Distributed Manufacturing _ Commons-oriented Productive Capacities (stream 2)

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draft revised (post-cumbre) version: 20 June 2014

Executive Summary

This document examines the application of social knowledge economy principles to the secondary economic sector, with an emphasis on manufacturing. The first part of the *Introduction* dissects the concept of the knowledge economy, highlighting the role of access to knowledge as the fundamental criterion for determining the character of a knowledge economy: in contrast to capitalist knowledge economies which block access to knowledge through the use of patents and restrictive IP rights, social knowledge economies use inclusive IP rights to provide free access to knowledge. In the second part of the Introduction, we look at how the use of restrictive IP rights has been theoretically justified: in short, IP rights are supposed to promote innovation and increase productivity. However, the available empirical evidence on the effect of IP rights on innovation and productivity furnishes no such proof. On the contrary, looking at the way in which capitalist firms actually use IP rights reinforces the conclusion that they do not promote innovation but are in fact hindering it.

The next section, *Alternatives to Capitalist Models*, as its title implies, introduces the FLOK (Free, Libre and Open Knowledge) model, which has emerged in the course of the last two decades as a powerful alternative to cognitive capitalism and describes briefly its main features: (a) the practice of free sharing of knowledge undergirding it, (b) the pervasive involvement of the surrounding community and (c) the use of the Internet as a platform for distributed collaboration.

In the follow-up section, *Open knowledge commons in the secondary economy sector,*we illustrate the FLOK model and its features through two case studies based on the RepRap 3D printer and the Wikispeed car project respectively, which are paradigmatic of how the secondary sector could be transformed in the direction of a post-fossil fuel economy through the development of distributed manufacturing structures enabled by the open design commons.

In the next section, *Preliminary general principles for policy making*, we sum up the conclusions drawn from the case studies in the form of general policy principles, which, as the follow-up section demonstrates, are aligned with the Ecuadorian policy framework, as reflected in the aims and policies put forward in the Constitution and in the National Plan for Good Living. The concluding section develops these policy principles into a set of policy recommendations for the development of a decentralised and inclusive social knowledge economy founded on the knowledge commons of science and technology.

Introduction and focus: basic principles

This policy paper examines the application of principles of social knowledge economy to the secondary (manufacturing) sector of the economy. But before we proceed to an in-depth exploration of those principles and their economic application, in the next section we clarify the concept of the knowledge economy and draw a distinction between social knowledge economies and capitalist economies.

The concept and forms of the knowledge economy

In contrast to traditional conceptions of the economy which centre on land, labour and capital as the three factors of production, the concept of the knowledge economy emphasises the role of knowledge as the key driver of economic activity (Bell 1974; Drucker 1969; for a critical analysis of the concept, see Webster 2006). This implies, of course, that the decisive means of production in a knowledge economy is *access to knowledge*. From this standpoint, it is precisely the question of how access to knowledge is being managed that determines the character of an economic system. Capitalist knowledge economies use the institution of intellectual property to create conditions of scarcity in knowledge: in this way knowledge is privatised and locked up in property structures which limit its diffusion across the social field. A social knowledge economy, by contrast, is characterised by *open access to knowledge* (Ramirez 2014) and so reconfigures the application of intellectual property rights to prevent the monopolization and private expropriation of knowledge: 'knowledge must not be seen as a means of unlimited individual accumulation, nor a treasury generating differentiation and social exclusion' but as 'a *collective heritage* [which] is...a catalyst of economic and productive transformation' (National Plan for Good Living, p. 61, italics ours) and 'a mechanism for emancipation and creativity' (Ibid, p. 41). In a nutshell, a social knowledge economy is an economy which thrives on the '*open commons of knowledge*' (National Plan for Good Living, spanish version, italics ours, p. 67).

A critique of cognitive capitalism

Intellectual property rights and their supposed role in cognitive capitalism

Capitalist knowledge economies use intellectual property (IP) rights as means of enclosing knowledge and as mechanisms by which to realise the extraction of monopoly rents from knowledge that has been thus privatised. That is ideologically justified as follows: exclusive IP rights provide incentives for individuals and companies to engage in research and develop new products and services. That is, they promote innovation: the expectation of profitable exploitation of the exclusive right supposedly encourages economic agents to turn their activities to innovative projects, which society will later benefit from (e.g. Arrow 1962). But is that actually an accurate description of the function of IP rights in capitalist knowledge economies? Do they *really* spur innovation?

A synopsis of empirical evidence on the effect of exclusive intellectual property regimes on innovation and productivity

To answer this question, it is instructive to look at the available empirical data on the effect of exclusive IP rights on technological innovation and productivity. The case of the United States is indicative of a capitalist knowledge economy in which the flow of patents has quadrupled over the last thirty years: in 1983 the US Patent Office granted 59.715 patents, which increased to 189.597 in 2003 and 244.341 in 2010 (US Patent Office 2013). Looking at these numbers begs the question: how has the dramatic increase in the number of patents issued by the US Patent Office over time impacted technological innovation and productivity in the US? Well, according to the US Bureau of Labor Statistics, the annual growth in total factor productivity in the decade 1970-1979 was about 1,2%, while in the next two decades it fell below 1%. In the same period, R&D expenditure hovered around 2,5% of GDP. In short, what we see is that the dramatic increase in patents has *not* been paralleled by an increase in productivity or technological innovation. No matter which indicator of productivity or innovation we use in the analysis, we are invariably led to the conclusion that 'there is no empirical evidence that they [patents] serve to increase innovation and productivity, unless productivity [or innovation] is identified with the number of patents awarded' (Boldrin and Levine 2013, p. 3; also, see Dosi et al. 2006).

Another argument often voiced by proponents of exclusive IP rights in defense of patents is that they promote the communication of ideas and *that*, in turn, spurs innovation. They claim that if patents did not exist, inventors would try to keep their inventions secret so that competitors would not copy them (e.g. Belfanti 2004). From this standpoint, the solution to the problem is a trade between the inventor and society: the inventor reveals his innovation and society gives him the right to exploit it exclusively for the next twenty or so years. Presumably then, to the extent that they replace socially harmful trade secrets, patents promote the diffusion of ideas and innovations (Moser 2013, pp. 31-33). In *reality* though, patents have exactly the opposite effect, encouraging ignorance and obstructing the diffusion of ideas. In what has become a standard practice, 'companies typically instruct their engineers developing products to avoid studying existing patents so as to be spared subsequent claims of willful infringement, which raises the possibility of having to pay triple damages' (Boldrin & Levine 2013, p.9; Brec 2008). Even if that were not always the case, the way in which patent documents are written actually renders them incomprehensible to anyone except lawyers (Brec 2008; Mann & Plummer 1991, pp. 52-53; Moser 2013, p. 39).

The real function of intellectual property rights in cognitive capitalism: how do capitalist firms actually use them?

What, however, more than anything else disproves the claimed positive effect of patents on technological innovation and creativity is the way in which patents are actually used by capitalist firms. In a capitalist knowledge economy, patents are used primarily as (a) means to signal the value of the company to potential investors, (b) as means to prevent market-entry by other companies (so they have *strategic* value independently of whether they are incorporated in profitable products) and (c) as weapons in an 'arms-race', meaning they are used defensively to prevent or blunt legal attacks from other companies (Boldrin & Levine 2013; Cohen et al. 2000; Hall & Ziedonis 2007; Levin et al. 1987; Pearce 2012). It would take a heroic leap of logic for any of these applications of patents to be seen as productive. On the other hand, there is a plethora of cases in which the effect of patents on innovation and productivity has been undoubtedly detrimental. Indicatively, consider how Microsoft is currently using a patent (*no. 6370566*) related to the scheduling of meetings in order to impose a licensing fee on Android mobile phones (Boldrin & Levine 2013; Brodkin 2011; Mueller 2012a, 2012b; Protalinski 2010; Wingfield 2010). In this case, patents become a mechanism for sharing the profits without any participation in the actual process of innovation. As such, they discourage innovation and constitute a pure waste for society. Interestingly, not that long ago, Bill Gates (1991), Microsoft founder, argued that 'if people had understood how patents would be granted when most of today's ideas were invented, and had taken out patents, the industry would be at a complete standstill today...A future startup with no patents of its own will be forced to pay whatever price the giants choose to impose'. It is ironic, of course, that Microsoft, not being able to penetrate the mobile telephony market, is now using the threat of patent litigations to raise a claim over part of Google's profits.

In conclusion, the manner in which patents are used in capitalist knowledge economies makes it blatantly obvious that 'in the long run...patents reduce the incentives for current innovation because current innovators are subject to constant legal action and licensing demands from earlier patent holders' (Boldrin & Levine 2013, p.7). This becomes readily understood, considering that technological innovation is essentially a *cumulative process* (Gilfillan 1935, 1970; Scotchmer 1991): Cumulative technologies are those in which every innovation builds on preceding ones: for example, the steam engine (Boldrin et al. 2008; Nuvolari 2004), but also hybrid cars, personal computers (Levy 1984), the world wide web (Berners-Lee 1999), YouTube and Facebook.

But if patents have at best no impact and at worst a negative impact on technological innovation and productivity (Dosi et al. 2006), then how is it possible to explain – especially from the legislator's side – the historical increase in patents and the ever more restrictive IP regimes that developed in the last thirty years? Many analysts have pondered this question. The conclusion to which they have been led is rather unsettling: the actual reason behind the proliferation of patents and the expansion of IP laws consists in the *political influence of large, cash-rich companies* which are unable to keep up with new and creative competitors and use patents to entrench their monopoly power (Boldrin & Levine 2013; Drahos & Braithwaiter 2002).

Alternatives to capitalist models

The real enablers of innovation

Since, as we have seen, restrictive IP rights do not promote innovation, then *what* does? In our capacity as authors of this policy document, we are siding with a multitude of researchers and practitioners from around the world in whose view what promotes innovation is exactly the opposite of restrictive IP rights (e.g. Bessen & Meurer 2008; Boldrin et al. 2008; Drahos & Braithwaiter 2002; Ghosh 2005; Von Hippel 2005; Moser 2013; Pearce 2012a; Weber 2005). To elucidate this point, we will discuss several case-studies in the following section which demonstrate that innovation thrives on openness and free sharing of knowledge as well as that IP rights can be used in a way that is diametrically opposed to their application in capitalist knowledge economies so as to *include* – rather than exclude – the broader community in the innovation process. In other words, the case-studies can be seen as working examples of an *alternative model* of economic and technological development enabled by (inclusive IP regimes founded on) the open knowledge commons. But before we proceed to the case-studies, let us briefly examine the general outlines and organising principles of this model.

The FLOK model

The FLOK model is an alternative to capitalist models of economic and technological development. It has three main features: (a) it is based on the practice of free sharing of knowledge, which is sustained and reinforced by an innovative and, arguably, subversive use of IP rights; (b) it is community-driven and (c) it leverages the Internet for distributed collaboration.

Open knowledge commons

The cornerstone of the FLOK model is the practice of free sharing of knowledge underlying it. Its founding credo is that technology is most efficiently developed in conditions of openness and collaboration, rather than secrecy and knowledge hoarding. To set up such open and collaborative structures for the development of technology, the FLOK model has evolved legal mechanisms (known as open source licenses [Wikipedia 2014b] or simply as open licenses) which ensure that anyone is free to use, modify and redistribute technologies produced through the FLOK model. By democratising access to technology and knowledge through open licensing, the FLOK model effectively empowers the global community to participate in the productive process. There is only one limitation: improvements and modified versions should be made available under the same conditions. Thus, technologies and knowledge released under open licenses form an open, yet *protected*, knowledge commons that anyone can use but none can expropriate. In this way, open licensing serves as a protection against the danger of private expropriation and commercial co-optation (Dafermos & van Eeten 2014; Kloppenburg 2010; Moglen 2004; O'Mahony 2003).

Community-driven development

The FLOK model challenges the dominant view that the institutional environment most conducive to the development of knowledge and innovation is that provided by large, hierarchically-organised corporations. Instead it suggests that open, community models trump corporate ones in accommodating creativity and delivering innovation. In practical terms, this means that anyone can participate in the development process of a FLOK project but none can exercise heavy-handed control over the project or the other participants (Benkler 2006, p. 105; von Krogh & von Hippel 2006). Tasks are self-selected by participants, while decision-making is collective and consensus-oriented. Consequently, the direction of development of FLOK projects derives from the cumulative synthesis of individual community contributions, rather than from a central planner (Wenden de Joode 2005).

Internet-enabled collaboration

The FLOK model leverages the Internet for massively distributed collaboration. For example, as we shall see below, the development of the RepRap 3D printer is distributed across hundreds of hardware hackers and hobbyists from all over the world, who share improvements and coordinate changes over the Internet. Same goes for the energy-efficient car developed by the Wikispeed project, which we will discuss in the next section to illustrate the FLOK model through its application into farming, building and manufacturing.

Open knowledge commons in the secondary economy sector

Case-study 1: RepRap

RepRap[2] is an open source[3] printer which can be used to manufacture three-dimensional objects. The project which spearheaded its development was launched in 2005 by Dr. Adrian Bowyer at Bath University in the UK, with the aim of developing an open source 3D printer that can replicate itself by re-producing its own components, ultimately creating a small-sized, affordable, 'homebrewed' manufacturing device that can be used to produce most of the objects people use in daily life.

Open licensing and distributed development From the very beginning, the project leveraged the Internet for distributed collaboration: it open-sourced the design and all technical specifications of the RepRap technology so that others could experiment with it and improve it. Based out of various hackerspaces and makerlabs around the world, a loosely-coupled network of hardware hackers and hobbyists sharing ideas and modifications soon formed, resulting in rapid and significant improvements. The first version of RepRap, codenamed 'Darwin', was released in May 2007; version 2 (called 'Mendel') followed in 2009 and version 3 ('Huxley') a year later (see Fig. 1 below). By 2010, the project had evolved in a global community of about 5000 members and community size is doubling every six months (de Bruijn 2010).

Fig. 1: Rep Rap v. 3 ('Huxley'), May 2007 (Source: http://reprap.org/wiki/Huxley)

Effect of IP rights on development of 3D printing What accounts for this remarkable community growth? First of all, to put the development of RepRap into perspective, one must look at the effect of IP rights on the historical development of 3D printing technology. 3D printing has been used in the manufacturing industry for about forty years but the fact that it was a patented technology effectively excluded the broader community from participating in its development. Then in the mid-2000s the expiration of a set of patents on 3D printing galvanised the emergence of the open source 3D printing movement, which coalesced around the RepRap project. Hackerspaces played a crucial role in this process of community involvement by providing hardware hackers and hobbyists around the world with access to a sort of communal workshop or shareable toolshed, which they could use for community projects. Thus, by helping hackers more effectively organise themselves, such user-managed spaces formed a key component of the distributed technological infrastructure underlying the development of RepRap. As a result of this influx of contributors from the open hardware community, the project soon managed to improve RepRap's design and performance and slash the production cost of 3D printers down to about $500 (Banwatt 2013a, 2013b, 2013c). In parallel, several start-ups sprung out of the bosom of the RepRap community and began to make low-cost 3D printers based on the RepRap design for the consumer market.

Fig. 2: Stratasys is a 3D printing company co-founded by Scott Crump, who was granted in 1992 a key patent for 3D printing. The patent expired in 2009. MakerBot Industries was founded in the same year (Source: von Hippel 2011, p.59)

[1>Implications<1] The involvement of the open source 3D printing community in the development of RepRap is not confined to experimentation with its design parameters but also extends into the range of objects that RepRap printers can manufacture. To date, RepRap 3D printers have been used to make clothes (Materialise 2013), wind turbines (Kostakis et al. 2013), prosthetic body parts (Molitch-Hou 2013), wearable technologies (e.g. wearable mobile phones [Cera 2012]) and even guns (Greenberg 2013). In fact, the spectrum of objects that 3D printers could manufacture is potentially infinite: for example, a group of architects called 'KamerMaker' is currently using a 3D printer to build a canal house in Amsterdam, the Netherlands (KamerMaker; Holloway 2013), while the European Space Agency is planning to build lunar space stations using 3D-printed bricks made from moon dust (Carter 2013; European Space Agency 2013a, 2013b). As US President, Barack Obama, says, '3D printing has the potential to revolutionize the way we make almost everything' (quoted in Gross 2013).

The implications of such a paradigm shift in manufacturing for environmental sustainability are enormous. 'Because they only use the exact material required, 3D printers could eliminate waste from traditional manufacturing – in which up to 90% of raw material is discarded' (Webster 2013). In addition to realising economies in the use of raw materials, the type of distributed manufacturing undergirded by RepRap-like 3D printing implies a massive reduction in global transportation costs attendant upon the localisation of production (Rifkin 2011). Clearly, large-scale industrial infrastructures and the mass production model itself are no longer needed if people are able to micro-manufacture whatever they need in the comfort of their homes. And that is good for the environment: unlike large-scale industrial manufacturing, which is based on the cheap availability of fossil fuels, 'home 3D printing' is illustrative of an on-demand manufacturing model which emphasises application that is small-scale, decentralised, energy-efficient and locally controlled. Thus, the diffusion of small-sized, affordable 3D printers promotes a model of environmentally sustainable technological and economic development.

To sum up, the RepRap 3D printer is paradigmatic of a case in which the open design commons enabled a global community to engage in distributed, participative development which, in turn, resulted in significant technical improvements and production cost reductions, paving the way for the rise of a new market in low-cost 3D printers. In parallel, the RepRap project illustrates the workings of a distributed manufacturing model that is germane to a post-fossil fuel economy.

Case-study 2: Wikispeed

Wikispeed is a project focused on the development of an energy-efficient car (see Fig. 3 below). [[4]] What is especially interesting about the Wikispeed car is that it is developed by a global network of volunteers, who, by using methods drawn from the realm of open source software development, have managed to reduce development time and cost down to a fraction of that which conventional car manufacturing requires.

Fig. 3: The Wikispeed car (Source: Wikispeed Project 2013)

The birth of Wikispeed can be traced back to the 2008 Progressive Insurance Automotive X-Prize competition for the development of energy-efficient cars, which captured the attention of Joe Justice, a Seattle-based software consultant. What set Justice apart from the other participants in the competition was his strategy and his resolve to apply open source software development methods to car manufacturing. In the beginning, he was alone. But as he announced his plan on the Internet, volunteers came to help and in three months he had a team of forty-four volunteers and a functioning prototype (Denning 2012; Halverson 2011). Now the project is jointly developed by more than 150 volunteers distributed around the world, who aim to deliver Wikispeed as a complete car for $17,995 USD and as a kit for $10,000 USD (Wikispeed 2012).

To speed up the development process and reduce its cost, the Wikispeed team, inspired by the *lean manufacturing*and*open source*philosophy, evolved an approach that constrasts sharply with conventional manufacturing. First, the entire manufacturing process is designed with a view to minimising the expenditure of resources that do not add any value to the end-product from an end-user's point of view. For example, while an average manufacturer uses 'a $100M CNC milling machine...WikiSpeed uses a $2.000 machine found in the average FabLab...While modern cars embed various costly, non-interoperable, proprietary computers to manage various features ranging from airbags, to gas levels, to air conditioning, WikiSpeed uses a single $20 Arduino circuit board' (Tincq 2012).

Second,*modularity* is the core design principle: Wikispeed is made up of eight components that can easily be removed and re-assembled (see Fig. 4 below). Such a product architecture makes it easy to modify and customise the car, for individual components can be modified without necessitating changes in the rest of the car. As a result, 'the whole car can transform from a race car, to a commuter car, to a pickup truck, by changing only the necessary parts' (Tincq 2012).

Fig. 4: The Wikispeed modular design (Source: Tincq 2012)

Third,*scale* is not important to Wikispeed: 'cars are produced on-demand, when a client offers to pay for it. This implies almost no capital investment upfront to produce a Wikispeed car' (Tincq 2012). Through the use of on-demand manufacturing and lean production methods, Wikispeed has achieved significant development cost reductions. But the production of Wikispeed is not only 'lean' and 'on-demand', it is also *distributed*: Wikispeed is being developed by a distributed network of largely self-managing teams – each working at its own garage – who coordinate their work through the Internet. This kind of computer-mediated collaboration is enabled by the modular structure of the Wikispeed car, as product components can be developed autonomously and independently of each other by different individuals or teams with little, if any, need of central coordination (Dafermos 2012). The resulting distributed organisational structure, according to the Wikispeed team, is key to realising significant *economies of scope* and *flexibility*: so, to reinforce distributed manufacturing, 'WikiSpeed members are currently practicing to build cars within a rectangular space marked on the ground. By achieving this, micro factories could be encapsulated within containers, and shipped to where there is demand for local production. Once the work is done, a micro factory could be moved to a surrounding area to meet new demand' (Tincq 2012). The sustainability implications of such a paradigm shift in manufacturing are obvious: just like RepRap-like 3D printing, Wikispeed is proposing a model of distributed manufacturing which leverages the global open design commons for local production. Unlike large-scale industrial manufacturing, which depends on the cheap availability of fossil fuels, Wikispeed's on-demand manufacturing model emphasises application that is small-scale, decentralised, energy-efficient and locally controlled. In that sense, it promotes a model of sustainable development that recognises the limits to growth posed by finite resources and so organises material activities accordingly (Bauwens 2012b).

Fourth, the development of the Wikispeed car is built around the defining hallmark of open source software production: all *technical specifications are shared freely* with the community so that anyone can contribute to its development. In this way, by opening up the product development process, the Wikispeed project can tap into the contributions of a global community of volunteers. But for the Wikispeed team, freely sharing design information is not only a means of engaging the global community in the collective development of the Wikispeed car, but also the basis of a model of *distributed entrepreneurship* which allows hobbyists and enthusiasts from all over the world to download the blueprints of [2>Wikispeed and use them as a springboard for developing their own cars at their garage<2].[5]

To date, the Wikispeed project has financed its operation mainly through crowdfunding campaigns and small donations from sympathisers (the so-called 'micro-investors'). For its long-term sustainability, however, it aims to sell the cars it makes. The price for a Wikispeed prototype is 25,000 USD and the project is currently working on the development of a commuter car which will be launched as a complete car for $17,995 USD and as a kit for $10,000 USD. In recognition of its community character, the Wikispeed project has announced that the proceeds from sales will be redistributed back to the community of contributors.[6]

To sum up, the case of Wikispeed, just like that of OSE and RepRap, demonstrates how a technology project can leverage the open design commons and the Internet to engage the global community in its development. Most important, Wikispeed proposes a model of distributed manufacturing that is well-suited to a post-fossil fuel economy: a model which is small-scale ('on-demand'), decentralised, energy-efficient and locally controlled.

Preliminary general principles for policy making

Through the above case-studies, we have come to identify a set of enabling conditions, from which we can draw several general principles to guide policy making efforts aimed at reinforcing the development of a social knowledge economy.

The commons as a key enabler. It is obvious that the emergence of the community-driven development model characteristic of both Wikispeed and RepRap would have been impossible in the absence of the *open design commons*. Taking this into consideration, it is obvious that policy-making should be geared towards supporting and enriching the commons as a shareable infrastructure for the social knowledge economy.

The importance of distributed technological infrastructures. The development of the FLOK model is unthinkable without a distributed technological infrastructure (Bauwens 2005; Benkler 2006). At the most basic level, the scaling up of the FLOK model requires *distributed access* (a) to the *Internet*, which members of FLOK projects use to exhange information and coordinate their activities, and (b) to *fixed capital*, by which we mean a spectrum of hardware technologies such as personal computers and 3D printers, which constitute the essential means of production in this setting.

The need for investment in knowledge. The development of such distributed technological infrastructures by itself is unlikely to generate positive results, unless people, too, know how to use them. The task, therefore, of building these infrastructures should be complemented with and reinforced by appropriate processes and structures of learning designed to harness the diffusion of 'mass intellectuality' (Bauwens 2005; Virno 2001; also see Rushkoff 2004) that is required for the expansion of the FLOK model.

Hackerspaces as a territorial infrastructure for cognitive work. *Hackerspaces* (as well as hackerlabs, makerspaces and so on) are commonly used by individuals and groups with limited financial resources as a local, physical platform for the mutualisation of resources and the provision of shared access to those means of production that are not yet as distributed and generally available as personal computers and Internet connectivity.[7] As such, they form a territorial infrastructure for the development of commons-oriented, open hardware projects such as RepRap and Wikispeed.

The importance of access to credit and investment resources and the role of public policy. As we saw, in order to raise money to finance its operations, the Wikispeed project has turned to its base of supporters, on whose contributions it relies, and to crowdfunding campaigns as a vehicle to reach out to the Internet community. This choice to mobilise the community was largely dictated by the fact that the project has been so far unable to attract investment capital from the private sector. That is not accidental. On the contrary, it is the general case with technologies like Wikispeed which are not 'protected' by exclusive IP rights, given the private sector's aversion to invest in technologies and projects that do not have the potential to generate patentable results. For example, that is why capitalist investments in agricultural science and technology have long favoured the development of products such as seeds that cannot be reproduced in the farming process, rather than agroecological methods which are rendered practically un-patentable by virtue of their inherently collective and communal character (Vanloqueren & Baret 2009, p. 977). From an investment standpoint, the 'problem' with artefacts and methods that are not patented lies in the fact that they are not locked up in property rights which can be leveraged to capture rents. There is nothing strange, therefore, about the absence of capitalist investment in commons-oriented, open source technology projects like Wikispeed or RepRap, which would have not survived without the support of civil society. The fact, however, that the business sector cannot be relied upon to develop the products and technologies that fuel a social knowledge economy suggests the importance of setting up appropriate public policies to reinforce the development of the commons of science and technology.

In the next section we situate the above principles in the Ecuadorian policy context.

The Ecuadorian policy framework

The basic axis of the *National Plan for Good Living 2013-2017* revolves around the transformation of the productive structure of Ecuador in the direction of a *social knowledge economy* powered by the fruits of science, technology and innovation.

The task of transformation of the productive matrix is dictated by the fact that the nature of the existing economic system is clearly both environmentally and economically unsustainable. 'Since its origins as a republic, Ecuador has produced commodities with low or no value-added, creating an incipient proto-industrial textile industry in colonial sweatshops. The country’s insertion in the worldwide capitalist system accentuates this pattern of accumulation based on exploiting the country’s huge natural wealth, and encourages rentist, non-innovative behavior among the economic groups that have dominated the country. This historical situation has placed Ecuador in a highly vulnerable situation of external dependence' (National Plan for Good Living, p. 49, english version). The aim, therefore, of the transformation of the productive matrix is precisely to break free from this legacy by turning 'Ecuador from a commodity-exporting economy [in]to a knowledge economy: *turning finite* (non-renewable) *resources into infinite* (inexhaustible) *goods* such as knowledge, which multiplies when distributed rather than depleting itself' (Ibid.; also, see pp. 18, 37, 38)(see Fig. 5 below).

Fig. 5: Long-term strategy of accumulation, distribution and redistribution (Source: National Plan for Good Living 2013-2017, p. 37, english version)

In recognition of the importance of *distributed access to the means of production* in undergirding a social knowledge economy with a strong focus on broadening participation in productive activities, *Policy 2.4* of the National Plan focuses on the need 'to democratize the means of production [so as to] generate equitable conditions and opportunities' for participation in the economy (also see pp. 41, 61). Considering that the decisive input into production in a knowledge economy is *access to knowledge*and that the management of knowledge is more efficient when knowledge is seen as a common good, the National Plan proposes the development of an '*open commons of knowledge'* (National Plan, spanish version, italics ours, p. 67). To the same end, the Constitution emphasises the democratisation of the means of production (Art. 276/2) and the need to 'prevent the concentration or hoarding of production inputs and resources...and eliminate privileges or inequality in access to these inputs' (Art. 334/1).

Equally important, the transformation of the productive matrix should encourage *social self-organisation* (*Policy 1.12*) and economic experiments with respect both to form and size of organisation. Characteristically, to support pluralism and diversity in the economy, the National Plan proposes:

- To strengthen the popular and solidary economy (EPS) and micro-, small-, and medium enterprises (MSMEs) within the productive structure (*Policy 10.5*).

Another recurrent theme is *sustainability*. Crucially, its importance implies that 'the economic system does not automatically come first; on the contrary, it is subordinated and serves the lives of human beings and Nature' (Senplades [2009: 329] quoted in National Plan, p. 73). The energy sector is a focal point: 'Energy is the lifeblood of the production system, so it is essential to increase the share of energy obtained from renewable sources...in order to achieve long-term sustainability' (National Plan, pp. 43-44). In the same spirit, the Constitution 'promote[s] energy efficiency, the development and use of environmentally clean and healthy practices and technologies, as well as diversified and low-impact renewable sources of energy' (Art. 413).

To sum up, both the National Plan for Good Living 2013-2017 and the Constitution of Ecuador give explicit policy support to the development of a decentralised and inclusive post-fossil fuel economy driven by the forces of science, technology and innovation, and propose a set of supportive policies towards this direction, such as the provision of (a) distributed access to the means of production, (b) economic incentives (e.g. democratisation of credit access) and (c) training in the requisite skills.

The next section puts foward several policy recommendations that are designed to support and reinforce the aforementioned aims and policies of the Ecuadorian policy framework.

Ecuadorian policy recommendations with institutional participation

To close this policy paper, we put forward several policy recommendations which address such strategic objectives of the National Plan for Good Living as:[8]

- The transformation of the productive matrix towards a post-fossil fuel economy characterised by transparent, inclusive and participatory structures (*objective 10*, pp. 78-81).
- The construction of a knowledge society founded on the open knowledge commons which distributes massively the capacity for participation in the development of science, technology and innovation (pp. 17, 47-50).

We have seen how patents in specific and restrictive IP rights in general run counter to the aims and needs of a social knowledge economy. In contradistinction, as our case-studies demonstrate, the kind of inclusive, yet protected, commons regimes established by free/open licenses are indispensable to the development and operation of a social knowledge economy. Consequently, to *support the development of the knowledge commons of science and technology and protect it against the danger of private enclosure*, we propose to **transform the legal framework (that pertains to industrial and intellectual property) so as to promote collaborative and distributed production based on the use of free knowledge** (PRIORITY 1: Titulo 3, Libro 1). More specifically, we propose:

- The implementation of a legal framework based on free/open licenses, such as the GNU GPL,[9] for the licensing of scientific and technological artefacts.
- The *de facto* abolition of the patent system. This can be done through the use of royalty-free and copyleft-style patent licenses, that is, by means of 'licensing patents for royalty-free use, on the condition that adopters license related improvements they develop under the same terms' (Wikipedia 2014d).
- That a representative group be set up to review and amend the law of industrial and intellectual property.

Moreover, to *support the development of commons-oriented projects and organisations*, we propose:

- The provision of special economic incentives for commons-oriented projects and organisations. This can be implemented in a variety of ways: for example, through tax benefits and (state-supported) micro-credit systems.
- The development of a legal framework that provides co-ops and collectivist organisations operating in the secondary sector and in the social and solidarity economy with the organisational autonomy as well as institutional support which is required for their operation.[10]

Concomitantly, to *democratise access to credit and investment resources,* we propose:

- The creation of a community-managed *Community Investment Fund* for commons-oriented projects and organisations, such as that operated by co-op federations in Northern Italy (i.e. the so-called 3% Fund)[11] and proposed by Kleiner (2010, pp. 23-25) for the support of worker-owned organisations.

Considering that public procurement can be used as a very effective instrument to promote open and free technologies, we propose that the **use of free and open technologies be encouraged in public procurement programs** (PRIORITY 1: PBV 10.4, 10.7c & Libro 1 de la Gestion del

Conocimiento). For that purpose, we propose that public procurement legislation be amended to prioritise the use of free technologies.

At the same time, it goes without saying that policies aimed at the transformation of the productive matrix in the direction of distributed production structures based on the open design commons should be responsive to the exigencies of the local context. It is absolutely critical to ensure that those **policies are designed to address existing problems of the Ecuadorian productive sector through the use of free technology, collaborative work methods and civil networks** (PRIORITY 1: Libro 2 & 3). To this end, we propose:

- That repositories be set up to promote the diffusion of free knowledge, such as that embodied in 'free-use' patents (i.e copyleft-style patent licenses. See Wikipedia [2014]) and publications distributed under free/open licenses.
- That free technology labs be set up with the objective to investigate, facilitate and incubate projects based on the principles of free knowledge.
- To transform the productive associations and guilds of the former gunsmiths and artesanos of San Jose del Chimborazo through the adoption of free technologies. As a first step in that direction, we propose that a micro-factory for open-source tools and machines be set up in San Jose del Chimborazo.
- To modernise and transform the technological infrastructures available to the agricultural community in Sigchos through the adoption and use of free technologies. To this end, we propose to design and implement a pilot project in Sigchos around the following infrastructures: (1) An open-source seed bank and a repository of micro-organisms (that could be used as natural substitutes for synthetic fertilisers and chemical pesticides), (2) a micro-factory for the manufacturing of open-source farm machines and a centre for the assessment of the machines, (3) a training centre focused on the use and maintenance of open-source farm machines.
- To support initiatives, such as the Quichua Institute of Technology, which develop and promote free knowledge and free technologies.
- To promote the use of free technologies in Ecuadorian state programs of technology development (e.g. open-source body prosthetics and farm machines). As a first step in that direction, we propose to implement the following pilot project: a non-profit lab at a public University for the design and manufacturing of 3D-printed body prosthetics as a public service.
- To promote the development of workshops for the fabrication of machine tools (e.g. fablabs, makerspaces, hackerspaces, etc.) and the provision of the necessary components. Furthermore, it has been remarked how the use of hackerspaces, makerspaces, fablabs and co-working spaces for the mutualisation of resources and the provision of shared services to members constitutes a crucial infrastructure for both co-located and distributed cognitive work. So, to *support the development of shareable, territorial infrastructures for cognitive work*, we propose that supportive policies be developed for the setting up of hackerspaces, hackerlabs, makerspaces and co-working spaces as a territorial infrastructure for cognitive work, skill sharing and technology transfer.

In a similar vein, with the aim to **incentivise the development of local structures of free technology, e.g. through 'special zones of economic development'** (PRIORITY 2), we propose:

- That pilot projects be set up around free technology labs and 'special zones of economic development' ('ZEDES') for open design and free production structures.

Equally important, our analysis has highlighted the *importance of the diffusion of knowledge* in empowering people to participate in projects of a technical character. That is why it is imperative to **popularise free knowledge in all areas and make it an integral part of the education system** (PRIORITY 1: PBV 10.7e). With this aim in mind, we propose:

- The introduction of free culture and (training in the use and development of) free technologies into the basic school curriculum and across university programs.
- The re-orientation of science and technology towards models of *open science* (Wikipedia 2014c) with the aim of making the fruits of scientific and technological research accessible to all the members of society. To achieve this, we propose that publicly funded research and development in science and technology be released under free/open licenses (e.g. GNU GPL).[[12]]
- The incorporation of free educational material and tools in study plans.
- The promotion of the use of and research in free knowledge.
- The setting up of spaces for informal training (continuous education) as an enabling infrastructure for the development of a free culture.

In complement to the above policy recommendations, we propose that **academic institutions make use of free knowledge to assess the performance of training centres and professionals** (PRIORITY 1). In specific, we propose:

- To include publications distributed under free licenses in the academic evaluation and assessment system (for the purpose of assessment of professional performance).
- To promote scientific standards and free licensing in academic journals.
- To comply with the existing regional-federal Agreement on Open Repositories ('La Referencia').

Last, in order to provide expert support for the task of design, implementation, monitoring and evaluation of the above public policies and pilot projects, we propose:

- That a National Observatory for Free Technologies be set up with the objective (a) to promote free technologies (e.g. in public procurement), (b) to promote the development of repositories of free technologies and (c) to assess the economic viability and fitness of free technologies to meet existing needs.

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Notes

[1] This work is licensed under the *Creative Commons Attribution-Share Alike 3.0 Ecuador*. To view a copy of this license, visit https://creativecommons.org/licenses/by-sa/3.0/ec/ or send a letter to Creative Commons, 171 Second Street, Suite 300, San Francisco, California, 94105, USA.

[2] URL: http://reprap.org

[3] The RepRap design information is licensed under the GNU GPL.

[4] URL: http://wikispeed.org

[5] Wikispeed considers itself to be such a *distributive enterprise*: 'a transparent enterprise that promotes—at the core of its operational strategy—the capacity for others to replicate the enterprise without restrictions...[a kind of] an open franchise system that focuses on being replicated by others' (Open Source Ecology 2012; Thomson & Jakubowski 2012: 62).

[6] Wikispeed has devised an interesting method of remunerating community contributions to the project. According to the project website: 'If I give money, time, cookies, or supplies to WIKISPEED and WIKISPEED is profitable, WIKISPEED will pay me back the value of what I put in plus interest commensurate with their level of success' (http://wikispeed.org/join-the-team/our-ethics/).

[7] It is no coincidence that the majority of RepRap 3D printers have been prototyped, tested and operated at such user-managed spaces. Indicatively, the first RepRap 3D printer in the city of Heraklion, Greece (which is the author's birthplace) was developed at the tolabaki hackerspace (http://tolabaki.gr).

[8] Resolution No. CNP-001-2013, published in Official Gazette No. 950, on 9 May 2013. Article 1.- Setting the Ecuadorian Government’s priority for the 2013–2017 period: building the knowledge society, changing the productive structure, closing gaps to eradicate poverty and achieve equality, environmental sustainability, social peace and implementing districts and circuits (National Plan for Good Living 2013-2017, p. 89, footnote 34, english version).

[9] URL: http://www.gnu.org/copyleft/gpl.html

[10] For an elaborate discussion of what that task entails and how it can be achieved, see the FLOK policy documents by Restakis (2014a, 2014b).

[11] The 3% Fund is operated by co-op federations in Italy whereby member co-ops contribute 3% of their annual profits to a collective Fund that is used for investment purposes (Logue 2006; Mancino & Thomas 2005).

[12] For a discussion of the proposal to release publicly funded R&D under the GNU GPL, see Boldrin and Levine's (2013, p.19) as well as Pearson's (2012a) recent contribution in the *Journal of Economic Perspectives* and *Nature* respectively.