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ABSTRACT

Is intellectual property inimical to the development and deployment of technologies specifically designed for markets with no consumer power, i.e. for the poor? This paper examines the role of intellectual property in innovation for the poor in developing countries through two in-depth case studies of technologies emerging from Lawrence Berkeley National Laboratory: a novel water purification system and a new cook stove designed to improve health and environmental outcomes. The discussion highlights how intellectual property operated within different funding environments that mixed public and private elements in novel ways. The paper offers an assessment of the kinds of work patents and licenses performed in each case, and analyzes the consequences—some intended and some not—of using intellectual property in developing technology. Besides providing some instructive lessons for the use of patents and licenses, the cases also demonstrate how new approaches for funding humanitarian innovation have blurred the categories of for-profit and non-profit.

1. Introduction

Although the causes of endemic poverty are various and complex, low-cost technologies can play a vital role in improving the lives of billions of people. These technologies are, however, severely underprovisioned (Cash et al., 2003). One of the many tools available to incentivize development for technologies is intellectual property (IP). But IP has traditionally been used in profit-making ventures for the private sector, whereas developing technologies for the “bottom two billion” is often an endeavor driven by academic non-profits and government-funded researchers. Is there a role to play, then, for IP in development of technologies for the poor, and, if so, what is it?

This paper seeks to understand whether and how IP can help foster research and development in technologies created in industrialized countries but designed to enhance the basic life conditions of the global poor. The innovation literature is replete with analyses of intellectual property as an incentive to innovate, and case studies of technologies for the poor are growing increasingly common. However, there is a need to combine these two threads in order to consider the special case of IP in engineering for the global poor, especially for technologies other than medicines. We do so by analyzing two case studies: UV Waterworks and Improved Cookstoves for Ethiopia. These two cases reveal how patents perform important kinds of work within a new kind of humanitarian innovation ecosystem—from structuring networks of private and public actors, to preserving inventor control for follow-on work. At the same time, intellectual property can erect barriers within the innovation network that are difficult to overcome. Together, these case studies suggest the importance of understanding the effects of using market-oriented tools such as IP for technologies aimed at improving basic living conditions.

2. Background

2.1 Evolving Landscape of Innovation in Technology for the Poor

Although the explicit aim of designing and disseminating technologies for the global poor is not new, perceived failures in traditional development methods have renewed interest in technological innovation for the developing world (Easterly, 2003). In part because private investment has been inadequate to address human need for these technologies, foundations and governments often support early research and development in places like non-profit organizations, universities, and national labs. However, good results are rare: developing any technology, let alone one for which there is need but little consumer market, is a complex proposition involving many obstacles all along the supply chain from invention to distribution to adoption. After initial development and even prototyping, most technologies designed for the poorest never make it into the hands of their intended beneficiaries. This is as much true of medicines as it is for “mundane” technologies (Kammen and Dove, 1997) or what we call “technology for the poor”: hardware projects such as water purifiers, solar lights, irrigation pumps, and improved cookstoves that are designed specifically for use by the poor in developing countries and have the potential to enhance health, generate income, and conserve local environments.[1]

Partly in response to perceived development failures of the past, new approaches seek to incorporate actors and tools from the for-profit sector. Prahalad's "Bottom of the Pyramid" approach (Prahalad and Hammond, 2002), for example, argues that multinational corporations, through creative adaptation of their current products, can meet many of the needs of the global poor while still realizing a profit. At the same time, growth in socially responsible investment (SRI) and so-called "patient capital" has meant that even with very low return on investment, those seeking to develop and distribute technologies for the poor may be able to obtain investment capital instead of traditional donor funding. For those situations in which the incentives for private businesses are not fully developed, public-private partnerships have become popular vehicles through which to combine the strengths of the public and private sector using hybrid organizational and funding structures.

According to their proponents, market-based approaches have potential advantages over the traditional system of philanthropic support. They may create greater efficiency in organizational operations. Further, since they rely less on annual grants and the fluctuating attention of donors, they may be more sustainable over the long term. As such, many humanitarian engineering initiatives, even those funded by the non-profit sector, are experimenting with market-based approaches and investor financing as a means of raising the necessary funding and implementing new technological systems (Thomas and Amadei, 2009; Prahalad and Hart, 2002).

However, many of the actors and organizations experimenting with these new forms are unfamiliar with for-profit R&D investment tools, including intellectual property (IP). Although IP can be useful in generating the financing needed to develop and implement new technological systems, many organizations transitioning to market-based approaches are struggling to define the role it should play, i.e., whether and how to invoke intellectual property protection in their products for the poor.

2.2. Intellectual Property and Innovation for the Poor

The role of intellectual property in promoting the research, development, and dissemination of technologies for the poor technologies is not well understood. In general, research in this area falls into four camps. The first attempts to ensure that IP does not block reasonable spillovers or transfers of appropriate technologies to humanitarian applications, e.g., the use of licensing to allow for generic drug distribution in particular geographical areas (Lanjouw, 2002; Kapczynski, 2009). The second, following the strategy pioneered by PIPRA,[2]

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[1] "Poor" is a somewhat problematic term because it is inherently relative, and because of its pejorative connotations. We define "the poor" here as those of the lowest socioeconomic classes living within developing countries or middle income countries, keeping in mind that the poor are not one entity and that part of the challenge of alleviating poverty is developing a finer grain.

[2] Established in 2003 by a coalition of a dozen universities and research institutes with seed funding from the Rockefeller Foundation, PIPRA (Public Intellectual Property Resource for Agriculture) seeks to make agricultural biotechnologies more easily available for the

develops licensing approaches that engage in market differentiation between higher income commercial market applications and humanitarian applications. The third is how IP might be used to incentivize development of technologies arising from developing country (typically public) R&D for local, regional, or global commercial applications. The fourth is the use of IP to incentivize development of technologies arising from industrialized country R&D for developing markets or humanitarian use in the global South (e.g., Mimura et al., 2011).[3] This fourth angle is the remains the least developed in the literature. This is a significant gap given that the use of intellectual property strategy is becoming more important at foundations, universities and firms that are funding R&D for the poor. For this reason, we seek to generate empirical evidence of the effects of using IP to incentivize development of technology for the poor.

The rationale for intellectual property appears to be weak in these cases for a number of reasons. First, the lack of "market pull" seems to nullify the theoretical benefits of IP: in the near absence of profit from a product, there is little use in expending resources to protect that product from competition. Moreover, in some important cases, primarily those concerning vaccines, fears have been raised that, due to monopoly pricing on the resulting product, IP blocks access by the poor to these very products (Muzaka, 2009; Sell and Prakash, 2004). Since patents are theoretically useless as an inducement mechanism where market pull is weak and have restricted access in some cases, patenting has often been portrayed as unnecessary, perhaps even harmful to the interests of the poor. Therefore, a leading option would appear to be the use of public financing followed by the release of the resulting innovations into a commons or the public domain. Yet patenting is occurring in the domain of mundane technology, and this demands analysis.

3. Case Studies

The two technologies at issue, *UV Waterworks* and *Improved Cookstoves for Ethiopia*, aim to improve basic living conditions through purification of drinking water and reducing fuelwood consumption and emissions, respectively. Water sanitation and indoor air quality—strongly affected by emissions from household cooking—are critical components of human health and well-being. Because twenty percent of the global poor lacks access to clean drinking water (Bartram et al., 2005), mass adoption of water purification technologies has the potential to save millions of lives. Without intervention, unsafe drinking water and poor sanitation will lead to the deaths of as many as 135 million people by 2020 (Gleick, 2002). Cookstoves also play a central role in the health of the poor, especially women and children. Two billion people worldwide use biomass for cooking, largely on inefficient traditional three-stone fires that require an excess of firewood and produce large amounts health-damaging pollutants (Smith, 1994; Smith et al., 2010). These stoves are strongly associated with number of negative health effects including pneumonia, tuberculosis, and low birthweight (Fullerton et al., 2008).

UV Waterworks and the Improved Cookstoves share a number of key characteristics. Like many of the inventions categorized as humanitarian, they came out of an academic

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development and distribution of "orphan crops"—meaning both subsistence crops developed for humanitarian purposes in the developing world and specialty crops developed for smaller-scale and often regional commercial markets.

[3] We are indebted to Greg Graff for insights in this paragraph.

laboratory. Home to significant resources in science and technology (both human and material), and driven by public missions, universities and national laboratories are particularly well-suited for innovation for the poor (Cash et al., 2003; Kammen and Dove, 1997). Universities, in particular, have long histories of involvement with engineering these technologies.[4] In this case, both technologies came out of work done at the University of California–Berkeley ("U.C. Berkeley") and the Lawrence Berkeley National Laboratory ("LBL" or "the Lab"), which have a close partnership. In fact, the two technologies discussed below also share an inventor: Ashok Gadgil, a Senior Scientist at LBL and professor at U.C. Berkeley. In addition, they were patented by the same Technology Transfer Office (TTO) at LBL.

Despite sharing common characteristics, the innovation paths and outcome for each technology were quite different. Because intellectual property concerns were central to these different outcomes, and because they both emerged from the same institutional milieu, the contrasts of the cases furnish insight into the role of intellectual property in enabling and obstructing humanitarian R&D.

3.1 Case Study 1: UV Waterworks[5]

3.1.1 *Invention and Patent*

UV Waterworks is a community-scale water purification technology deployed by the private, for-profit company WaterHealth International and invented by Dr. Gadgil. Born and raised in India but working at LBL, mostly on U.S. indoor air pollution issues, Gadgil turned his attention to designing a water disinfection technique that was effective, affordable, and scalable after a large cholera outbreak hit India in 1993. After exploring various alternatives, he concluded that ultraviolet (UV) disinfection offered a sound method for getting clean drinking water to the hundreds of millions of people in the developing world who were without access. Dr. Gadgil had no funding to work on this project, but in the summer of 1993 was able to get a colleague to pay a graduate student to work on the UV water disinfection project over the summer. The student, Derek Yegian, began by working out the economics of UV water purification under ideal conditions. Dr. Gadgil quickly became convinced that, given the size of the market and the low cost of the UV disinfection process, they could create a cost-effective solution using a UV technology.

By 1995, after a series of field tests and modifications, Dr. Gadgil had developed a prototype of the UV water-disinfection system, eventually known as "UV Waterworks." This system, designed for community level use, uses a 36-watt ultraviolet bulb to disinfect

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[4] See, e.g., various projects from any of the numerous university programs targeted at developing technologies for the poor including Engineers Without Borders <www.ewb-usa.org>, U.C. Berkeley Blum Center <http://blumcenter.berkeley.edu/>, University of Colorado Mortenson Center in Engineering for Developing Communities <http://ceae.colorado.edu/mc-edc/>, and MIT D-Lab <http://d-lab.mit.edu/>. All last visited May 2, 2012.

[5] Except where otherwise noted, information in this section comes from interviews with Ashok Gadgil (November, 2009), representatives from the TTO at the Lawrence Berkeley National Laboratory (June 10, 2010), and Elwin Ewald (June 9, 2010).

contaminated groundwater. It delivers 120 mJ/cm^2 of ultraviolet radiation to the water surface, which disrupts the DNA of microorganisms in the water, deactivating 99.9999% of contaminating pathogenic bacteria and microbes. By delivering a UV dose to the water that is three times higher than that required to disinfect the water per U.S. Environmental Protection Agency (USEPA) standards, UV Waterworks ensures a very large margin of safety in the disinfection process. Gravity moves the water through the system, and, in the case of malfunction or loss of electricity to power the ultraviolet light, a valve shuts automatically, preventing further water from entering the device. One unit can provide safe drinking water for approximately 2000 people (LBL, 2010a). Although the use of UV light to disinfect water was well-known and not in itself a new invention, Gadgil's design was innovative in that it used a gravity feed that eliminated the need for a pressurized water delivery system and complicated maintenance, both of which made it more applicable to developing country contexts (LBL, 2010b). Also, careful attention to hydrodynamics ensured a reliable dose of UV energy to the water (Fig 1).

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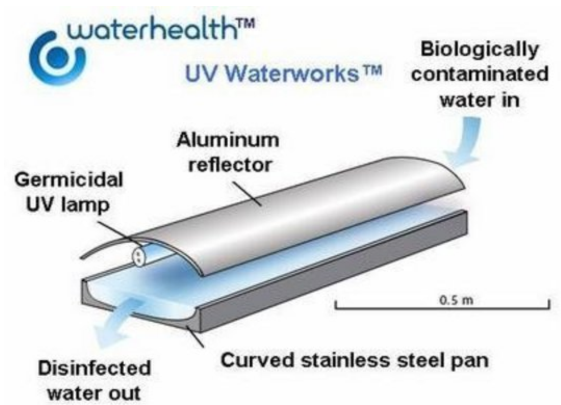


Figure 1. UV Waterworks Technology

As required by his employment agreement, Dr. Gadgil disclosed the prototype to the technology transfer office (TTO) at LBL so that they could decide how to proceed with the IP. Gadgil's original intent had been to post the design publicly on the internet so that anyone could build a UV Waterworks system. However, personnel at the TTO dissuaded him. Their argument, which Dr. Gadgil found persuasive, was that individuals would not have the interest or capability to build a UV Waterworks system on their own; it needed to be developed and manufactured by a company. They argued that it was unlikely that a company would invest resources into distribution systems and the other infrastructure unless they had some kind of IP protection to guarantee the "lead time" needed to recoup the initial investment before competitors entered the market. Gadgil ultimately agreed. He had done some rough calculations to show that there was potential for the technology to become profitable and agreed that large-scale dissemination would be more likely if the technology were developed by a for-profit organization.

In 1996, the LBL office of technology transfer filed the patent for protection in the US and several other countries internationally, excluding India under a deal with the joint inventor of the technology. They then put the technology up for licensing with a caveat stating that the technology must be disseminated in a developing country chosen from a list compiled by the TTO. If the licensee complied with that requirement, they could also enter the US market. A number of companies showed interest, each wanting an exclusive license. LBL chose to grant the exclusive license to the Elwin Ewald Group, a group of "socially-conscious" investors that had been searching for a technology upon which to build a company to serve the poor. The Elwin Ewald Group then formed the for-profit company WaterHealth International and began the process of developing and disseminating UV Waterworks in India.

3.1.2 *Investors*

Elwin Ewald, the founder of the Elwin Ewald Group, had spent many years working in developing countries. Not seeking a personal profit, Ewald sought to serve the needs of the world's poorest through the development of a technology. When he found the UV Waterworks technology at LBL, he believed it offered a unique opportunity to benefit the poor and decided to procure it from the TTO at LBL. In searching for a technology, Elwin Ewald had initially preferred to pursue a non-profit route to development and distribution. However, he did not believe that he had enough money to start an effective non-profit and instead decided to create a for-profit company, which would allow him to bring in investors. In the initial round of financing, Ewald was able to attract about $500,000 in investments from socially responsible investors (half coming from his own family) who were interested in humanitarian endeavors. While these investors wanted to make back the money that they were investing and make a small profit, roughly 4%, they were not motivated by a desire for a large return on investment.

Having secure IP rights to the technology was instrumental in allowing Ewald to finance the project. In fact, the power and necessity of IP protection for the "socially conscious" investors became clear when a number of them threatened lawsuits when a licensing dispute erupted in the early days of the venture. Ewald had understood that his group had exclusive worldwide rights to the technology. In fact, LBL had previously given a joint inventor rights to license the technology in India in exchange for LBL's undivided right to license it in the rest of the world. When this situation came to light, Ewald's investors threatened to withdraw funding unless Ewald could consolidate the rights to the technology. Ultimately, the Elwin Ewald Group, now WaterHealth International, was able to purchase the India-specific rights after the Indian venture went bankrupt. It has now gone through several additional successful rounds of financing, attracting the socially-responsible arms of multiple corporations.

3.1.3 *Commercialization and Dissemination*

The process of developing the UV Waterworks technology for the market was not a smooth one. When Ewald purchased the license for UV Waterworks in 1996, the technology was still at the prototype stage. Moreover, there was no business model for how to distribute devices, and WaterHealth International (WaterHealth) had to spend much more time and resources than they had anticipated in experimenting with versions of the technology and different business models, each of which depended on the other.

In the beginning, WaterHealth intended to use an approach that Gadgil describes as the "lightbulb factory." Under that business model, the role of WaterHealth would be to simply produce and sell community-sized UV Waterworks units that consumers would take to their communities and plug in to receive clean water in the same way that they might buy a lightbulb, take it home, screw it in, and get bright light. WaterHealth soon realized, however, that this model is effective only because the utility and all the other components of the electricity system are in place and of high quality: you can't use a lightbulb if there is no socket, no power, no switch and no grid. In the case of UV Waterworks, the analogous system was lacking, which meant that the lightbulb factory approach turned out to be unsuccessful, nearly driving the company into bankruptcy.

The problems with this approach involved both profit and quality. Regarding profit, those installing the storage tanks and water pumps—so-called system integrators—were charging high rates for their services so that much of the money that consumers were paying for the purification units was actually going to these system integrators, not to WaterHealth; the system integration turned out to have much higher profit margins than the sale of the UV Waterworks units. Furthermore, some of these system integrators were taking shortcuts to save costs such as using poor quality pumps and low-grade plastic for the storage tanks, and these shortcuts were giving the WaterHealth system a bad reputation, even thought they were the fault of the system integrators, not the units themselves.

WaterHealth came close to bankruptcy before it developed its ultimate business model: fully integrated, community-scale water treatment plants. In this model, WaterHealth constructs "WaterHealth Centers" which are each intended to provide enough clean drinking water per day to serve either 2,000 or 6,000 people, depending on the type and size of the unit. These civil structures house the UV Waterworks units, which include plumbing, machinery and controls for pumps, tanks, motors and leveling, and are owned by the local village council. WaterHealth employees provide ongoing staffing, water quality testing, and maintenance under contract from the village council. The company also uses an innovative financing model in which communities that desire a Center must provide a down payment, with the rest of the cost financed either through either local banks or the International Finance Corporation, which provided $15 million in financing to WaterHealth in 2009 (WaterHealth, 2009). As a result, Centers can be paid for by the community over time, and can become an income-generating asset for the community. The company also partners with a local NGO to provide education around clean water to its consumers.[6]

WaterHealth is now a sustainable operation with about 500 WaterHealth Centers, the majority of which are in India. Their service capacity now exceeds five million people per year, and they were estimated to have earned $10-25 million in revenue in 2009 (Zoominfo, 2009). They have also expanded to Philippines, Sri Lanka, Ghana, Nigeria and Liberia.

[6] Description of WaterHealth's approach and facilities as well as more information on their activities is available at <http://www.WaterHealth.com>.

3.2 Case Study 2: Cookstoves for Ethiopia[7]

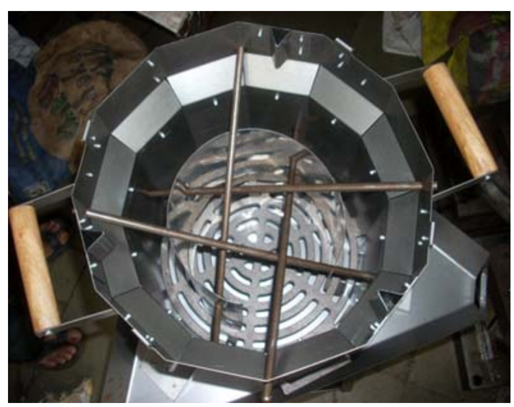
3.2.1 Invention and Patent

In late 2004, a caller from the the Office of Foreign Disaster Assistance of U.S. Agency for International Development (USAID) requested that Dr. Gadgil to develop a screw-compactor to pelletize sun-dried kitchen waste so it could be used to partially replace fuelwood by Darfur refugee women. The women were being systematically raped as they left their camps to forage for fuelwood in the semi-desert region (Kristoff 2005), spurring USAID and others to search for technologies that might decrease the use of firewood in the camps. Dr. Gadgil quickly showed that kitchen waste would make an insignificant impact on fuelwood demand. However, in a few months of further investigation, he discovered that almost all refugee women cooked on very inefficient three-stone fires. Replacing these three-stone fires with more efficient cookstoves could potentially lead to significant reductions in the amount of firewood needed. He raised funds and assembled a team to visit Darfur in 2005 to collect data on fuel food, cooking methods and local technical capacity. Dr. Gadgil and his team also brought along and tested three different stoves, and also one that was made locally. He concluded that none of the stoves was sufficient but that one of them, the metal wood-burning “Tara” stove from India, offered a good starting point from which to develop a culturally-acceptable and fuel-efficient cookstove designed especially for the people of Darfur.

Over the next three years, Gadgil and his colleagues worked on improving the technology, now known as the Berkeley-Darfur Stove, with the assistance of engineers at LBL, Engineers Without Borders, and many different students from the U.C. Berkeley. In all, he estimates that around 150 people were involved in the project in some way by late 2008. The costs, not accounting for time donated, had reached around $300,000, which were met mostly with private donations and USAID grants to a host NGO in Darfur. Since 2009, in addition to private donations, significant support was received from U.C. Berkeley's Blum Center and the Sustainable Products and Services Program. The stove, now in its fourteenth version, uses less fuel and burns more cleanly than the three-stone fires or mud cookstoves traditionally used in the region and has been adapted to the cooking styles and pots specific to the Darfur region. Over the period 2008-2010, the Berkeley-Darfur Stove was also modified for use in Ethiopia with funding from the U.S. Department of Energy and support from international NGOs. This new model of the stove is known as the Berkeley-Ethiopia Stove (BES) and is more fully described below.

[7] Except where otherwise noted, information in this section comes from interviews with Ashok Gadgil (December, 2009), representatives from the TTO at the Lawrence Berkeley National Laboratory (June 10, 2010), and representatives from World Vision Australia (June, 2010).

Figure 2: The Ethiopian version of the Berkeley-Darfur Stove



Initially the technology transfer office (TTO) of LBL decided not to patent the Berkeley-Darfur Stove, primarily because, given the weaker legal systems in Sudan, the patent would likely not be enforceable and, thus, not confer any benefit. However, Dr. Gadgil believed that because the stove could eventually be widely used in Africa, with potential application to as many as 70 million people, it was worthwhile to protect the invention and try to draw the interest of a company, much as was done with UV Waterworks. He also hoped that the stove, if commercially successful, might generate a small stream of revenue for LBL which could be used to further similar work on humanitarian engineering projects. A third rationale for a patent was to retain some power to prevent the distribution of knock-offs of inferior quality: because design modifications of even a centimeter or changes in material specifications could make the stove much less efficient, short-lived, or a safety risk, quality control was perceived to be essential. Poor manufacturing or knock-offs can be sold cheaper, driving good quality out of the market, and, in addition, hurting the name of the design around the world. Patents were seen as one way to increase the amount of control LBL might have in assuring the bona fides of manufacturers.

Improved cookstoves had not traditionally been profitable enough to draw the interest of private investors, but many in the stove community believed that the advent of the carbon market was about to change that. While NGOs, governments, and academics had long been interested in improved cookstoves for their promise of better health for women and children and reduced local deforestation, the carbon market added a profit-motive to these so-called social and environmental "co-benefits" (see, e.g. Haines and McMichael, 2009**).** Because improved cookstoves can generate cost-effective carbon emission reductions through reduced fuel use, private investors were beginning to show interest in the stoves as an opportunity to make profits in the carbon market. Given this changing outlook for cookstoves as a commercial venture, the TTO decided that it would be worth filing a patent in order to interest carbon companies that might require IP protection as a condition of investment in developing the stove. In 2007, LBL applied for and was granted a design patent, weaker than a utility patent, which covers the "look and feel," of the Berkeley-Darfur Stove.[8] Since then, there have been a number of organizations seeking free licenses or free access to the stove's technical specifications. These have been denied, spurring some criticism among some advocacy groups.

3.2.2 *Development Partnership*

Dr. Gadgil hoped that the licensing would proceed similarly to UV Waterworks, that one or more companies would come forward to commercialize the stoves and develop a viable business model. However, though the stove had gotten positive attention in the media and in academic circles, no companies approached LBL to purchase a license. There began to be interest, though, from NGOs with activities in Africa.

In fall of 2008, Dr. Gadgil was approached by World Vision International (WVI), the world's largest NGO, which describes itself as a "Christian relief, development and advocacy organization dedicated to working with children, families and communities to overcome poverty and injustice."[9] WVI had heard of the Berkeley-Darfur Stove and was interested in using it in a project in Ethiopia to be partially funded by carbon credits generated through use of the stove. WVI had an international investor who would supply the up-front money in exchange for a portion of the carbon credits, which could then be sold at a profit on the European market. World Vision's intention was to distribute 100,000 cookstoves, which would be large enough to

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[8] In general, a "utility patent" protects the way an article is used and works (35 U.S.C. § 101), while a "design patent" protects the way an article looks (35 U.S.C. § 171) (U.S. Patent and Trademark Office 2011).

[9] World Vision International website, <www.wvi.org>, last visited May 2012.

generate the kind of profit necessary to interest a private investor. In preliminary estimates, an Ethiopian version of the stove would cost about $30, last five years, and generate ten metric tons of carbon offsets worth more than $150, thus enabling a carbon-credit financed self-sustaining cookstove dissemination program.

In the first stage of the project, WVI was seeking multiple stove models to test in Ethiopia for efficiency and user preference in order to determine which models they would ultimately distribute. Initially, WVI wanted to simply purchase the stoves from LBL. But as a research laboratory, LBL never sells products, relying on partners to take the technology from the invention stage through commercialization. WVI did not typically engage in product development, but Dr. Gadgil proposed that together LBL and WVI could apply for a technology commercialization grant in response to a competitive call put out by the Department of Energy. This grant could pay for testing and modification, as well as technical support by Gadgil and his students for the commercialization process. World Vision agreed to partner with LBL to develop the stove for Ethiopia because they were very interested in certain aspects of the stove, such as its potential for local manufacture in Ethiopia. In addition to their technical support, Gadgil and LBL also promised assistance with the supply chain they had set up as part of the Darfur stove project. The grant application was successful, and in March 2009 LBL received $138,000, to be matched by World Vision (now World Vision Australia, not World Vision International, see below) to pursue the modification, commercialization, and distribution of the Berkeley-Darfur Stove using carbon credit financing.

3.2.3 *Commercialization and Dissemination*

To obtain the project funding, each side had to sign a cooperative research and development agreement (CRADA), a boilerplate contract required for any such partnership with a national lab. CRADAs typically run several pages and include some items that are negotiable, such as the royalty terms of the license, and some that are not, such as liability. One piece of the CRADA between LBL and World Vision Australia (WVA), as is typical, was a licensing agreement, in this case specifying that WVA would agree to a non-exclusive license of the Berkeley-Darfur Stove.

The CRADA licensing agreement deployed innovative terms that reflected a desire on both sides to promote wide dissemination. First, although the TTO did not give WVA the license for free, they set the up-front payment very low but not at zero. Why not give the licenses away for free? The LBL TTO required some form of up-front payment because they wanted the organizations purchasing licenses to demonstrate sufficient resources for developing the technology. Further, LBL did not want to create any precedent for free licensing for technologies whose charitable purpose was more questionable. Second, they decided to try a novel approach whereby the Lab would receive a fraction of the carbon credits instead of traditional royalties, again making the license more affordable to WV and delaying royalty payments until such time as the project was successfully selling carbon credits. Third, World Vision did not demand an exclusive license as they wanted other NGOs in the region to be able to use the stove if they so desired.

During the grant application process, control of the project on the World Vision side was transferred to the Australian office, WVA, which had already successfully undertaken a carbon forestry project in Ethiopia. However, while World Vison International had indicated willingness to license the technology, WVA was more reluctant. Specific terms in the licensing agreement proved problematic. While WVA was willing to pay the up-front sum and the carbon credit royalties, they were unwilling to indemnify LBL and UC Berkeley against all liability: they felt the organization simply could not take on this kind of risk. For the TTO at LBL, use of the clause indemnifying the Lab in case of harm was a non-negotiable piece of all its licenses, a position that is echoed in many universities and national laboratories.[10] Because of this indemnification issue, LBL and WVA were unable to come to agreement over the license, so it was eventually removed from the CRADA.

In August 2009, five months after the grant was initially awarded, the CRADA, now without the licensing agreement, was signed and funds released for the project. At that time, WVA had plans to produce and disseminate up to 1000 of the stoves, even without a license from LBL. At the same time, LBL signed a "nonassert" covenant saying that they would not seek to enforce their patent against WVA. These covenants (or "nonasserts") are usually signed statements giving explicit permission to third parties to practice a patent they would otherwise infringe.[11] In signing the "nonassert," LBL enabled the project to move forward, but lost out on any future carbon royalties, which may turn out to be significant. In this case, both WVA and UCB/LBL believed that the absence of a formal license offered them some liability protection. However, because there was no official agreement on the use of the stoves, the site of legal liability if someone were to decide to sue for damages from the stove remains unclear.

4. Discussion

Sociologists and economists of innovation have moved from a linear model of technological development to an ecological one, and from a notion of technology as a bounded material objects to heterogeneous networks of institutions, things, and actors (see, e.g. Latour, 1993; Bijker, 1995). In theory, intellectual property can help configure and shape those networks (Strathern, 1996) by making legal fences to keep certain actors out, and opening restricted byways to selective collaborators. Its role in innovation for the poor must be understood in the context of such network structures and relationships.

Based on the cases of UV Waterworks and Cookstoves for Ethiopia, we identified issues that should be considered when attempting to determine the effect of IP on this innovation in technology for the poor. Perhaps the most important is that of organizational structure. As described in this paper, the institutional ecology of innovation for the poor is complex, often consisting of multiple partners at various stages. Yet our cases suggest that the role of IP can be

[10] Universities and national labs require indemnity so as not to threaten their broader educational and research missions with liability lawsuits resulting from their licenses, which form a relatively minor part of their operations. As entities with "deep pockets," they may be attractive targets for such lawsuits and, as such, carefully protect themselves from liability.

[11] To execute a nonassert, a patent holder usually makes a public or private declaration that they will not legally enforce the patent with respect to certain uses and users. "Legally, nonasserts are patent-infringement settlement agreements that are designed and drafted with the purpose of preemptively resolving future infringement disputes" (Krattiger, 2007).

usefully mapped onto two distinct funding models of the commercialization and distribution partners. The first type, *Investor-Financed Commercialization/Distribution*, is rather more straightforward, while the second type, *Donor Funded Commercialization/Distribution*, calls for further considerations.

4.1 Type 1: Investor-Financed Commercialization/Distribution

If the development and distribution process requires private capital at any point, then securing IP protection may be useful. In the case of UV Waterworks, LBL took out a patent to help induce investment. As it turned out, the patent was necessary: socially responsible investors involved in the early stages of WaterHealth demanded that the technology be patented so that if the necessarily large up-front investments eventually paid off, they would be able to, at the minimum, recoup their investment, even at the relatively modest levels that WaterHealth initially required. After all, the Elwin Ewald group had to not only move the technology from prototype to product, but also develop the enabling infrastructure and distribution systems. Equally challenging was the process of finding a business model that would be profitable and sustainable.

These difficulties suggest that patents can be important in garnering the investment funding necessary to establish the periphery infrastructure, build local capacity, and overcome the various obstacles of working in an undeveloped market. These costs are significant for the kinds of organizations involved, typically NGOs or small start-ups, and are very high relative to the potential revenues. Even more importantly, initial entrants into markets for the poor face a high degree of risk, especially on the distribution side—they must find the right business model and then prove that it is viable. As Gadgil describes this process, “It is not sending another product down the road. There is no road!” Getting financing to operate in such risky environments can be difficult, especially for the first mover. However, once these pieces are put in place by the initial developer and the model is proven, later entrants benefit from the work done by the first innovator and face much lower costs of entry. Therefore, IP protection may be necessary to incentivize initial entry.

The UV Waterworks case also suggests that patents play an important signaling function to investors, whether warranted or not, even where profits may be low and enforcement of IP rights may be difficult, if not impossible. This finding mirrors research on innovation markets in the developed world showing that patents with no intrinsic value to the company still had extrinsic or “optical” value to investors (Graham and Sichelman, 2008, p. 1078). Even though it was highly unlikely that LBL would sue patent infringers in India, unless they were large multinational companies, the investors felt secure in their investment only when they had the patent and exclusive license in place. We should caution, however, that this observation about investor attitudes in the technology-for-development space does not necessarily militate for patenting such technologies from the perspective of public policy.

4.2 Type 2: Donor Funded Commercialization/Distribution

The contrasting case occurs when the commercializing or distribution partner does not rely on investors for financing but uses grants and donations for their operations. In this case, there is no need to pull in for-profit investors who might require the legal power to sue unauthorized makers, users, and sellers of the technology. The organizations distributing the technologies, generally non-profit development organizations, have already built substantial links to their donors, so that the attractive force of IP is not necessary for moving through the R&D network. Yet, particular aspects of the stove case above cast doubt on the idea that IP should be avoided in all of these situations. When the implementing partner is not investor-funded, simply eliminating IP does not resolve the fundamental difficulties of development of technologies for the poor, and there may still be benefits to pursuing IP protection in certain cases. Based on our cases, we have identified two distinct effects that should be considered in assessing the use of IP in a donor-funded context: risk of liability and control of technology.

4.2.1 *Donor Funded: Risk of Liability*

The Cookstoves for Ethiopia case illustrates how, in donor-driven cases, IP can in fact impede technological development and deployment. The mechanism by which it did so in this case, however, was distinct from those typically discussed in the literature: it was not price or access by the poor that was at issue, but rather attribution of risk and liability on the part of the patent-holder and the implementing partner. The formal and legal linkage that IP establishes between the inventor and the implementer brought the perception of unacceptable risk to these organizations.

The case further indicates what seems to be a clash of cultures problem. The culture of a non-profit organization like WorldVision Australia was unaccustomed to dealing with technology transfer and product development. The TTO is a unique kind of commercial agency working within a non-profit research institution, primarily licensing technology to industry, not NGOs. LBL and WorldVision are both organizations with broad social missions and significant assets that they are unwilling to put at risk through the technology transfer process. The partnership between a National Lab/University and a non-profit organization was new territory for both parties, so assigning and accepting risk was the subject of drawn-out negotiations. Whereas for UV WaterHealth, product liability was just one of many risks known and accepted by the investors as a part of doing business, WV Australia refused to accept this kind of liability.

The non-assert letter used in the cookstove case was a pragmatic way to work around this perceived liability risk by attempting to weaken that link so that liability could not be traced back to either WorldVision or LBL. However, the actual legal outcome, should a lawsuit arise from harm caused by the cookstove, is far from clear given the foreign jurisdictional issues. Ironically, the stalemate was resolved in a way that potentially left both parties open to the very legal and monetary threat they were attempting to avoid. The discussion of a possible solution is reserved for the conclusion.

4.2.2 *Donor-Funded: IP as a Method of Control over Technology*

The cases discussed above suggest that even where humanitarian motives are dominant, inventors within academic research laboratories look to IP, but for a somewhat unexpected reason: to maintain control over design. Through a design patent, Gadgil sought to retain a commanding position in the assembly chain of a technological network and become what actor-network theorists have called an “obligatory passage point” (Callon 1986).

Both Gadgil and the LBL TTO expressed concern that putting the designs for the Ethiopia cookstove into the commons would likely result in poor quality knock-offs. This in turn could have the effect of driving out the genuine product from the market, and spoiling not only the reputation of designers, but also any chance at re-entry.[12] This quality issue was less important for the UV Waterworks design, as its construction required a level of knowledge and experience in engineering beyond that of the common person. Indeed, the fact that the design could not be built by the average individual was one key reason why LBL chose to patent—they thought that wide-scale dissemination would depend on finding a business to produce the technology. But for something like the stove, a relatively simple technology, many actors and organizations possess the knowledge and tools necessary to produce it or something that closely resembles it. Such reproduction may produce accurate replicas or yield an inferior product, but the difference between these would not be apparent in the marketplace.

Technologies like the cookstove, while deceptively simple in appearance, require precise design, engineering, and manufacturing if they are to perform well. They are also relatively specific to certain kinds of cuisine, cultures, fuels, and cooking implements. By patenting the stove, Gadgil and the TTO at LBL hoped to prevent it from being produced by a fly-by-night organization that would produce low quality stoves or distribute them in inappropriate locales. Such a result could not only fail to achieve the immediate results but also spoil the market for improved cookstoves, and damage the reputation of the university.

4.3 Notes on Organizational Structure

Although traditional development work has been done through NGOs and governments, there do appear to be some technologies and some populations well-suited to an investor-funded business model. The distinctions discussed above are important because both of these types of cases exist in the space of technologies for the poor, and in bringing market-based solutions into this realm traditionally dominated by NGOs and governments, caution must be used in broadly applying the tools developed for a world of private actors. The UV Waterworks case suggests that when operation and maintenance costs of equipment require long-term attention, an investor-funded model may be the best policy option for achieving deployment and significant scale-up. Technologies that need an infusion of up-front capital for development of the technology itself or the supporting infrastructure may be more successful with private investors rather than traditional donors—provided a business model exists for financial viability. Models with for profit actors do not necessarily require intellectual property: the bottom line is that the technology and business model must be such that a viable business appears possible. For-profit investors must believe that revenue will exceed costs in the not-too-distant future, either because the costs to produce the technology are so low as to make market prices affordable even to the very poor, or some kind of innovative consumer finance options are available (see, e.g., Prahalad and Hart, 2002). WaterHealth demonstrates that there are cases in this realm in which IP is necessary for achieving that.

[12] As an example of how this can happen, Margaret Taylor (2008) has described how the market for solar hot-water heaters was impeded in California for 30 years due to badly performing products.

In contrast, as the Ethiopian Cookstove case suggest, neither a for-profit concern nor patents may be necessary or desirable when there is little long-term technical maintenance required. When the technology remains too expensive for consumers, there is no profit to be made, so an investor-funded model is out of the question, and distribution must be through other sources, such as the NGO or the government sector.[13] Intellectual property has less of a rationale in these cases. Control over design is cited above as a rationale, but it is not clear that patent protection would increase this control where there may be no credible threat of legal action. However, a technology that is unprofitable today may not be so in the near future. This is one reason why Gadgil pursued a patent on the stove, to pave the way for an investor-funded model in the future should the stove eventually become a profitable technology, either through carbon credits or some other mechanism. Retroactive filing is not legally possible. Putting the patent into place early on would, he hoped, protect the stove, at least against large industrial competition: if opportunities for expansion presented themselves in the future, he would be able to pursue funding from private investors should he so choose.

5. Conclusion

Intellectual property is often justified on the grounds that it generates private investment in inventive activity by offering valuable monopolies on new technologies. What should the role of IP be where profit is not the aim, and where initial funding is often supplied by the charitable sector or the state? Increasingly, it is technology transfer offices at public research institutions that must grapple with these questions, especially as they explicitly take up technological development for the global poor as a mission.

Through new concerted programs of “socially responsible licensing,” many technology transfer offices are taking a more active role in structuring technological development partnerships to serve the least well off. For instance, the University of California, Berkeley’s “Socially Responsible IP Management and Licensing Program” aims to promote “solutions to critical needs in the developing world, including by stimulating outside investments, to maximize the societal benefits of U.C. Berkeley research” (Mimura et al.). The “Global Access Principles” developed by the office of technology transfer at University of British Columbia assert the importance of extending the impacts to university-developed technology to “broader global settings,” and ensuring “fair access to the world’s poor within an evolving framework of licensing practices, legal concerns, business opportunity and time constraints.”[14]

Even as they articulate these special obligations, TTOs will need creative IP approaches to foster good development strategies. To date, socially responsible licensing has mostly been used in the life sciences—especially pharmaceutical agents and agricultural biotechnologies—where guidelines and best practices are slowly emerging (e.g., PIPRA). But the transfer of mundane technologies—water purifiers, solar lights, irrigation pumps, and improved cookstoves designed specifically for use by the global poor—have received less attention. As we have hopefully

[13] However, even in these cases, there may be opportunities to sell these technologies as product to NGOs and government agencies at the price necessary to sustain profitability.
[14] Available at <http://www.uilo.ubc.ca/pages/knowledge-mobilization/global>, last visited May 2, 2012.

shown, these pieces of hardware pose different kinds of problems for development and implementation. Depending on particular circumstances, patents can either help or hinder development and adoption, and licensing can either facilitate or impede the proper partnerships.

These two case studies help fill what we see as a gap in the literature on engineering for the bottom of the pyramid. They provide detailed narratives that might be useful for inventors, TTOs, and technology developers alike, and they highlight considerations for how particular approaches to patenting and licensing might affect dealmaking. However, beyond providing this analysis, our discussion supports two specific policy ideas that would help facilitate good practice in this area.

The first is to compile best practices and strategies for handling these kinds of engineering projects. The PIPRA handbook (2007) for licensing in agriculture and medicine for the developing world is a good model. Because technologies are unique, and developing and deploying these technologies often require unique sets of resources across a heterogeneous collection of actors—from scientist inventors, to TTOs, to NGOs and for profit ventures—such a manual must aggregate case studies like ours. But this intellectual resource would also abstract principles to guide inventors and technology transfer officials as they seek to develop inventions for the global poor at all stages of development. It would suggest when patenting would be a mistake, and when commercial partnerships are necessary. It would also provide licensing templates to make technology transfer smarter and more efficient.

The second is the creation of an insurance system for product liability in the arena of mundane technology. Here, perhaps more forcefully than in other fields, indemnification rears its ugly head. Public research institutions do not like to take on product liability, but indemnification clauses are also rejected out of hand by players in the non-profit world, especially those without experience in developing technology. Nonassert approaches, while they might avoid the kind of negotiations that almost torpedoed the Ethiopian Cookstove Project, do not actually clarify and assign legal liability. A promising solution would be to create an insurance organization that would accept liability in cases where both the inventor and the implementer are risk averse. Such an organization could be funded by dues from participating public research organizations and subsidized by charitable foundations.

Both of these policy interventions require financial and normative support from across the public and private sector. Only with such broad support can innovation emanating from public research institutions better serve the least well off.

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REFERENCES

Bartram, J., K Lewis, R Lenton, and A Wright 2005. Focusing on improved water and sanitation for health. *The Lancet,* **365**(9461), 810-812.

Bijker, W 1995. *Of Bicycles, Bakelites and Bulbs. Toward a Theory of Sociotechnological Change.* Cambridge, MA*:* MIT Press.

Callon, M 1986. Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay. In *Power, Action and Belief: A New Sociology of Knowledge?,* ed. J. Law, (Ed.), pp. 196-233. London: Routledge and Kegan Paul.

Cash, D W, W C Clark, F Alcock, N M Dickson, N Eckley, D H Guston 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences of the United States of America,* **100(**14), 8086-8091.

Easterly, W 2003. Can foreign aid buy growth? *The Journal of Economic Perspectives,* **17**(3), 23–48.

Fullerton, D G, N Bruce, and S B Gordon 2008. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. *Transactions of the Royal Society of Tropical Medicine and Hygiene,* **102**(9), 843-851.

Gleick, P H 2002. *Dirty Water: Estimated Deaths from Water-Related Diseases 2000-2020.* Pacific Institute Research Report. Available at: <http://www.pacinst.org/reports/water_related_deaths/index.htm>, last accessed 25 May, 2011.

Graham, S J and T M Sichelman 2008. Why Do Start-Ups Patent? *Berkeley Technology Law Journal*, Vol. 23, 2008.

Haines, A, A J McMichael, K R Smith, I Roberts, J Woodcock, A Markandya, et al 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers. *The Lancet*, **374**(9707), 2104-2114.

Kammen, D M, and M R Dove 1997. The virtues of mundane science. *Environment,* **39**(6), 10-41.

Kapczynski, A 2009. Commentary: Innovation Policy for a New Era. *The Journal of Law, Medicine and Ethics*, **37**(2), 264-268.

Krattiger, A 2007. The use of nonassertion covenants: A tool to facilitate humanitarian licensing, manage liability, and foster global access. In A. Krattiger et al. (Eds.) *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices.* Oxford, U.K: MIHR, and Davis, CA: PIPRA. Available online at <http://www.ipHandbook.org>, last accessed 6 September, 2011.

Kristof, N 2005. A Policy of Rape. New York Times. June 5.

Lanjouw, J 2002. A New Global Patent Regime for Diseases: U.S. and International Legal Issues, Harvard Journal of Law and Technology 16(1), 1-40.

Latour, B 1993. *We have never been modern.* Cambridge, MA: Harvard University Press.

Lawrence Berkeley National Lab (LBL) 2010a. *Success stories: WaterHealth International.* Available at <http://www.lbl.gov/tech-transfer/success_stories/articles/WHI_more.html>, last accessed 1 November, 2010.

Lawrence Berkeley National Lab (LBL) 2010b. *Success stories: UV Waterworks.* Available at <http://www.lbl.gov/techtransfer/success_stories/practical_application/uv_waterworks.html>, last accessed 1 November, 2010.

Mimura, C, J Cheng, and B Penhoet 2011. Socially responsible licensing, Euclidean innovation, and the Valley of Death. *Stanford Journal of Law, Science and Policy*. Issue on Access to Medicines.

Muzaka, V 2009. Developing countries and the struggle on the access to medicines front: victories won and lost. *Third World Quarterly,* **30**(7), 1343-1361.

PIPRA 2007. *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices* (eds. A Krattiger, RT Mahoney, L Nelsen, et al.). MIHR: Oxford, U.K., and PIPRA: Davis, U.S.A. Available at <http://www.ipHandbook.org>.

Prahalad, C K, and A Hammond 2002. Serving the world's poor, profitably. *Harvard Business Review,* **80**(9), 4-11.

Prahalad, C K, and S L Hart 2002. "The fortune at the bottom of the pyramid." Strategy + Business, 26: 1-14.

Sell, S K and A Prakash 2004. Using Ideas Strategically: The Contest Between Business and NGO Networks in Intellectual Property Rights. *International Studies Quarterly***, 48**(1), 143-175.

Smith, K R 1994. Health, energy, and greenhouse-gas impacts of biomass combustion in household stoves. *Energy for Sustainable Development,* **1**(4), 23-29.

Smith K R, J P McCracken, L Thompson, R Edwards, K N Shields, E Canuz, and N Bruce 2010. Personal child and mother carbon monoxide exposures and kitchen levels: Methods and results from a randomized trial of woodfired chimney cookstoves in Guatemala (RESPIRE). *Journal of Exposure Science and Environmental Epidemiology,* **20,** 406–416.

Strathern, M. 1996. Cutting the Network, *Journal of the Royal Anthropological Institute* (N.S.) 2, pp. 517-535.

Taylor, M.R. 2008. Beyond Technology-Push and Demand-Pull: Lessons from California's Solar Policy. *Energy Economics*, **30**(6), 2829-2854.

Thomas, E and B Amadei, 2009. Accounting for human behavior, local conditions and organizational constraints in humanitarian development models. *Environment, Development and Sustainability*, **12**(3), 313-327.

U.S. Patent and Trademark Office 2011. *A guide to filing a design patent application.* Available at: <http://www.uspto.gov/web/offices/pac/design/definition.html#difference>, last accessed 10 September, 2011.

WaterHealth 2009. WaterHealth International Announcing $15 million Financing from IFC [Press Release]. Available at <http://oracle.sys-con.com/node/843541>, last accessed 10 September, 2011.

Zoominfo 2009. *WaterHealth company profile.* Available at <http://www.zoominfo.com>, last accessed 10 September, 2011.