills startup companies in a manner that clearly reduces innovation. At least under the current system in the USA, this investigation argues that software patents are clear innovation killers.

Policy makers need to establish patent regimes that are innovation enhancing – by, for instance, encouraging invention but discouraging predatory use of monopoly powers. Policy makers are also able to encourage open source by enhancing, using, and protecting these forms of production. For example, in Brazil the state has actively adopted open source software for their computer systems noting the economic benefits such a program enjoys.[63] In doing so they become one of the world's largest customers to free/open source software. Regulators can take similar steps both in term of their internal operations and externally through advocacy and education.

Open spectrum is another important innovation enabling policy area.[64] In an effort to provide maximum flexibility for innovation and lower entry costs for some types of ubiquitous wireless devices, policymakers and regulators in many countries have set aside certain bands for license-exempt (also known as unlicensed) uses. In other bands, license exempt and licensed services share frequencies. Many commonly used wireless devices, such as cordless phones, garage door openers, and smart meters for water and gas, depend on unlicensed spectrum. In addition, municipal wireless networks, such as the ones described in the case study above, often use unlicensed spectrum to create mesh networks that cover downtown areas or even entire cities. Wi-Fi is perhaps the most widespread example of unlicensed use. According to ABI Research, consumer devices with Wi-Fi functionality surpassed 770 million units in 2010, an increase of nearly 33% compared to 2009.[65]

Open spectrum can have significant innovation enhancing value. Indeed as one expert put it, when "you give spectrum to operators you are frozen in terms of innovation."[66] But when the spectrum is open to unlicensed use, innovative systems can flourish thanks to reduced licensing barriers to experimentation. Research has also shown that spectrum license exemptions correlate with a country's level of internet penetration, even when controlling for population, region, and level of economic development.[67] It seems likely that these open spectrum policy provisions actually spur internet penetration, and thus are likely to encourage broadband enabled innovations. Spectrum allocations and licensing policies are squarely in the purview of policymakers and the telecommunications regulator; open spectrum is generally in their hands.

Finally, network infrastructure can be provided through open access models. Historically, telecommunications and data networks are vertically integrated facilities where a single corporation owns the physical infrastructure and sells and provides retail services over that infrastructure. According to some scholars such vertical integration has faults.[68] First it limits innovation by creating dependencies between the various levels of the network and services. Second it diminishes competition by, for instance, requiring all service providers to own their own facilities. As these same authors put it, "innovative operators cannot afford the cost [of a new access network], while incumbent operators do not see any strategic advantage in the investment [in new services]." And finally, it diminishes the ability to fully utilize a network resource through statistical sharing of it among multiple services.

Instead, open access networks allow all service providers access to the physical network facilities at non-discriminatory terms. Some authors have taken to calling this the "third way" because it lies between the extremes of a fully privatized vertically integrated operator and the case where a government steps in and directly provides retail network services.[69] Open access networks have been attempted, with various levels of success, by municipalities, community-based organizations, and corporate operators. (See the GSR discussion paper on open access regulation for a full review of open access networks.)

While network openness is innovation enhancing, some authors have identified ways in which such openness can also create vulnerabilities including issues related to: "

- Privacy and data protection;
- Emergency services;
- Cybersecurity;
- Distribution of unlawful content; and
- Lawful intercept."[70]

Interestingly, however, while such vulnerabilities are cause for concern, they are often also engines of innovation, for instance cybersecurity concerns catalyze innovations in cryptography.

1.5.7 Neutrality[71]

Neutrality is another policy area with unique relevance for *broadband enabled innovation*. Like openness, neutrality is a policy area that is itself broadband enabled and has emerged directly out of the ICT sector. Neutrality concerns ways that policy makers and regulators can offer licensing regimes that are indifferent to particular technologies, to the services that a provider can offer, and to the ways that an operator can use a particular band of licensed spectrum. Neutrality implies that an operator transports forms and sources of content in an equal and non-discriminatory manner.

Technology neutrality is based on the premise that service providers and network operators should be allowed to use the technology that best meets the needs of their network and their customers' demands;

it is therefore considered best practice to adopt a regulatory framework not prescribing any specific technology. In the past, regulators often tied licenses to specific technology requirements. As new technologies have developed, however, such constraints have come to be seen as too inflexible and a threat to greater innovation and competition. For instance, tying an operator down to a particular technology can disincentive technology producers from inventing new systems since the restrictive license may constrain operators from adopting the new technology. Rather, policymakers and regulators are looking to provide greater incentives for innovation by allowing operators flexibility in what technologies they choose to deploy.

In the licensing context, technology neutrality refers to the concept that different technologies capable of providing the same or similar services should be licensed and regulated in a similar way.[72] In the broadband context, this means that broadband service providers abide by similar licensing processes and conditions regardless of whether they deliver services via DSL, fiber, cable modem or other technology. However, a licensing framework that is generally considered technology-neutral does not have to treat all providers in exactly the same way; it may treat certain broadband technologies differently. This is particularly the case for wireless vs. wireline broadband technologies due to the need for separate spectrum authorizations and other spectrum-related issues such as avoiding interference, etc.

Service neutrality, in contrast, is based on the premise that providers should be allowed to provide whatever services their technology and infrastructure can deliver. In the past, due to the limitations of technology, networks were "purpose built;" a cable television network could only provide television services, while the public telephone network could only provide voice or low-speed data services. As information and communications became increasingly digitized, however, it became possible for different networks to all provide the same services and conversely a single network could provide multiple services. Thus both cable and telecommunications networks can now provide a wide range of voice, data and video services, and telephony is available from both fixed and mobile operators. Given this convergence, policymakers and regulators have generally come to realize that constraining network operators' services based on old conceptions of technology is no longer appropriate. They have began to adopt more liberal licensing regimes that allow companies to provide a wide range of services under a single license or authorization, which thereby enables the operator to take "cues from the market as to which services are most in demand or most cost-effective."[73] For example, the Botswana Telecommunications Authority (BTA) issued the country's first service-neutral license to the operator in 2007, which permits it to offer fixed telephony, mobile telephony and Internet access services, as well as other services, under a single license.[74] Many other countries have taken similar steps.

In the case of spectrum licensing, both service and technology neutrality have created opportunities for broadband innovation. Flexible spectrum use rules may be applied to maximize the benefits of technological evolution and development of advanced services. Countries are generally moving away from more traditional spectrum management practices that restrict the types of networks and services a licensee may provide and are moving toward more flexible, open spectrum management regimes. For example, the EU's 1987 GSM Directive reserved the 900 MHz band (890-915 MHz/935-960 MHz) for GSM networks and services only; however, this was revised in 2009 to permit greater flexibility in choice of technology and encourage the growth of mobile broadband within this band.[75]

Furthermore, specific new technologies are themselves opening up greater flexibilities in spectrum use. Emerging software defined radio technologies allow far greater flexibility in spectrum use then previously available when spectrum use specifics (e.g. the exact frequencies broadcast and received on) were fixed in the hardware. This flexibility means that smart systems, or "cognitive radios", can more efficiently share and use spectrum by reconfiguring to best account for current local conditions.[76] Cognitive radios are themselves broadband enabled innovations – but in addition through smarter and more efficient use of spectrum they open up areas for innovation and growth that can increase spectrum efficiency and thus broadband availability globally.

Together, technology and service neutrality recognize and facilitate technological convergence and promote new and innovative services and applications by reducing the number of licenses that an operator must obtain and expanding the variety and breadth of services an operator may provide. It may also contribute to reducing unnecessary or even contradictory regulatory obligations, such as different reporting standards and requirements provided under service-specific regimes. As in Botswana and elsewhere, a country's licensing regime often requires substantial reforms from traditional service-specific licensing to a more unified licensing framework capable of accommodating technology and service neutrality.

Finally, network neutrality ("net neutrality") generally refers to the notion that an ISP should treat all subscribers' activities on the internet equally, including use of devices and traffic related to any content, application or service. This principle, which is often referred to as "non-discrimination" is characterized by several specific activities that proponents of net neutrality wish to prohibit, most notably the blocking or slowing of certain types of content or content from certain providers or, conversely, the prioritization of other content types or providers.[77]

In addition to seeking to prevent such activities, net neutrality proponents also generally seek to improve the transparency of what the ISPs are doing with regard to traffic management and other internet-regulating actions. This involves whether an ISP discloses to consumers its network management practices, such as blocking, degrading or prioritization, as well as transmitting to users information about the actual speeds that they are receiving with their service.

As policymakers consider whether non-discrimination or network neutrality provisions are needed in their country, it is important to note that the possible approaches to net neutrality may be viewed along a spectrum. At one end of the spectrum, a policy would require "pure" net neutrality of no discrimination; the ISP would be prohibited from managing internet traffic in any way, and would simply work on a "best efforts" basis delivering all content on equal terms. Companies would be prohibited from charging content providers for priority or favored access. At the other end of the spectrum are policies that would permit an ISP to engage in any network management practice, including allowing an ISP to actively block users from accessing certain types of legal content, applications, or services without the users' knowledge. It should also be noted that although a country may not have specific "net neutrality" policies or rules in place, issues related to blocking, delaying, or prioritizing traffic may be addressed under competition laws, while transparency and disclosure may be addressed by consumer protection laws.

1.5.8 Beyond Coverage to Innovation

The significant percentage of broadband policies enacted by states to date has focused on coverage over change and innovation. Indeed a lot of policy attention, especially among regulators, has focused on universal service.[78] As a wrap-up to our policy considerations, we would like to suggest a possible adjustment to universal service provision put to operators of telecommunication services, including broadband. Instead of an obligation mostly focused on coverage and access (with perhaps some small investment in R&D), operators may instead respond through invention and innovation. A Universal Innovation Obligation.

What might a Universal Innovation Obligation look like? It might require operators to put particular resources towards the seven policy areas that were already identified above – for instance obligating certain levels of R&D investment, or consumer education and training, or that some degree of their inventions be developed as open intellectual property.

1.6 Conclusions

Innovations are inventions with impact. In recent decades, ICTs have come to dominate global innovation and business value-addition. Within ICTs, broadband now plays a major role in enabling innovation, perhaps more so than other computer and communications technologies. But innovation in wealthy and rapidly industrializing countries can look very different than innovation in the developing world. To better understand innovation in the developing world, both policymakers and scholars must broaden their definitions of innovation to include all economic sectors, all aspects of technological change, all forms of learning, and both indigenous and imported knowledge.

This does not mean that innovation in the developing world is entirely unique. In fact across the globe innovation suffers from a number of classic market failures. Without patent protections, free-riders can simply copy new innovations and eliminate the incentives for investment in R&D. The presence of monopolies can slow innovation due to a lack of competitive forces. High costs and risks, imperfect information, and the unpredictability of results can also stymie private investment in R&D.

Wealthy countries address these market failures with heavy government subsidies in R&D and education, as well as the construction of infant industry protection, strong patent regimes, and attractive FDI policies. Many of these policies are not quite as accessible to less wealthy, more vulnerable economies. However, they are not helpless, especially within the ICT sectors and broadband enabled innovation in particular is expected to be one of the main drivers of future growth of national economies. All governments can foster innovation in ICTs by ensuring regulatory independence from local politics, creating clear and consistent policies, and putting a premium on accountability, with close attention to demand development and consumer affairs.

Finally, government actions to maintain openness and neutrality can foster innovation specific to ICTs. Openness in content and infrastructure can allow networks of innovators and investors to form. Such networks can work towards solving the classic public goods problems associated with innovation, while still allowing new knowledge and technologies to diffuse to those who can best use them. Neutrality implies that an operator transports forms and sources of content in an equal and non-discriminatory manner. Neutrality allows service providers and network operators to use the technology that best meets the needs of their network and their customers' demands; it prohibits governments from dictating such choices in an inefficient, arbitrary, or politically driven manner.

Simply put, governments can consider a range of policy interventions to encourage innovation– including broadband enabled innovation – in a number of areas such as:

- Funding:
  - When resources are available invest in public research and development. Universal Service Funds, for instance, could be used to provide partial funding for R&D activities.
  - Always encourage private investment in R&D.
  - Reduce regulatory risk, which can spur such private investment.
  - Reduce barriers to broadband enabled R&D entry through the creation of ICT innovation incubators, and cheap and pervasive broadband networks.
- IPRs
  - Encourage innovation through intellectual property regimes that offer limited-time monopoly use of ones invention.
  - Balance this monopoly use with ultimately building a rich public domain of raw intellectual materials.
  - Avoid software patents.
- Education & research
  - Invest in all forms of education. Invest particularly in ICT education from early training to advanced instruction.
  - In particular, invest in research universities and other public research institutions. Leverage international linkages when possible and advantages.
- Trade & investment
  - Facilitate global trade and keep the ICT sector open to trade and foreign investment.
- Openness
  - Enable openness – open content, open source, open spectrum, and open access.
  - Encourage innovation enhancing competition.
  - Avoid predatory intellectual process regimes.
  - Use public consultations with a wide range of stakeholders when drafting national plans, policies and strategies for the development of the ICT sector in general or the deployment and take up of broadband in particular. Nurse a positive relationship with stakeholders, e.g., through enabling policy incubators to crowdsource ideas and brainstorm on out-of-the-box solutions for taking broadband to the next level.
- Neutrality
  - Ensure technology and service neutrality in licenses and policies.
  - Support net neutrality.

Taken together, countries at any level should be able to foster innovation in ICTs. In doing so, governments and the private sector must work together to form an agile relationship guided by mutual obligations and respect. Governments must provide an environment of incentives and resources, without letting its policies fall victim to corruption or powerful interest groups. Public and private actors can then become the source of new ideas, networking into the technological and organizational problem-solvers, which are the key to innovation in all economies.

Annex 1

Table 1 shows regression details for three multivariate correlation models, all three with patents per capita as the dependent variable. All data is from the 2007 World Bank World Development Indicators dataset. The first regression has as its explanatory variables the number of internet users per 100 people along with national GDP. The second model regresses fixed and mobile phone subscriptions per 100 people and GDP with the dependent variable, and the third model regresses fixed and mobile broadband subscriptions per 100 people and GDP with the dependent variable. The table shows the regression value for each of the two explanatory variables and for the constant (or intercept), along with their corresponding p values and their t-statistic in parenthesis. The number of observations (countries) in each model is 50 except for the regression with the broadband variable where the number of observations drops to 49. The overall fit to each model, R^2, and the model's F-statistic are also given.

Please see the introductory section on Broadband Enabled Innovation, above, for an explanation of these models' meaning.

Table 1: Three regression results for dependent variable, patents per capita, with internet users per 100, fixed and mobile phones per 100, and fixed and mobile broadband per 100. All regressions control for national GDP. Phone and internet penetration does not explain variation in number of patents while broadband penetration does. Number in parenthesis is t-statistic. Source: author's analysis of World Bank World Development Indicators, 2007 data.

Explanatory Variable	Dependent Variable: Patents per capita	p
GDP (USD)	1.70E-10 (–4.14)[a]	0.0001
Internet users per 100	3.28 (1.94)	0.06
Constant	–123.1 (–1.5)	0.14
Observations	50	
R^2	0.459	
F-statistic	19.97	<.0001
Explanatory Variable	**Dependent Variable: Patents per capita**	**p**
GDP (USD)	2.36E-10 (5.66)[a]	<.0001
Fixed + mobile phone per 100	0.45 (0.49)	0.63
Constant	–48.53 (–0.39)	0.7
Observations	50	
R^2	0.42	
F-statistic	16.95	<.0001
Explanatory Variable	**Dependent Variable: Patents per capita**	**p**
GDP (USD)	1.71E-10 (4.14)[a]	0.0001
Fixed + mobile broadband per 100	7.3 (3.67)	0.0006
Constant	–127.33 (–2.23)	0.031
Observations	49	
R^2	0.55	
F-statistic	28	<.0001

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1 Edquist, C. (1997). Systems of Innovation. (J. Fagerberg, D. C. Mowery, & R. R. Nelson, Eds.)*The Oxford handbook of innovation, 21*(5), 181-208. Oxford Univ. Press.

2 J.A. Schumpeter. (1942). *Capitalism, Socialism and Democracy.* New York: Harper.

3 Freeman, C., & Soete, L. (1997). The economics of industrial innovation (3rd ed.). Cambridge, MA: The MIT Press.: 19.

4 Marburger, J. H. (2011). Dimensions of innovation in a technology-intensive economy. *Policy Sciences*.

5 Kao, J. J. (2007). *Innovation Nation: How America Is Losing Its Innovation Edge, Why It Matters, and What We Can Do to Get It Back*. New York: Free Press.

6 Adam B. Jaffe and Josh Lerner. 2006. *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It*. Princeton, NJ: Princeton University Press.

7 Breznitz, D., & Murphree, M. (2011). Run of the Red Queen: Government, Innovation, Globalization, and Economic Growth in China. New Haven, CT: Yale University Press: 2.

8 AstraZeneca. (2011). AstraZeneca Innovation Survey. Wilmington, DE. Retrieved from www.astrazeneca.com/innovationsurvey.

9 First let's establish some statistical background (for those already with a background in this material please forgive the simplifications). A regression is a tool that establishes if two or more variables are related, namely if a change in one variable corresponds to a change in another variable (perhaps while holding fixed additional variables). The level of this relation is sometimes called a correlation and a positive correlation means that when the one variable increases so does the other variable (while a negative correlation means that when the one variable increases the other variable decreases). Regressions of this sort produce a number of merit figures, but only two are critical for our immediate purpose – the strength and direction (positive or negative) of the correlation and the likelihood that the correlation is not due to chance. The computed probability that a correlation is simply due to chance is expressed as a percentage and if this percentage is below some threshold set by the researchers than the correlation is said to have statistical significance. In the social sciences a threshold of five percent is often used; in other words if the correlation has a 95% likelihood to *not* be due to chance than it is excepted as significant.

10 Lundvall, B-A, Muchie, M & Gammeltoft, P. (2003). Introduction. In M. Muchie, P. Gammeltoft, B-A. Lundvall (Ed.), *Putting Africa First: The Making of African Innovation Systems* (pp. 1-10). Aalborg, Denmark: Aalborg University Press.

11 Sharif, N. (2006). Emergence and development of the National Innovation Systems concept. *Research Policy*, *35*(5), 745–766.

12 Freeman, C. (1987). *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.

13 Johnson, B & Lundvall, B-A . (2003). National Systems of Innovation and Economic Development. In M. Muchie, P. Gammeltoft, B-A. Lundvall (Ed.), *Putting Africa First: The Making of African Innovation Systems* (pp. 13-28). Aalborg, Denmark: Aalborg University Press.

14 Mytelka, L. K. (2003). The Dynamics of Catching Up: The Relevance of an Innovation System Approach in Africa. In M. Muchie, P. Gammeltoft, & B.-A. Lundvall (Eds.), *Putting Africa First: The Making of African Innovation Systems* (pp. 29-42). Aalborg, Denmark: Aalborg University Press.

15 Adapted from Bertelsen, P., & Müller, J. (2003). Changing the Outlook: Explicating the Indigenous Systems of Innovation in Tanzania. In M. Muchie, P. Gammeltoft, & B.-Å. Lundvall (Eds.), *Putting Africa First: The Making of African Innovation Systems* (pp. 123-138). Aalborg, Denmark: Aalborg University Press.

16 E.g. see Sullivan, K. (2006). In War-Torn Congo, Going Wireless to Reach Home. *Washington Post*, A01.

17 Innovative Partners Inc. (2009). *A Model for Sustainable and Replicable ICT Incubators in Sub-Saharan Africa*. Washington, DC.

18 Portions adapted from the forthcoming infoDev *Broadband Strategies Handbook*. Available: www.broadband-toolkit.org .

19 http://ihub.co.ke/pages/about.php

[20] Macharia, K. (2011). Kenya's iHub grows 10-fold. *ITWeb.* Retrieved July 4, 2011, from www.itweb.co.za/index.php?option=com_content&view=article&id=42813:kenyas-ihub-grows-10fold&catid=86.

[21] Macharia, K. (2011). Mobile incubation hub opens in Nairobi. *ITWeb*. Retrieved July 4, 2011, from www.itweb.co.za/index.php?option=com_content&view=article&id=44949:mobile-incubation-hub-opens-in-nairobi&catid=250.

[22] Macharia, K. (2011). Kenya's iHub grows 10-fold. *ITWeb*. Retrieved July 4, 2011, from www.itweb.co.za/index.php?option=com_content&view=article&id=42813:kenyas-ihub-grows-10fold&catid=86

[23] Blenford, A. (2009, September 16). New Africa broadband link "ready". BBC News. Retrieved from http://news.bbc.co.uk/2/hi/technology/8257038.stm

[24] Communications Commission of Kenya. (2011). *Quarterly Sector Statistics Report*. Nairobi. Retrieved from www.cck.go.ke

[25] *Ibid.*

[26] Farkas, K., Szabo, C., & Horvath, Z. (2009). Motivations, technologies, and sustainability models of wireless municipal networks. *IEEE Communications Magazine*, 47(12), 76-83.

[27] Galperin, H., & Bar, F. (2007). The Microtelco Opportunity: Evidence from Latin America. *Information Technologies and International Development*, *3*(2), 73-86.

[28] Gibbons, J., & Ruth, S. (2006). Municipal Wi-Fi: big wave or wipeout? *IEEE Internet Computing*, *10*(3), 66-71.

[29] Pinto, F., Garcia, A. C. B., & Ferraz, I. (2004). A New Model for Digital Inclusion in Brazilian Cities. *IADIS International Conference e-Society* (pp. 79-86).

[30] Teles, A., & Joia, L. A. (2011). Assessment of digital inclusion via the actor-network theory: The case of the Brazilian municipality of Pirai. *Telematics and Informatics*, 28(3), 191-203.

[31] Galperin & Bar (2007).

[32] Teles & Joia (2011)

[33] infoDev *Broadband Strategies Handbook*. Available: www.broadband-toolkit.org.

[34] Budge, E. C. (2003). Chile Case Study: E-Gov Experiences and Lessons. In *A Sourcebook on Access and Applications: Models of Use & Case Studies* (pp. 369-382). Washington D.C.: AED LearnLink.

[35] European Commission. Europe 2020 – EU strategy for smart, sustainable and inclusive growth. (2011). Retrieved August 8, 2011, from http://ec.europa.eu/europe2020/index_en.htm

[36] Council of the European Union. (2010). Council conclusions on Cross fertilization between Europe 2020 flagship initiatives Digital Agenda for Europe and Innovation Union. Brussels.

[37] Council of the European Union (2010).

[38] Freeman, C., & Soete, L. (1997). *The economics of industrial innovation*. Cambridge, MA: The MIT Press.

[39] Arrow, K. J. (1962). Economic Welfare and the Allocation of Resources for Invention. In R. R. Nelson (Ed.), *The Rate and Direction of Inventive Activity* (Vol. pp, pp. 609-627). Princeton, NJ: Princeton University Press.

[40] Phillips, S. (2007, July 25). A brief history of Facebook. The Guardian. Retrieved July 8, 2011, from www.guardian.co.uk/technology/2007/jul/25/media.newmedia.

[41] Mahan, A. K., & Melody, W. H. (Ed.) (2005). *Stimulating Investment in Network Development: Roles for Regulators*. Lyngby, Denmark.

[42] Dusollier, S. (2011). *Scoping Study on Copyright and Related Rights and the Public Domain*. Geneva : World Intellectual Property Organization.

[43] Smith, B. L., & Mann, S. O. (2004). Innovation and intellectual property protection in the software industry: An emerging role for patents. *The University of Chicago Law Review*, 71(1), 241.

44 Benkler, Y. (2007). *The wealth of networks: How social production transforms markets and freedom*. New Haven, CT: Yale Univ Press.

45 Zittrain, J. (2004). Normative Principles for Evaluating Free and Proprietary Software. *The University of Chicago Law Review*, 71(1), 265-287.

46 Bessen, J., & Hunt, R. M. (2007). An Empirical Look at Software Patents. *Journal of Economics & Management Strategy,* 16(1), 157-189.

47 Varsakelis, Nikos C. 2006. Education, political institutions and innovative activity: A cross-country empirical investigation. *Research Policy.* 35

48 Von Hippel, E. 1988. *The Sources of Innovation*. Oxford University Press; Von Hippel, E. (2005). *Democratizing Innovation*. Cambridge, MA: MIT Press.

49 Von Hippel (2005):4.

50 www.dbieducation.org/

51 DBI. (2010). Digital Bridge Institute: International Centre for Communications Studies. Abuja, Nigeria.

52 Percentage of respondents rating a particular link as “very important” or “moderately important” for industrial R&D shown in parentheses.

53 Cohen, Wesley M., Richard R. Nelson, and John P. Walsh. 2002. Links and Impacts: The Influence of Public Research on Industrial R&D. *Management Science 48*(1): 1-23.

54 Breznitz, D. (2007) *Innovation and the State.* New Haven, CT: Yale University Press.

55 ITU-infoDev *ICT Regulation Toolkit*. at: www.ictregulationtoolkit.org/en/Section.1695.html.

56 IDRC. (2011). *Information and Networks Program Prospectus for 2011-2016. Program*. Ottawa.

57 Anderson, C. (2009). *Free: The future of a radical price*. New York, NY: Hyperion Books.

58 Miller, P. D. (2004). *Rhythm science*. Cambridge, MA: MIT Press.

59 http://creativecommons.org/

60 Benkler, Y. (2007). *The wealth of networks: How social production transforms markets and freedom*. New Haven, CT: Yale Univ Press: 427-438.

61 Benkler, Y. (2007).: 60, 63.

62 Blumberg, A., & et al. (2011). When Patents Attack! This American Life. Retrieved from www.thisamericanlife.org/radio-archives/episode/441/when-patents-attack

63 Kingstone, S. (2005, June 2). Brazil adopts open-source software. *BBC News.*

64 Portions adapted from the forthcoming infoDev *Broadband Strategies Handbook*. Available: www.broadband-toolkit.org.

65 ABI Research, *Wi-Fi IC Shipments Forecast to Surpass 770 Million Units in 2010* (Nov. 2010), available a*t* www.abiresearch.com/press/1664-Wi-Fi+IC+Shipments+Forecast+to+Surpass+770+Million+Units+in+2010.

66 Steve Song, personal communication.

67 Neto, I., Best, M. L., & Gillet, S. E. (2005). License-Exempt Wireless Policy: Results of an African Survey. *Information Technologies and International Development, 2*(3), 73-90.

68 Battiti, R., Lo Cigno, R., Orava, F., & Pehrson, B. (2003). Global growth of open access networks: from warchalking and connection sharing to sustainable business. *Proceedings of the 1st ACM international workshop on Wireless mobile applications and services on WLAN hotspots* (p. 19-28).

69 Cohill, A. M. (2010). *Broadband for America: The Third Way*. Retrieved from www.designnine.com/bradband-the-third-way.html.

[70] Macmillan, R. (2009). *Connectivity, Openness and Vulnerability: Challenges Facing Regulators.* ITU: Geneva.

[71] Adapted from the forthcoming *info*Dev *Broadband Strategies Handbook*. Available: www.broadband-toolkit.org.

[72] ITU-*info*Dev, *ICT Regulation Toolkit, Module 7: Technology neutrality*, available at www.ictregulationtoolkit.org/en/Section.1833.html.

[73] ITU, *Trends in Telecommunications Reform 2004-2005: Licensing in an era of convergence* (Dec. 2004), available at www.itu.int/ITU-D/treg/publications/Trends05_summary.pdf.

[74] ITU, *Botswana: BTA grants BTC a service-neutral license* (Mar. 21, 2007), available at www.itu.int/ituweblogs/treg/Botswana+BTA+Grants+BTC+A+Serviceneutral+License.aspx.

[75] EU, *Directive 2009/114/EC of the European Parliament and of the Council amending Council Directive 87/372/EEC on the frequency bands to be reserved for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community* (16 September 2009), available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:274:0025:0027:EN:PDF.

[76] Akyildiz, I., Lee, W., Vuran, M., & Mohanty, S. (2006). NeXt generation/dynamic spectrum access/cognitive radio wireless networks: A survey. *Computer Networks, 50*(13), 2127-2159. doi:10.1016/j.comnet.2006.05.001

[77] Robert D. Atkinson and Philip J. Weiser, *A "Third Way" on Network Neutrality*, The Information Technology and Innovation Foundation (May 30, 2006) at www.itif.org/files/netneutrality.pdf.

[78] E.g. see ITU. (2003). *Trends in Telecommunication Reform 2003: Promoting Universal Access to ICTs*. Geneva: ITU.