BENDING THE RULES: THE FAB LAB INNOVATION ECOLOGY[†]

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ABSTRACT

Digital fabrication becoming available at low cost and open source ideas approaching the physical realm are changes that challenge rules of manufacturing and intellectual property protection. Emerging innovation ecosystems begin to embrace these developments; one of them is the network of MIT conceived fabrication laboratories (Fab Labs).

The paper reports two studies; the first examines intellectual property (IP) protection and licensing in the context low-cost fabrication and commons-based peer production, the second investigates the business models of selected Fab Labs located in urban neighbourhoods in industrialized countries.

Study 1 indicates that open source as an alternative to conventional IP rights protection is possible and established practice, yet it is still a novelty to many. Study 2 finds that Fab Labs mainly portray themselves as providers of fabrication facilities, but some actually market the possibility of low-cost fabrication to business customers who previously conceived making things as not viable.

The paper proposes a model for the value creation, delivery, and capture mechanisms essential to a Fab Lab innovation ecology based on the combination of an open source approach and low-cost fabrication employed in unforeseen applications.

Keywords: Intellectual Property, Business Model, Commons-based Peer Production.

1. BACKGROUND

The division of labour within innovations systems and even more in society at large has undergone major shifts, which have been described in terms of open innovation (Chesborough 2003), or in terms of learning in communities of practice (Brown & Duguid, 1991). Recently, the topic has attracted wider attention, mainly thanks to the growth of commons-based peer-production projects such as Wikipedia, Open Source Software, Open Design (for a discussion see Helfrich, 2010). This raise of individuals collaborating in producing cultural content, knowledge, and other information and indeed physical goods, is commonly attributed to 'digital revolutions', the broad availability of new information technologies (see e.g. Benkler, 2006). First there was a digital revolution in computation (personal computer), then in communications (convergence and mobile phones). The next digital revolution, according to Gershenfeld (2005), is in the field of manufactured physical goods (personal fabrication).

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Fab Labs (fabrication laboratories) are 'place[s] to make (almost) anything' (Gershenfeld, 2005). They offer access to a range of low-cost fabricators and they are based on an commons-based peer production approach. The New York Times Magazine even ran a cover story under the title 'The Amateur's Hour' (Hitt, 2007) about how 'America's basement brainstormers, workbench concocters and garage tinkerers' are reviving e.g. NASA's space program, a domain formerly reserved to specialist scientists and engineers.

Yet the theory of open innovation has no explanation for the growth or even the existence of commons-based peer production: Chesborough (2003) calls it the 'puzzle of Open Source Software'; von Hippel acknowledges that 'the empirical finding that users often freely reveal their innovations has been a major surprise to innovation researchers' (von Hippel, 2005). The major issue is the absence of a business model built around intellectual property rights (Chesborogh 2006, 25): 'By construction, open source software is created without any one firm owning the technology. No firm can patent the technology, or exclude anyone else from accessing the software code. Enhancements to the code are available to everyone on an equal basis. Is this simply an exception to the general rule [i.e. that the value of a technology is determined by the business model], is this due to a business model of a different kind, or is there something fundamentally wrong with the above claims of Open Innovation regarding the importance of business model for the behavior of firms?' Commons-based peer production is, seemingly, not obeying the rules.

2. RESEARCH OBJECTIVE

The overall objective of this paper is to investigate how commons-based peer production could deal with intellectual property and consequently how business model(s) could be built. The international network of Fab Labs serves as an empirical field to study these two questions.

The first question addresses the issue of intellectual property. The open source movement has fundamentally questioned traditional beliefs in the very notion of intellectual property (see e.g. Boldrin & Levine, 2008a). The empirical analyses carried out by Bensen & Meurer (2008a, 2008b) indicate that the patent system provides little innovation incentive to most public firms; even more, they find that 'intellectual property rights have at best only a weak and indirect effect on economic growth'. This not only holds for the US but also for the EU (see the economic analysis by Graham & Harhoff 2006, Hall & Harhoff 2004; Graham et al. 2002). Economists in general find it hard to justify the patent system or its abolition, as Penrose already in 1951 eloquently put it: 'If national patent laws did not exist, it would be difficult to make a conclusive case for introducing them; but the fact that they do exist shifts the burden of proof and it is equally difficult to make a really conclusive case for abolishing them.' However, in the world of commons-based peer production, we expect the relevance of intellectual property protection do diminish, the question at hand rather being how to balance openness and protection to stimulate rather than to stifle an innovation ecology.

The second question addresses the business model. Traditional, static approaches of business modelling (see e.g. Müller-Stewens & Lechner, 2005, Christensen, Johnson & Kagermann, 2009, Kagermann & Österle, 2007) have been contrasted by the need for business model innovation (see e.g. Osterwalder, 2009) and the growing number of social entrepreneurs (for an overview see e.g. Elkington & Harigan, 2008). The quest for a business model for commons-based peer production is not yet solved; at least in

current Fab Lab practice there is no single business model (Boeing, 2003) and literature is mainly focusing on Fab Lab users (e.g. Mikhak et al., 2002, Gershenfeld, 2005, Gjengedal, 2006, Pfeiffer, 2009) rather than the labs and their innovation ecology. This paper aims to describe existing and envisaged business models of Fab Labs already in operation, and to suggest business model options for new Fab Labs currently under development. These descriptions and suggestions explicate and model the value creation, delivery, and capture mechanisms essential to the Fab Lab innovation ecology.

3. METHOD

Two studies have been carried out looking particularly into the issues of IP protection and the development of Fab Lab business models for new Fab Labs positioned in an urban-industrial operational context.

Study 1 on intellectual property (IP) protection includes an examination of the legislative basis and the licensing practice in the area of IP rights with a focus on the UK jurisdiction. It particularly addresses the opportunities and limitations in the context of low-cost fabrication. It examines the requirements of commons-based peer production regarding IP rights and discusses legal options to make IP open source.

Study 2 addresses the business model using a two-tiered approach. Firstly, a top-level description of the positioning of all 45 Fab Labs was derived through document analysis. This description served the selection of labs to be studied in detail. For the context of the study, labs needed to be located in an industrialized country and situated in urban settings. Further, they had to be at least partly open to the general public. So a subset of twelve Fab Labs was identified for further investigation. Three of them were not included in the study: one did not respond, one chose not to take part, and one eventually turned out not to be publicly accessible. The business models of the nine remaining labs were analyzed more deeply in expert interviews with Fab Lab managers or, where applicable, with business managers at their hosting organisations. Themes covered were value proposition, revenue model, processes, resources, marketing, and innovation partnerships. The findings of this study have been validated with focus groups of representatives from existing Fab Labs and from two labs that are under development at the time of writing.

4. CONTRIBUTION

4.1 STUDY 1: INTELLECTUAL PROPERTY PROTECTION AND LICENSING

Intellectual property protection refers to the legal protection granted to inventions or to manifestations of creations of the mind, so called ‘intellectual property’ (IP). This legal protection gives the owner of the IP a monopoly on the exploitation of that IP. Types of IP protection include registered and unregistered industrial designs rights, copyright, patents and trade marks.

Commons-based peer production challenges the conventional concept of IP protection. In areas such as literature, music, film and software this has attracted wide-spread attention, whereas the field of personal fabrication remains largely uncovered and under researched. In his investigation into the intellectual property (IP) implications of low-cost rapid prototyping, Bradshaw (2008) found that there was little literature on the subject and (UK) case law was incidental.

Examining UK legislation and pertinent case law, Bradshaw (2008) concludes ‘that the legal environment, in the UK at least, is surprisingly favourable towards the use of low-

cost fabricators for personal and even in many cases commercial purposes' (p. 33). The 'many cases' of allowed commercial uses include the production of unbranded spare parts that do not qualify for design protection (p. 20), or the use of trade marks e.g. in toy models where the mark is not being used 'in the trade mark sense' (i.e. 'as an indication to customers that there is a link between the owners of the mark and the person using it') (p. 32). Note that in both cases IP is not protected.

IP protection	Legal basis	Allowed uses
Registered Design	Registered Designs Act 1949 (as amended)	private and for purposes that are not commercial
Unregistered Design	Copyright, Designs and Patents Act 1988	non-commercial
Copyright	id.	personal, private use
Patent	Patents Act 1977	private and non-commercial; experimental
Trade Mark	Trade Marks Act 1994	personal use
Passing Off	common law tort	private use

Table 1. Allowed uses under UK IP protection regimes (according to Bradshaw 2008).

From Bradshaw (2008) we can conclude that using low-cost fabricators to reproduce protected IP for non-personal or commercial purposes is prohibited by UK IP protection regimes. To legally re-use protected IP, the users would first have to seek a license from the owner of the IP, granting the right to use the IP for their own ends, typically in exchange for a fee.

Yet in a commons-based peer production system, the intent is not to monopolize IP but rather to assure it cannot be monopolized (Benkler & Nissenbaum 2006). Protection of registered designs, patents and trade marks require registration to be enforceable. So if owners of IP intend to allow all subsequent use and exploitation of their IP by others, they may simply choose not to register for protection. Contrary to the situation of registered IP however, where registration is proof of the owner seeking protection, there is little certainty for a third party user that a particular piece of IP has in actual fact not been registered – other than trust in the owner of that IP. There are currently various systems under discussion to remediate this problem, e.g. by creating a registry and 'trust label' for not-registered IP (OHANDA 2010).

Equally, there are initiatives to open up already registered patents to commons-based peer production (e.g. the Open Invention Network (Open Innovation Network 2005), GreenXchange (Willbanks 2009) and Creative Common's patent tools (Nguyen 2010)). In these initiatives, patent owners (either original owners or bodies specifically set up to acquire certain patents) commit to not enforce patents against certain uses or offer to license their patents on standard terms either to the public or to a certain user group, akin to the French Government in 1839 acquiring Daguerre's patent on a photographic process and 'nobly endow[ing] the whole world with this discovery' (Wood 1996).

For unregistered design protection and copyright the system works differently. For these two protection regimes, protection starts with the creation of the IP and lasts for a certain period which is 10 years for unregistered design rights[1], the life of the author plus 70 years for copyright. As a consequence, designs and creative and artistic works are always protected initially, and any commercial or non-personal use would be considered an infringement.

To 'open' creative and artistic works (including software), a large range of public licensing systems have been developed (for an overview, see e.g. Hall 2003, Liang 2004); the most relevant for works outside the realm of software are the Creative Commons licenses (Creative Commons 2002). By applying such a public license to a work, the author grants the public certain rights, e.g. the rights to reproduction or modification, under certain conditions, e.g. non-commercial or the condition to re-license derivative works under the same license, etc. Public licenses are typically available free of charge, and most licenses require that explicitly.

Responses to 'open' approaches beyond software in general and the applicability of such licensing systems in the realm of digital fabrication are mixed. Newcomers to the scene initially react hesitant at best, they question the viability of business models and the possibility for innovation, and they are quite simply not used to peer production. Yet there is clear evidence for the uptake of 'open' approaches in product design (see e.g. Arnold & Smith 2005, Bollier & Racine 2005, Kadushin 2005, Shah 2005, Balka et al. 2009).

4.2 STUDY 2: FAB LAB BUSINESS MODELS

There are currently 45 Fab Labs around the world that use the power of diversity and the disciplinary mastery of their staff to stimulate an innovation ecology accessible to everyone. The first Fab Lab was set up at MIT's interdisciplinary Center for Bits and Atoms, a second one in Boston's inner city. They serve youth, tinkerers, inventors as well as companies and students. Fab Labs can be used by all disciplines in teaching, professional development, applied research and research services. In this study, nine Fab Labs from the United States of America, Spain, Iceland, The Netherlands, and Norway were analysed in terms of value proposition, revenue model, processes and resources, marketing, and innovation partnerships.

Regarding the value proposition, all labs indicated that their envisaged clientele be distributed across the board, including students, researchers, companies and the general public. However, eight labs reported that students were the main users at the labs, only three labs involved the general public, and only one lab attracted researchers and companies respectively (see table 2).

[1] In the UK, the rights duration is 10 years from the end of the calendar year in which the design was first made into a marketable product, and it should not exceed 15 years from the end of the calendar year in which the design was first recorded. Within the European Community, unregistered design rights last for 3 years from the point the design was first disclosed or made available to the public in some manner.

	Students	Researchers	Companies	General Public
Target user groups	9	8	6	8
Current main users groups	8	1	1	3

Table 2. Target vs. Current Main User Groups at Fab Labs (N=9).

All labs indicated that their core competence was in technology, while five of them explicitly specified IT as additional core competence. Six labs additionally had core competencies in arts and design.

The main contribution to their users' processes was seen equally in education, research, and development and prototyping.

While all labs indicated their main value proposition was providing access to infrastructure that users would have no access to otherwise, and six indicated that access to experts was equally part of their value proposition, only four of the labs saw giving access to knowledge of the Fab Lab network as part of their value proposition (see table 3).

	Infrastructure	Experts	Fab Lab Network
Part of value proposition	9	6	4

Table 3. Value Proposition of Fab Labs (N=9).

Current revenue of the Fab Labs included in this study came mainly from public sources or from a hosting institution. Revenue from sponsoring or from users so far remained the exception. However, all labs indicated that they needed to become self sufficient within two to three years.

Regarding processes and resources, seven of the nine Fab Labs had their own employees, three were run by a faculty of their host university, and five were supported by volunteers. In terms of manufacturing technology, the labs typically adhered to the equipment proposed by MIT, sometimes excluding one single machine; eight labs offered their users extra equipment (such as 3-D-printers or embroidery machines).

Eight of the nine labs included in the study position their offering as 'social-tech', and one as 'green-tech'. None of them, however, positioned themselves as 'high-tech' or 'smart-tech' (e.g. intelligent materials etc.).

In terms of marketing, Fab Labs typically have their own Internet presence, however, only three of the nine labs in this study actively engage in PR.

The innovation ecosystems of the labs were relatively limited with few network and industry partners and few, if any sponsors (see table 4).

	0	1…5	6…10
Network partners	0	6	3
Industry partners	4	1	4
Sponsors	7	2	0

Table 4. Innovation Ecosystem of Fab Labs (N=9)

Also, labs rarely made use of the possibilities the Fab Lab innovation ecosystem offers. Only one lab indicated that nearly all projects required support from the network, two reported that on average every third project required support, while for the remaining labs this was the case on even fewer occasions.

In summary, the Fab Labs included in this study were primarily offering infrastructures to students, and they were relatively passive in reaching out to potential other users. Their funding came from government or hosting institutions. They have so far created a limited innovation ecosystem, which gets used rather rarely.

Looking at single labs in the sample, there is a notable tendency that labs engaged more actively in PR attract also non-students as users. Also, labs that more explicitly saw themselves as providing access to the knowledge in the Fab Lab network tended to have more network partners in their innovation ecology and were more often asked by users to support their projects. This seems to indicate a distinction between Fab Labs that are focusing on supporting innovation, and those that primarily offer the lab as a production facility.

Those who focus on offering innovation support provided a complete product-service-system that delivered the experience of effective and fast innovation to their users. Such Fab Labs accompanied their users on a certain section of their innovation journey – as opposed to the facility approach, which accompanies users merely during the time of their stay at the lab, their use of the equipment, and their experience of a well-run personal production process. The difference, hence, is not in the single elements of the offering, but the overall value proposition. Making things still remains the function of the lab, yet it is not the primary objective of its users. Rather, the innovation lab allows its users to make things in situations where previously making things has been conceived as not viable. For the Fab Lab *as a facility,* the value proposition is providing the best value in terms of the digital production processes; for the *innovation* Fab Lab the value proposition is providing the best outcome for its users and their innovation journey using the right mix of ingredients determined by the facilities and (networked) competencies available.

5. BENDING THE RULES, CREATING THE ECOLOGY

Deciding what route to take when setting up a Fab Lab indeed depends on the aims one wants to achieve and on many factors in the direct environment of the lab. In this paper we discussed two aspects, intellectual property protection and the focus of the lab. For both, we find a dichotomy. For IP protection this is the classical opposition of ‘closed’ versus ‘open’; for the focus of the lab we labelled it as the choice between ‘lab as facility’ and ‘innovation lab’. Combining these, four prototype positions emerge that a Fab Lab could occupy, from traditional machine shop to the typical Fab Lab approach and from typical innovation consultancy to a Fab Lab innovation ecology (see figure 1). The Fab Lab approach itself is already ‘bending the rules’ of conventional IP belief,

replacing strict protection with an open source type approach to IP. The consultancy approach is moving away from making things for the sake of making things to making things for a specific business purpose and in a setting where formerly making things was not considered an option. Finally, combining these two approaches results in what we chose to call the Fab Lab innovation ecology.

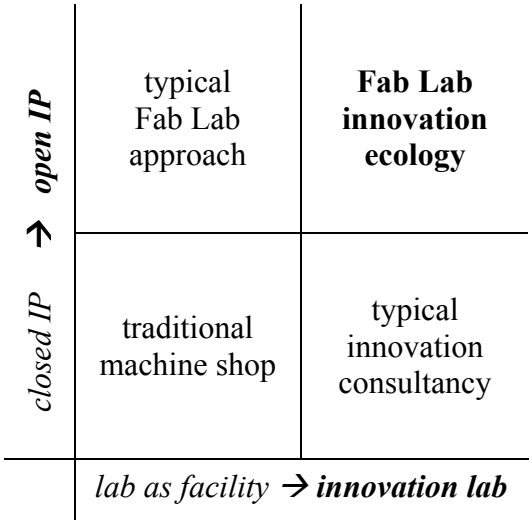

Figure 1. Decision Table for 'Breaking the Rules': from closed to open IP, from lab as facility to innovation lab.

The primary clientele of a Fab Lab innovation ecology are those actually embarking on an innovation journey, i.e. innovators, companies (particularly SMEs) and researchers. Students and the general public – while easy to reach and being important multipliers – may therefore not be considered the most important users of the Fab Lab. Key communication channels to reach this clientele are assumed to be existing networks, events and word of mouth, rather than traditional PR and media channels or trainings that enable individuals to use the facilities.

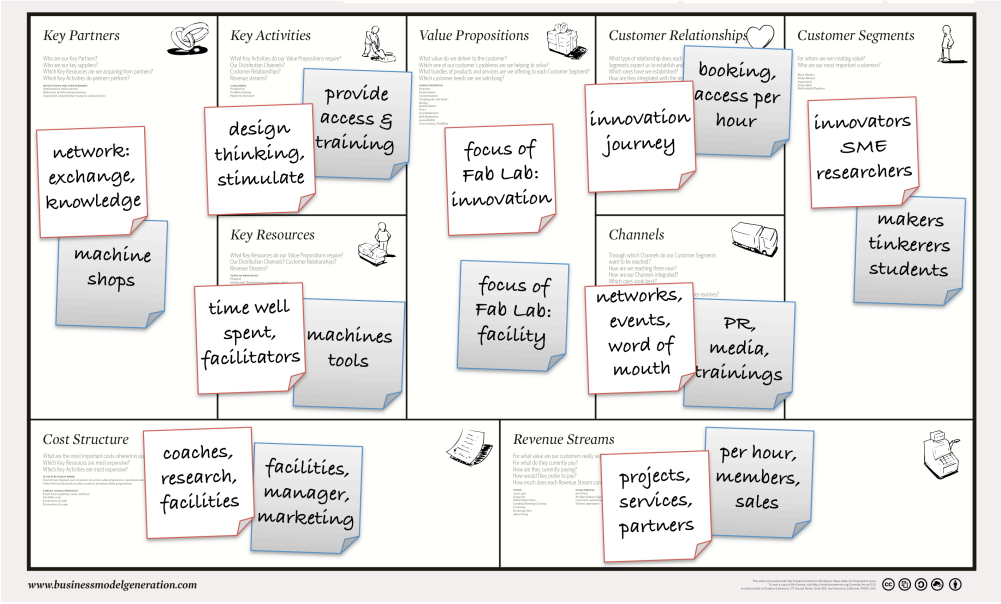

Figure 2. Proposed Fab Lab Business Models (white: innovation lab; grey: lab as facility).

Key activities in such a Fab Lab correspondingly will focus around design thinking and stimulating innovation (much more than just providing access and training). The Fab Lab provides its users with an experience of time well spent, probably with the help of facilitators. Machines and tools should be seen as enablers rather than key resources.

The Fab Lab innovation ecosystem will have to consist of a network of partners with whom Fab Lab users can engage and exchange experience and knowledge. To a Fab Lab as facility other machine shops would play a much more important role.

In terms of cost and revenue structure, coaches, extra research (potentially through the ecosystem) and facilities will be the main expenses – as opposed to the costs for facilities, marketing and the lab manager in a Fab Lab production facility. Equally, revenue will come from projects, services provided and partners engaging with the lab, rather than per hour or membership fees and possible sales of products or IP.

In conclusion, value creation in the Fab Lab innovation ecosystem is through two mechanisms, the linking and exchange with a network of partners providing a rich pool of knowledge and experience, and the possibility to quickly and cheaply make things whenever required in the innovation process. Value delivery to customers in the ecology is through time well spent and improving the innovation journey. The Fab Lab captures value by capturing experience and feeding it back into the network.

6. DISCUSSION

This paper attempted to examine how commons-based peer production in the physical realm could deal with intellectual property and how Fab Labs could establish business model(s) to develop an innovation ecology. It did so by studying the mechanisms of IP protection and their application and by analyzing existing business models in the innovation ecology of Fab Labs. It proposed a business model for Fab Labs that builds on establishing a commons-based peer production innovation ecology.

The legal analysis regarding IP protection focuses on the UK which is a common law jurisdiction; it would be most valuable to carry out similar analyses for other jurisdictions, particularly since copyright legislation differs quite substantially between countries, even within the EU.

Current practice and trends in the application of both IP rights protection and ‘open source’ in the context of Fab Labs is an area that deserves further investigation. A corresponding study is currently carried out in the Netherlands. Preliminarily it confirms that business users tend to doubt the validity of open source approaches but are not inclined to similarly scrutinize the traditional closed IP route.

The selection of business models was limited to an urban-industrial operational context of labs. Yet the paper showed how Fab Labs as places of and for networked innovation could embrace openness rather than IP protection to stimulate innovation, and how they consequently could apply mechanisms for value creation, delivery, and capture essential to sustaining themselves. Given that many Fab Labs are actually located in developing countries it will be interesting to investigate how the proposed business model could be applied there.

Beyond the obvious promises of a commons-based peer production innovation ecology of possibly networked Fab Labs, it is evident from both studies that practice has just about started to pick up these ideas. Many innovators and even innovation researchers are still locked in antiquated beliefs in the efficiency of current IP protection regime despite open critique and mounting evidence to the contrary. In fact, IP protection has

created its own ecosystem of businesses, so its abolition 'may bring about collateral damages of an intolerable magnitude' (Boldrin & Levine 2008b, p. 244). On the other hand, Fab Labs are struggling to re-invent themselves as gate-keepers in a network of knowledge and experience and as agile fabrication partners for their clients' overarching innovation journeys. More analyses, experiments and developments are needed, to reap the promise of commons-based peer production and networked innovation, and Fab Labs seem well positioned indeed to be at the core of such endeavours.

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