Technology, Development, and the Post-2015 Settlement

Charles Kenny and Owen Barder

Abstract

This paper focuses on invented or created technologies of the type that could (theoretically) be subject to patents and the potential for international agreements including the Addis Financing Conference to better create and share such technologies. It discusses the nature of invented technologies and the standard policy tools used to support its development. It then addresses two separate questions related to inventions and development: 'what is invented' and 'how it diffuses.' With this background, it goes on to discuss the role of policy tools including patents, tiered pricing, research support, advance market commitments, and prizes in creating development-friendly technology. It concludes with some recommendations for language to be inserted in the Addis Declaration.

Center for Global Development
2055 L Street NW
Fifth Floor
Washington DC 20036
202-416-4000
www.cgdev.org

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Introduction

'Technology' broadly defined by economists studying economic development means anything that increases the productivity of capital and labor combined.[1] Jones and Romer estimate that only about one half of cross-country differences in GDP can be accounted for by differences in inputs of labor and capital. At the extremes –the differences between a Luxembourg and a Niger—the proportion of the difference will be smaller.[2] This suggests technology (in this broad sense) is the primary factor behind global economic growth. That includes 'institutions' – evolved social structures and systems like laws and (sets of) norms alongside things that are invented or created by individuals (often working together).

Technology defined in the different but equally broad sense of a method to combine inputs to create outputs has also played an immense part in making the quality of life higher at a given income. In Madagascar, for example, where income per capita has fallen by 17 percent since 1990, life expectancy has climbed from 51 to 65 years since then.

While there is no widely-agreed definition of 'technology transfer' in development, discussions of the issue cover both productivity more broadly (using joint ventures to 'import' higher productivity with spillovers to other firms through knowledge and social capital, for example) as well as particular invented technologies (a new drug or solar panel). The second set of technologies, perhaps more akin to what most non-economists mean by 'technology', overlaps heavily with 'things that can be patented.'

This note will focus on invented or created technologies of the type that could (theoretically) be subject to patents, and the potential for international agreements including the Addis Financing Conference to better create and share such technologies.

This is not because 'invented technologies' are more important than 'institutional technologies' for global development. At least when it comes to income *convergence* across countries, the reverse is probably true, and the role for policies around inventions is (overall) a minor factor.[3] The policy prescriptions at the national and global level around increasing

[1] This is 'technology' as total factor productivity.

[2] Jones, C. I., & Romer, P. M. (2009). *The new Kaldor facts: ideas, institutions, population, and human capital* (No. w15094). National Bureau of Economic Research.

[3] Diego Comin and Bart Hobjin argue for a role of technology diffusion in growth and (regardless) it is definitely the case that rich countries have higher stocks of technologies from computers to tractors and spindles. At the same time, this begs the question as to why these stocks are higher. A range of institutions potentially including but extending far beyond rules around intellectual property rights surely play a role. Comin, Diego A.,

total factor productivity through social and institutional change, and improvements in systems, are wide ranging and diverse, covering the business environment, rules on investment, education policies and governance amongst others. Much of the Sustainable Development Goals and Financing for Development discussion could be easily linked to these broader issues.

Nonetheless, there are some specific areas where current policy choices around invented technologies are having very significant economic and social impacts, especially in poor countries. These issues deserve both attention and detailed policy prescriptions as part of the post-2015 discussion. This essay will discuss those issues and some potential responses in the context of the upcoming Addis Financing for Development conference. The essay opens with a discussion of the nature of invented technology and the standard policy tools used to support its development. It then addresses two separate questions related to inventions and development: 'what is invented' and 'how it diffuses.' The two are linked, not least through the functioning of policies, but they are distinct –and so are responses.

We argue that the term "technology transfer" is misleading, because it can imply that enabling technology to be used in developing countries is somehow at the expense of industrialized countries. The shared commitment is not to transfer a private good, but to grow and share a public one.

For the sake of easy reading, 'technology' from now on should be taken to mean 'invented technology.'

The Nature of Technology and Intellectual Monopolies

Technology is (often) non-rival and non-excludable. My using an innovation does not stop you using it at the same time and (unless we create and enforce legal restrictions or I keep the technology a secret), I can't stop you using it if you want to. Think of the technology of writing: my writing creates no obstacle to you writing at the same time, and it would be very hard for me to stop you writing. Compare that to a rival, excludable good like my bicycle: if I'm riding it, you aren't. And I can stop you riding it by locking it to a fence post.

The non-rival, non-excludable features of technology are a big part of its outsized development impact. Once someone invents a technology, absent legal restraint it is

and Bart Hobijn. "Technology Diffusion and Postwar Growth." NBER Macroeconomics Annual 25 (2011): 209-259.

available to everyone, forever, at no social cost. I don't have to reinvent writing or pay anyone to let me write, I just use the existing technology. If humanity had to reinvent every innovation before we used it, we'd never have reached the Stone Age.

But that is also why technologies are likely to be under-produced in a market economy. The inventor only recoups a tiny part of the benefit of their invention. The innovators who came up with writing aren't getting a cent from me or anyone else for the use of their transformative technology, and nor are their descendants. And that suggests that in a free market, if it is expensive and time consuming to innovate, people may not bother to invest in innovations which would benefit humanity but from which they themselves would stand to gain little.

One tool that governments use to increase the incentive to innovate is to create a temporary intellectual monopoly (commonly and misleading called an 'intellectual property right'). Intellectual monopolies reward the creators of knowledge by giving them legal ownership (excludability) rights to their innovation. That allows them to charge above the competitive market price (which would be zero, since the marginal cost is zero) for the use of that knowledge, usually for a finite period.

Intellectual monopolies are, in effect, a form of state-sponsored subsidy to those engaged in the creation of knowledge. But instead of society as a whole paying for this subsidy, the state allows the creators of knowledge to charge a tax on the users of that knowledge, at least for some period of time. Because of their temporary monopoly, the inventors can sell goods that use the technology at a considerable profit without fear of competition (or they can sell the right to use the technology). Like all taxes, the creation of this monopoly by the state not only transfers resources from one person to another, but creates a welfare cost to society by distorting the price of the good that has been taxed.

These costs may be worth bearing if they are the price we have to pay to ensure that there is sufficient innovation. This is especially because other approaches to promote technology advance like awarding prizes, promising to purchase a particular technology or simply funding research tend to have the 'picking winners' problem (either by focusing research on 'the most important issue' or 'the most promising technological response'). Using prices to reward inventors helps to ensure that knowledge is created which is genuinely valuable to people. The arguments against a command economy apply as much to research and development as to any other allocation of resources.

But patents are a tool that needs to be used with appropriate caution –limited to the reward of true innovations hard come by that are easily replicated by others. We will see that these limits have been increasingly breached, tipping the complex balancing act which the intellectual property regime attempts to achieve too far towards the monopolist. And patents need to be complemented by other approaches, particularly in the case of technologies related to development.

Another feature of technologies is that they are often 'embedded' in something physical –a computer, a car or a person, for example. For technologies embedded in physical capital, they can be 'embedded' in more or less of that capital. The technology of the internal combustion engine is embedded in a car or truck –hundreds of kilograms of glass, metal, rubber and oil requiring precision construction by skilled workers in factories that themselves can cost hundreds of millions of dollars to build. Contrast the technology of a vaccine: the actual costs of physical production of the liquid containing a weakened virus is often measured in the low cents.

Intellectual monopolies are likely to have a far bigger relative impact on the final (embedded) price of a drug than they will on the final (embedded) price of a truck. Put another way, and everything else being equal, otherwise 'cheap' innovations are those where the legal institutions governing technology will have their largest effect in terms of potential rollout.

Take the price of a course of triple-combination AIDS drugs in 2003: the rich country company that had developed the drug charged over $10,000 while an Indian generics company charged $200 for exactly the same (equally effective) course of drugs.[4] In defense of the rich country company, it was recouping the considerable costs of research and testing in a global environment where it may be hard to charge one price in one market and another prices in a second market. But the $200 figure is a considerably more accurate representation of the marginal cost of the drugs. And intellectual monopolies will really matter to quality of life when we want widespread or universal access to a cheap technology (vaccines and anti-retrovirals being prime examples) – not just an economy to have a stock commensurate with its size.

Despite the presence of intellectual monopolies, it is worth noting that most inventions appear to move around the world comparatively easily. Pretty much name your technology

[4] Subramanian, A. (2004). Medicines, patents, and TRIPS. *Finance and Development*, *41*, 22-25.

and it is about as distributed as you'd expect given it tends to be embedded in some capital – sometimes more equally than that (see Figure One). Exceptions tend to involve cases where there has been considerable extra effort to prevent the spread of the technology (nuclear weapons, for example).[5]

This suggests the development 'problem' with technology may be as much or more about *what* is invented as how it spreads. But especially for technologies embedded in little capital where externalities suggest the benefits of universal access, where stock per unit of GDP is an inadequate benchmark, flows of technology also remain a concern.

The Big Problem with Technology and Development: *What* Is Invented

The market in low income countries is simply much smaller than it is in rich ones. The market GNI of high income countries is $51 trillion, compared to $24 trillion for middle income countries and $634 billion for low income countries (a little more than one percent the size of high income economies). And so most technology is developed with rich countries in mind. Related to this, poor countries can afford less research and development: The OECD spends about 2.3 percent of GDP on research and development. LDCs spend a negligible proportion of a much smaller output.[6] When rich countries spend $1.2 trillion on research and development compared to around $300 billion in low and middle income countries, it is likely the technologies researched are going to be overwhelmingly those responding to 'rich world problems.' [7]

That means intellectual property is a terrible tool to create technologies that respond to poor world problems. Imagine a perfect monopoly over the sale of a drug aimed at a neglected tropical disease: even a small profit margin would likely make the drug simply unaffordable

[5] Diego Comin and Bart Hobjin's work suggests that technology adoption times are dropping rapidly towards zero across countries with a mean lag of about eight years for the Internet compared to 150 years for steamships, for example, and that 'technology lags' for electricity, trucks, tractors, cars, aviation, Internet PCs, cell phones and fixed telephones are far shorter than GDP per capita lags for poor countries. In other words, poor countries have more of a given technology than the US did when it was at a similar level of GDP per capita. Comin, Diego, and Bart Hobijn. "An Exploration of Technology Diffusion." American Economic Review 100, no. 5 (December 2010): 2031-59. Comin, Diego A., Bart Hobijn, and Emilie Rovito. "Technology Usage Lags." Journal of Economic Growth 13, no. 4 (December 2008).

[6] The Office of the High Representative for Least developed Countries, Landlocked Developing Countries and Small Island Developing States (2013) A Technology Bank and Science, Technology and Innovation Supporting Mechanism for the Least Developed Countries Informal Background Note available at http://www.unohrlls.org/UserFiles/File/LDC%20Documents/Tech%20Bank%20-%20Background%20Note%20for%203%20June%202013%20Event.pdf

[7] Calculated from World Development Indicators aggregate data for UICs, MICs, and LICs, using MIC R&D % GDP as estimate for LIC R&D % GDP. Accessed 4/28/2015.

for most potential consumers. Cross-country analysis supports this intuition: it suggests patent protection is associated with increases in research and development when adopted in high income countries, but not in developing countries –and that patent protection is a very weak tool to increase research and development activities on diseases that primarily affect poor countries.[8]

Of course many technologies invented for rich markets have proven hugely valuable for poor ones: the mobile phone, the measles vaccine, the internal combustion engine. But where the needs of developing countries are different from those in the rich world, there is likely to be a dearth of research in part because even the most generous patent protection would be a small incentive for the private sector to produce it. The mechanism that society has chosen to support research and development – the granting of a temporary monopoly – is not fit for purpose for technologies which are useful almost exclusively for the poorest people.

For example, the World Health Organization provides information on the top ten causes of death in high income and low income countries.[9] Only three conditions appear on both lists (stroke, heart disease and lower respiratory conditions). Big killers in poor countries including diarrheal diseases, malaria and tuberculosis are very rare causes of mortality in the rich world. Meanwhile, per capita pharmaceutical expenditures in 2005/2006 averaged US$ 7.61 in low-income countries compared to US$ 431.6 in high-income countries, and 16 percent of the world's population living in high-income countries account for over 78% of global expenditures on medicines[10] while low income countries account for about 1 percent. This will be why drugs companies are said to spend ten times more researching cures for baldness than they do on cures for malaria.

The problem around drug research in particular is made worse by the additional regulatory barrier of testing, which may cost in the region of $1.5 billion a drug[11] –placing a lower floor on the size of a market that is profitable for drugs companies to research in (note that $1.5

[8] Kyle, M. K., & McGahan, A. M. (2012). Investments in pharmaceuticals before and after TRIPS. *Review of Economics and Statistics*, *94*(4), 1157-1172.

[9] WHO: The Top Ten Causes of Death: http://www.who.int/mediacentre/factsheets/fs310/en/index1.html accessed 5/12/2015

[10] Lu, Y., Hernandez, P., Abegunde, D., WHO, G., & Edejer, T. (2011). The world medicines situation 2011. *Medicine expenditures. World Health Organization, Geneva.*

[11] Rick Mullin and Chemical & Engineering News (2014) Cost to Develop New Pharmaceutical Drug Now Exceeds $2.5B available at http://www.scientificamerican.com/article/cost-to-develop-new-pharmaceutical-drug-now-exceeds-2-5b/. Although note these high cost estimates are a subject of some controversy: http://www.bostonglobe.com/business/2014/12/02/critics-question-tufts-research-team-estimate-that-costs-billion-develop-drug/Y34czSIKnmfcfiNpV5EQlI/story.html

billion is equal to around 24% of the total annual pharmaceutical expenditure of all low income countries combined). What's more, safety standards which are sensible in the context of a very low need (e.g. side effects of a vaccine against rotavirus may make it inappropriate for use in countries with low mortality from rotavirus) may be disproportionate if they prevent the use of an effective treatment against a disease in countries where that disease is widespread (the same vaccine might be useful in countries in which rotavirus is a major cause of death, at least until a safer vaccine is developed). That is why it made sense to advance more quickly with testing an Ebola vaccine than would normally have been allowed.

Again, African agriculture faces some particular technological challenges related (not least) to specific microclimates which means the international agricultural technology stock is at times woefully inadequate to respond to local development challenges. Developing countries accounted for only five percent of global private sector agriculture research and development.[12]

More broadly, 'how do we effectively use a lot of people to make a world-class product' is pretty much never the question in rich countries where research is primarily about producing more by saving on labor –inventing a new machine that can save on employing a person. What developing countries need is technologies that replace an expensive machine with a much cheaper one requiring one more person to operate. Factors behind the phenomenally rapid rollout of the mobile phone in developing countries included that infrastructure costs per subscriber are low and prepaid scratch-card vendors could substitute for banking and postal networks for the billing system: compared to a fixed line telephone system, the mobile industry in the developing world is far less capital intensive and far more labor intensive. But we'd expect most rich world inventions wouldn't allow for that model.

What We Want Is Technology Development and Sharing, Not 'Transfer'

In response to the perceived problems of global technology spread, WTO TRIPs 66.2 and UNFCCC Article 4.5 both call for technology transfer. But that is an awful way to think about what the world should want more of as a response. *It is not (or shouldn't be) about passing over a private good, it should be about growing and sharing a public one.* We need to worry about

[12] Elliott, K. A. (2010). Pulling agricultural innovation and the market together.*Center for Global Development Working Paper*, (215).

creating more of that public good and allowing it to spread. We want to move to a system of more invented technology and fewer legally created monopolies especially on technologies that will help poor countries. At the moment the patent system of intellectual monopolies puts those two goals in opposition. We need to move away from monopolies and the idea of 'technology transfer' towards other incentives for more creativity and 'technology sharing.'

How Do We Create (Development Friendly) Technology?

Reforming the global patent regime would be to every country's benefit. At the national level in OECD countries, there is considerable evidence that recent legislative moves to strengthen intellectual monopolies are economically harmful and this ignores considerable international spillover effects. Especially given the broader set of countries now involved in R&D, this suggests it would be a fruitful moment for global cooperation on IP reform.

In their review for the Journal of Economic Perspectives, Michele Boldrin and David Levine summarize the case against patents: "There is no empirical evidence that they serve to increase innovation and productivity... in spite of the enormous increase in the number of patents and in the strength of their legal protection, the US economy has seen neither a dramatic acceleration in the rate of technological progress nor a major increase in the levels of research and development expenditure." In 1983 the US issued around 60,000 patents, in 2010 it issued four times that many.[13] Some of that increase is due to patent thickets (where innovative companies develop a patent portfolio to stymie competitors in their industry) and patent trolls (where companies who do nothing but collect patents do so for the purpose of extracting (often bogus) licensing payments out of innovating firms). Both thickets and trolls considerably increase the cost of innovation with little, if any, social benefit.

Official US statistics suggest that "patent assertion entities" (patent trolls) increased from being responsible for 29 to 62 percent of all infringement suits between 2011 and 2013 alone. The impact of this litigation is to slow innovation and hurt sales in companies facing a suit, with a cost in terms of lost share value of defendants that is ten times the rewards

[13] Boldrin, Michele, and David K. Levine. 2013. "The Case against Patents." Journal of Economic Perspectives, 27(1): 3-22

won by firms filing suit.[14] Between 1990 and 2010 James Bessen and colleagues estimate patent trolls were responsible for half a trillion dollars in lost wealth.[15]

Many large companies especially in the technology space own sufficient patents (thickets) that almost any innovation might be considered to infringe one of them. Microsoft is estimated to earn $3-6 for every Android handset that is sold, in royalties for patents.[16] It is not clear that these patents are valid, but handset manufacturers would rather pay Microsoft this 'tax' than contest their legality in court. This puts up the price of handsets across the world, including in developing countries, and so delays the spread of smartphones across the developing world.

The whole world suffers from the decline in innovation that results from the particularly American problem of patent trolls, but excessive patenting is hardly unique to the US.[17] China overtook the US in the number of patents issued in 2011, but quality is a concern. The median lifespan of a patent awarded to a domestic entity is only five years compared to twelve years in the US. Citations of Chinese patents are lower than all but one other out of 25 countries ranked by the OECD.[18] There appears to be little relationship between the rise of patenting and levels of research and development expenditure, although FDI inflows and industrialization may have played a role.[19] There are a number of reasons for the explosion of potentially low quality patents but they include government-set patent targets, which create the incentive to patent whatever the quality.[20]

It is worth noting that in other patent jurisdictions the growth in patenting has been slower than that in R&D expenditure, suggesting a declining 'patent yield' and less circumstantial evidence in favor of declining patent standards driving patent growth (which appears to be connected instead to an increase in the number of filing a patent for the same technology in

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[14] Executive Office of the President (2013) Patent Assertion and US Innovation available at https://www.whitehouse.gov/sites/default/files/docs/patent_report.pdf

[15] Bessen, J. E., Meurer, M. J., & Ford, J. L. (2011). The private and social costs of patent trolls. *Boston Univ. School of Law, Law and Economics Research Paper*, (11-45).

[16] Yarrow, J. Goldman: Microsoft Is Getting $444 Million Annually From Android Patent Licenses
Business Insider, SEP. 29, 2011 http://www.businessinsider.com/goldman-microsoft-android-2011-9#ixzz3ZxCtssAX

[17] It is a uniquely large problem in the US because the US has been more generous in patenting software and business methods and the legal system in the US tends to generate particularly large damages.

[18] Although note that citations are a poor measure of patent value/quality.

[19] Fink, Carsten, Mosahid Khan, and Hao Zhou. *Exploring the worldwide patent surge*. No. 12. World Intellectual Property Organization-Economics and Statistics Division, 2013.

[20] Dan, P. H. (2013). Measuring, Explaining and Addressing Patent Quality Issues in China. University Library of Munich, Germany.

multiple jurisdictions). Nonetheless, it appears to be a factor in at least the world's two biggest patent jurisdictions and may be elsewhere, especially in complex technology sectors like information and communications where patent thickets appear to be the greatest threat.[21]

Boldrin and Levine note that in countries with initially weak IP regimes there is some evidence that strengthening them increases the flow of foreign investment into sectors where patents are frequently used. But they also suggest that "the historical and international evidence suggests that while weak patent systems may mildly increase innovation with limited side effects, strong patent systems retard innovation with many negative side effects." It is in the economic interest of every country to limit patentable inventions to those that took significant effort to develop, and that really represent an advance over prior approaches. This is the stated purpose and language of most patent laws as well as the World Trade Organization TRIPS agreement, but it is at the whim of sometimes flawed examination capacity and practices. Again, it is in the interests of all countries to reduce patent term lengths. As the number of countries involved in significant research and development increases, the greater the global benefit in a worldwide patent system that shares these features.[22]

There could be a useful process of multilateral negotiation involving mutual moves towards higher patent standards (with limits on terms and coverage and agreement on costs), matching that towards free trade—perhaps Addis could be the start of that process. It should be possible to get agreements to harden patent terms by raising the costs of patents, the standard of innovation, the specificity of the application and the length of patent terms based on mutual accountability for self-interested action.[23]

With regard to the specific issue of high regulatory barriers to pharmaceutical rollout, Boldrin and Levine note that around 80 percent of the approximately $1 billion cost of developing a new drug in the United States comes from Stage III clinical trials, (Stage I and II are largely about ensuring the drug is safe to take at recommended doses, while Stage III

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[21] Fink, Carsten, Mosahid Khan, and Hao Zhou. *Exploring the worldwide patent surge*. No. 12. World Intellectual Property Organization-Economics and Statistics Division, 2013.

[22] Poor incentives don't only lead to bad patents, but also a lot of terrible scientific and technical journal articles alongside pay to publish journals. Again this is not just a problem in the rich world –China and India publish a growing number of junk journals themselves.

[23] Evidence from a substantial increase in patent fees in the US in 1982 suggests that raising fees is one tool to weed out low-quality patents (ones that are rapidly dropped and rarely cited De Rassenfosse, G., & Jaffe, A. B. (2014). *Are patent fees effective at weeding out low-quality patents?* (No. w20785). National Bureau of Economic Research.

tests if the drug actually works to improve or protect health on a large group of subjects.) If pharmaceutical companies were allowed to sell drugs at a low (economic) and regulated cost after Stage II but prior to Stage III approval, this would considerably shorten the approval process and reduce its cost –as well as getting (potentially) effective treatments into the market faster and at a low price. In emergency situations –or situations where the private return to Stage III trials is simply too low to justify drug development-- the tradeoff of possible low efficacy may be worth making. Alternatively, the Drugs for Neglected Diseases Initiative (which is discussed later) or another body, could be supported to create a fund to cover the cost of trials in cases where the drug has the potential to meet a global public health priority.

Countries do not rely solely on IP legislation to promote R&D. In rich countries, anywhere from 16-37% of total R&D is financed by governments themselves.[24] For example, the US National Institutes of Health have a $28 billion budget largely for research. The national and global impact of that research could be maximized if it were in the public domain. The US should return to the situation prior to 1980 and ensure that the results of federally funded research do not lead directly to patents but are open to all.[25] Other countries should follow suit. Again, this might be an area for multilateral negotiation, pushing for targets around the reduced use of intellectual property protections in publicly financed technology and creative works.[26]

But just as the IP system creates little incentive to work on technological solutions specific to problems in the poorest countries, nor necessarily do the budget systems underpinning public R&D in rich countries. That said, estimates suggest that 'neglected tropical diseases' receive $3,219m in R&D each year. Two thirds of that is into the three conditions of HIV/AIDS, malaria and tuberculosis, and two thirds of the funding comes from rich country governments.[27] Rich country governments could target more resources towards the R&D needs of low and middle income countries through advance market commitments

[24] National Science Board (2014) SCIENCE AND ENGINEERING INDICATORS 2014 available at http://www.nsf.gov/statistics/seind14/content/chapter-4/chapter-4.pdf

[25] In cases like pharmaceuticals where much of the cost of getting a product to market is in overcoming regulatory barriers, this might need to be twinned with support for trials.

[26] See proposals around an Agreement on Access to Basic Science and Technology, Barton, John H., and Keith E. Maskus. "Economic perspectives on a multilateral agreement on open access to basic science and technology.in World Bank (Washington, USA). *Economic development and multilateral trade cooperation*. Eds. Simon J. Evenett, and Bernard M. Hoekman. World Bank, 2006.

27 Global Funding of Innovation for Neglected Diseases (2014): G-FINDER report, available at http://www.policycures.org/downloads/Y7%20GFINDER%20highlights%20web.pdf

(AMCs), prizes, purchases of intellectual property and direct support for R&D, expanding on a number of existing initiatives.

Governments provide "push" funding through multilateral agencies directly supporting the research and development of technologies specifically designed to meet the needs of producers, consumers and patients in poor countries. CGIAR supports fifteen research centers generating and disseminating knowledge, technologies, and policies for agricultural development. The Drugs for Neglected Diseases initiative (DNDi) is a not-for-profit research and development organization that works on treatments for neglected diseases including trypanosomiasis (sleeping sickness), leishmaniasis, Chagas disease, paediatric HIV, filaria, and malaria. Working with public and private partners the Initiative finances and develops non-patented treatments for these diseases.[28]

There are promising opportunities to make more use of "pull" funding alongside push funding. The AMC for pneumococcal vaccines involved donors making $1.5 billion in commitments to purchase a pneumococcal vaccine suitable for use in developing countries at a fixed price of $3.50. Two pharmaceutical companies responded to the challenge and have produced vaccines that have since been rolled out. This instrument is useful for drugs and vaccines that are already being developed ('late stage') and for drugs and vaccines that are not yet close to market ('early stage').

Using state prizes for inventions has a long pedigree (including the Longitude Act of 1714, and the Kremer prize for human powered flight). On this model, society rewards inventors with a one-off payment for producing a socially useful invention, specified in advance. These 'winner takes all' prized are more useful for step change inventions than for incremental improvements. Prizes in agriculture might be awarded for the development of nutrient-fortified varieties of crops –vitamin-A enhanced rice or protein enhanced maize. Or they could be awarded for varieties that are more resilient to extreme weather or particular diseases or pests (drought resistant maize).[29]

An alternative proposal for "pull" funding is the "Health Impact Fund" which would reward firms from a shared fund, financed by governments and donors, in proportion to the

[28] Drugs for Neglected Diseases initiative (DNDi) (2014) New Hope for Neglected Patients, available at http://www.dndi.org/images/stories/pdf_publications/DNDi_Brochure_2014_ENG.pdf

[29] [29] Elliott, K. A. (2010). Pulling agricultural innovation and the market together.*Center for Global Development Working Paper*, (215).

amount of health benefit that their innovation would bring about, in return for which the firms would give up their intellectual monopoly on the product.[30]

How Do We Better Share Development-Friendly Technology?

The 'problem' of technology sharing is not (yet, significantly) with royalty payments: International royalty payments on intellectual property rights simply aren't very large worldwide. In Bangladesh they amount to around 0.2 percent of total business costs compared to an estimate of 2 percent due to costs related to electricity blackouts. The same figures for Kenya are 0.3 percent and 9 percent. [31] In 2013, World Bank data suggests low income countries as a group paid around $89 million in license and royalty payments to other countries. They received $82 million, creating a net $7 million payment. The numbers are more significant for middle income countries --$50 billion in payments, $8 billion in royalties suggesting a net outflow of $42 billion (or around 0.2% of GDP).

The low levels of transactions involving very poor countries will doubtless involve lower demand for use of the ideas under IP protection and limited appetite to license use to countries which may see weak IP enforcement. But there is evidence to suggest the first factor may be the largest. Reviews of the international evidence suggest that stronger IP laws may marginally increase FDI into middle income countries alongside increasing technology licensing, but the effect is small or absent in poorer countries.[32] The bigger problem regards the (global) monopoly cost of particular goods –perhaps particularly of pharmaceuticals.

Cross country evidence suggests that the implementation of TRIPS-compliant intellectual monopoly regulation led to faster launch, higher prices and higher sales (conditional on price) of pharmaceuticals. The effect in middle-income countries appears to be different, however, involving *lower* prices after TRIPS, perhaps because countries increased price controls on pharmaceuticals at the same time as they introduced stronger patents. [33] This suggests they may have canceled out the effect of stronger patent reform on drug introduction through tighter price regulation: TRIPS will have had limited impact, then.

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[30] Information available at http://healthimpactfund.org/

[31] EIFERT, B., GELB, A., & RAMACHANDRAN, V. (2006). Business Environment and Comparative Advantage in Africa: Evidence from the Investment Climate Data. *ABCDE*, 195.

[32] Hassan, E., Yaqub, O., & Diepeveen, S. (2010). Intellectual Property and Developing Countries. Mimeo, Rand Corp.

[33] Kyle, M., & Qian, Y. (2014). *Intellectual property rights and access to innovation: evidence from TRIPS* (No. w20799). National Bureau of Economic Research.

Compulsory licensing (where the government licenses a (second) local producer to produce a drug still under patent protection) is allowed under TRIPS, and a number of countries have used it to reduce dramatically the cost of drugs. Several countries have introduced compulsory licenses for HIV, while Thailand and India have both used the technique for drugs treating conditions including hypertension and cancer.

There are good precedents for compulsory purchase of property in the public interest (for example to build roads or railway lines), especially where this is necessary to prevent the holder of a particular property from holding the rest of the community to ransome (the so-called "hold out" problem). But excessive use of the compulsory purchase instrument reduces the incentive over time for private players to invest in the market.[34] It is also in the interests of developing countries that this strategy is combined with efforts to stop export of the compulsory licensed products, in order to limit the impact on incentives to invest in research (although it is worth noting this has not been a serious problem to date).

This suggests there is a stronger case than is often acknowledged for an approach called 'tiered pricing'. All else equal, a profit-maximizing monopolist who sees an opportunity to sell cheap products to poor people will not set prices so high above cost that her customers can't afford to buy them. Inventors with a monopoly trying to profit maximize would want to charge different prices for technology access depending on ability to pay --tiered pricing'. With the case of an anti-retroviral with a production cost of $100 for a year's supply, a company might maximize its profits by charging $10,000 for the drug in the US –where many people can afford to pay that-- and $200 in India –where a $10,000 price tag would limit the market to a fraction of a percentage point of patients.

The tiered pricing approach is used for air tickets, discounts for weekend stays and so on where different consumers pay very different prices for a similar or identical product. But the global regulatory and trading system makes tiered pricing difficult, for reasons set out below. As a result fewer people in developing countries have access to technologies than would do under an (sub-optimally) efficient market monopoly position.

[34] Note the development impact of *copyright* (as compared to patents, where counterfeiting can be harder) is significantly reduced by the ubiquity of piracy –industry estimates suggest that more than two thirds of all software in Russia is pirated, for example. The concern would be if a software technology sold at a high price became successfully protected against piracy. But a recent review of software piracy issues in the developing world concluded "We take it as self-evident, at this point, that $15 DVDs, $12 CDs and $150 copies of Microsoft Office are not going to be part of broad-based legal solutions... we find this view commonplace in the industry itself." Karaganis, J. (Ed.). (2011). *Media piracy in emerging economies*. Lulu. com.

The empirical evidence to date is that stronger IP protections in developing countries has not led by itself to the development of significant public tiered pricing. Drug manufacturers do sometimes segment markets nonetheless, negotiating prices in confidence, and there is some suggestion that prices are on occasion *higher* for some developing country public buyers than in the rich world.[35] Tiered pricing faces a number of challenges:

- If drugs easily cross borders, then firms cannot not (publicly) price-discriminate on an open market: instead they will respond by selling drugs at the 'global monopoly' price, effectively set to maximize profits from rich consumers, which will simply price poor consumers out of the market. Jenny Lanjouw suggested dyeing drugs from developing markets lime green in order to help with that problem (though this would only work to maintain price discrimination if a combination of regulation and consumer taste in rich countries prevented the widespread sale and use of lime green drugs).[36]
- Many countries use external reference pricing when regulating domestic drug costs – so that reducing the price in one market might create pressures for reductions elsewhere.[37] As well as formal reference pricing – such as that carried out by the UK's National Health Service – tiered pricing may be inhibited by informal reference pricing. If politicians and political commentators oppose price differentials – for example, complaining that drugs are cheaper in poorer countries – then this creates a reputational risk for pharmaceutical firms. Selling drugs cheaply in poor countries is not commercially viable for pharmaceutical companies if this threatens their ability to recoup their R&D costs in rich countries. Rich countries could ease the path towards tiered pricing regimes by explicitly excluding from external reference price calculations lower-income countries where tiered pricing has been officially introduced (and prices are published).

In another of Jenny Lanjouw's proposals, intellectual property protection in rich countries could be made contingent on allowing the same product to be sold at or near marginal cost in poor countries. This could be calibrated to have little effect on revenues (because the

[35] Hassan, E., Yaqub, O., & Diepeveen, S. (2010). Intellectual Property and Developing Countries. Mimeo, Rand Corp

[36] Lanjouw, J. (2006). A patent policy proposal for global diseases. *Innovations*,*1*(1), 108-114.

[37] Similarly, the US Supreme Court has prevented attempts by textbook publishers to block imports of cheaper copies of the same textbooks produced for foreign markets)

product would be sold cheaply in countries from which little revenue would have been obtained at a higher price) but to reach much larger numbers of people.[38]

An example of successful collaboration for tiered pricing is Research4Life --a collaboration of the WHO, FAO, UNEP and WIPO together with journal publishers and technical partners that makes articles from thousands of journals alongside patent databases available to researchers in developing countries at a low fee based on a sliding income scale. Perhaps Addis could call for a global collaboration between pharmaceutical companies, health ministries and drug regulators to develop and roll out tiered pricing regimes. The medicines patent pool, which is lowering the cost of AIDS drugs through voluntary licensing and patent pooling, is another similar model that could be expanded to non-AIDS drugs.

A technology bank could be a repository for donated and licensed intellectual property to be used in developing countries along with a source of technical assistance and monitoring with regard to export of related products. This could be located within the World Intellectual Property Organisation (WIPO).

In 2015, Google offered to buy patents from patent owners, to prevent those patents from falling in to the hands of patent trolls.[39] At the time of writing we do not yet know if this experiment will be a success. This idea could be taken up by governments, who could offer to buy patents for innovations of value for developing countries and then make that intellectual property freely available. So patent buyouts could be voluntary, which would be of more value to innovators but would drive up the price paid by the public, either in patent buyouts or in the patent monopoly price.

Finally, to deal with the issue of network externalities and technologies with spillover benefits, it may be worth pushing for (subsidized) universal access to particularly valuable network technologies or those with considerable spillover effects –universal mobile footprint coverage, commitment to free and/or open access software, or universal targets for basic vaccination, for example. In the case of network externalities, however, it is worth noting that the benefit of those externalities go to existing users, suggesting subsidies could be generated from current users rather than general government budgets –along the lines of

[38] Lanjouw, J. O. (2003). Intellectual property and the availability of pharmaceuticals in poor countries. In *Innovation Policy and the Economy, Volume 3* (pp. 91-130). MIT Press.

[39] See here: http://googlepublicpolicy.blogspot.co.uk/2015/04/announcing-patent-purchase-promotion.html

many existing universal access schemes for telephony that are funded with a charge on existing telephone subscriptions.

It is worth noting a final approach for improving technology diffusion and innovation in the developing world, which is worker mobility –and in particular mobility of research and development employees. This appears to have a considerable impact on the patent-generating productivity both the firms that workers join and the firms they formerly worked for.[40] Researchers outside the US registering their own patents are found to cite U.S. researchers of their own ethnicity 30%–50% more frequently than researchers of other ethnicities, suggesting the spillover benefits of a large emigrant researcher population. (For example, patents registered in India are far more likely to cite US patents that are registered to a person with an Indian name).[41] An Addis agreement could include a specific commitment on researcher mobility.

Conclusion

The analysis above suggests some language that could be appended to particular paragraphs of the Addis Financing draft to maximize technology creation and sharing for development:

104... We will increase the share of global and national R&D expenditures that support innovation in agriculture, environment, exploration, energy and health. Industrialized economy contributions to international research and development institutions with a focus on development issues will double as a percentage of global GDP by 2025. We will invest substantially in Advance Market Commitments for new technologies of particular value to developing countries, including pharmaceuticals, agriculture and clean energy.

105. ... Countries funding the bulk of global research and development will move toward multilateral agreement of policy reforms to reduce the problem of low-quality patents and patent thickets by 2020.

109... Countries home to the majority of pharmaceutical research and development will work with major pharmaceutical companies to develop approaches which allow tiered pricing of drugs and treatments as well as lower-cost regulatory approaches to bring drugs for neglected diseases to market with a global tiered pricing agreement by 2020.

Even after Addis, the importance of technology suggests that those interested in development should pay greater attention to technology policy and in particular intellectual

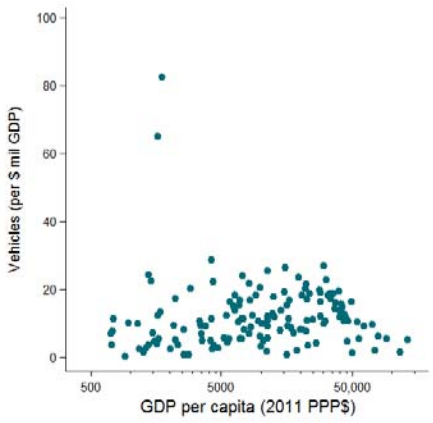
[40] Kaiser, U., Kongsted, H. C., & Rønde, T. (2011). Labor mobility, social network effects, and innovative activity. *Social Network Effects, and Innovative Activity. IZA Discussion Paper*, (5654).

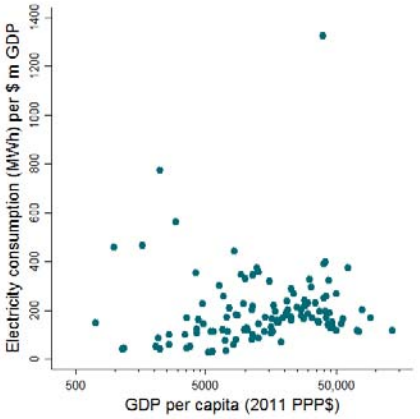
[41] Kerr, W. R. (2008). Ethnic scientific communities and international technology diffusion. *The Review of Economics and Statistics*, *90*(3), 518-537.

monopoly provisions and research support covering goods where there is a strong interest in universal access.

Figure One

Some technologies are spread about as equally as income/output…





…some are spread more equally than that.