Dynamics of Institutions and Markets in Europe is a network of excellence of social scientists in Europe, working on the economic and social consequences of increasing globalization and the rise of the knowledge economy.
http://www.dime-eu.org/

DIME Working Papers on

INTELLECTUAL PROPERTY RIGHTS

http://www.dime-eu.org/working-papers/wp14

Sponsored by the
6th Framework Programme
of the European Union

Emerging out of DIME Working Pack:

'The Rules, Norms and Standards on Knowledge Exchange'

Further information on the DIME IPR research and activities:

http://www.dime-eu.org/wp14

This working paper is submitted by:

Julien Pénin

BETA, CNRS-UMR 7522, Université de Strasbourg
penin@unistra.fr

Open source innovation:

Towards a generalization of the open source model beyond software

This is Working Paper
No 97 (April 2011)

The Intellectual Property Rights (IPR) elements of the DIME Network currently focus on research in the area of patents, copyrights and related rights. DIME's IPR research is at the forefront as it addresses and debates current political and controversial IPR issues that affect businesses, nations and societies today. These issues challenge state of the art thinking and the existing analytical frameworks that dominate theoretical IPR literature in the fields of economics, management, politics, law and regulation- theory.

Open source innovation: Towards a generalization of the open source model beyond software

Julien Pénin

BETA, CNRS-UMR 7522, Université de Strasbourg
61 avenue de la Forêt Noire, 67085 Strasbourg Cedex, France
E-mail: penin@unistra.fr

Paper presented at the DIME Final Conference, 6-8 April 2011, Maastricht

Abstract
This paper investigates the possibility to export the free-libre open source model that has proved successful in the case of software in other sectors. We propose a general definition of open source innovation that relies on two pillars: Openness and interactivity. First, the produced knowledge must remain open, i.e. it must be made available to all without discrimination. Second, actors of the innovation process must develop ongoing interactions in order to sustain a "bazaar" mode of knowledge production (Raymond, 1999). Open source innovation is therefore very different from open innovation (Chesbrough, 2003). We also discuss the possibility to use intellectual property rights, and patents in particular, in a copyleft way in order to secure open source innovation. Then, we investigate the contexts in which open source innovation might be successful. We argue that it may be especially promising when envisaged as providing an upstream platform of open knowledge in which firms can tap in order to develop downstream applications. We conclude by presenting two examples that fit our definition of open source innovation: The case of open source biology (Hope, 2008) and the case of creative industries (Bach *et al.*, 2010).

Keywords: open source innovation, Free-libre software, open innovation, patents, collective invention.

1) Introduction

In the software industry, the success of the principles that guide the open source movement can hardly be denied. The mix of a bazaar mode of organization (Raymond, 1999), of open disclosure of source codes and of copyleft type of legal licenses has provided a very successful recipe to produce reliable software on a very short spell of time. This initial success of the open source model in software raises the issue of the relevance to export it to other sectors (Burk, 2002; Maurer, 2003; Hope, 2008). Lakhani and Panetta (2007, p. 98) explain for instance that: "The achievements of OSS communities have brought the distributed innovation model to general attention so that it is rapidly taking hold in industries as diverse as apparel and clothing, encyclopedias, biotechnology and pharmaceuticals, and music and entertainment".

The objective of this paper is hence to explore whether the general principles that guide the production of FLOSS are reproducible in other sectors with a similar success. The immediate answer that profanes give to this question is that it has already been theorized: The concept of open innovation introduced by Chesbrough (2003) accounts for the extension of FLOSS beyond software. We have already emphasized the fallacy of this answer elsewhere and stressed the important differences between open source-like phenomena and open innovation (Pénin, 2009).

In this paper we suggest therefore a general definition of open source innovation (OSI in the following), sufficiently broad to encompass FLOSS but also other open source-like phenomena that are observed beyond software. Our approach is inductive. We start from the observation of the critical principles that enable the functioning of FLOSS and show that these principles can be applied in other fields. Obviously, many points are specific to software and do not make sense beyond this field. But overall, we show that the broad principles that underlie FLOSS can be expanded to other fields.

Our definition of OSI relies on the pillars that have permitted the success of FLOSS: The bazaar mode of organization, the openness dimension of the source code and the use of IPR in a copyleft way in order to prevent exclusion. We argue that a process of innovation can be qualified as open source if it exhibits, during a significant period of time, the three following properties: Actors of the innovation process (firms or individuals) voluntary disclose knowledge; The disclosure is open, meaning that it is not restricted to some well specified beneficiaries; There are continuous interactions among the actors of the innovation process. Furthermore, we also suggest that it may be necessary to use intellectual property rights (IPR), and specifically patents, in order to secure open source processes of innovation (Boettiger and Burk, 2004; David, 2006). The FLOSS example shows indeed that a specific use of IPR, on a copyleft mode, can help preserving the open dimension of the source code, thus fostering exchanges and collaboration among developers.

Having provided a definition of OSI, the second objective of the paper is to investigate the specific contexts in which an open source process of knowledge production may be successful, i.e. when it may substitute to the proprietary model based on exclusion. To do so, we link OSI to the dynamics of the innovation process. In particular, we argue that OSI settings are all the more promising that the context is emerging (Callon, 1999). In other words, OSI may not replace the proprietary model but may rather co-exist with it: OSI settings may serve as reservoir, a platform of upstream knowledge that firms can openly use to develop end-products and to compete on downstream markets.

The next section (section 2) defines OSI. The third section outlines the differences between OSI and open innovation *à la* Chesbrough (2003). The fourth section explains why and in which context the model of OSI might succeed also beyond the case of software. Finally, in the fifth section we provide two examples that fit this model of OSI. We consider the case of BiOS, which constitutes an attempt to setting up a framework of open source biology in the field of agronomics (Hope, 2008; Pénin and Wack, 2008) and the case of creative industries (Bach *et al.*, 2010).

2) A definition of open source innovation

2.1) Definition

Since our definition of OSI is a generalization of the open source one in software, it makes sense to start with a reminder of the broad principles that guide FLOSS. The extensive literature that has analyzed the functioning of FLOSS in the past decade has put forward three core dimensions: Technical, legal and organisational (Raymond, 1999; Lerner and Tirole, 2001; Bonaccorsi and Rossi, 2003; Dalle and Jullien, 2003; Lakhani and von Hippel, 2003; Lakhani and Wolf, 2003; Henkel, 2006).

- At the technical level, FLOSS are released with their source code. Within FLOSS projects participants deliberately and freely release their production (lines of code mostly), which is made available to everybody without discrimination (Pénin, 2009). The diffusion of the source code is thus fundamentally open since it is not restrained to members of the project but is made available to all.

- At the organisational level, FLOSS are developed following a loose organization called agora or bazaar (Raymond, 1999). This mode of development is opposed to the traditional, in-house conception of software, based on hierarchy, secrecy and control, which is compared by Raymond to the building of Cathedrals. Within the bazaar mode, hundreds of developers constantly interact in order to improve the code released by other developers. Improvements are, in turn, also released so that everybody can validate and, again, improve them. This collective and communitarian mode of development, coupled with the open disclosure of source code emphasized above, has proved very efficient. The open collaboration of developers on a large scale implies that FLOSS are rapidly designed and debugged (it is the so-called Linux' law).

- At the legal level, FLOSS are software protected by original licenses that prevent the appropriation of the software and of its subsequent modifications (de Laat, 2005). Open source projects use indeed a variety of licenses, more or less based on the copyleft principles introduced by the pioneer GPL license, in order to forbid the closure of the source code. Typically, the license stipulates that everybody can use, modify, copy and even distribute software "protected" by copyleft at the unique condition that any change is kept under the same regime (i.e. the source code of the improvements must also be copylefted). The license spreads therefore like a virus.

Any user of the software must keep improvements and modifications under the copyleft regime.

Those three dimensions (technical, organizational and legal) follow a logical order that can be explained as follows: The objective of most FLOSS project is to favor a bazaar mode of software development, which is considered by many as more efficient. Yet, this bazaar mode requires that source code is openly disclosed. The technical dimension is thus necessary to sustain the organizational dimension. And, in turn, the legal dimension (copyleft type of protection) aims at preserving the open nature of source codes. To put it differently, viral licenses, which are used in most FLOSS projects, intend to secure the dimensions of openness and interactivity. The legal dimension is therefore not constitutive to open source. It is a "supporting device", an instrument which aims at sustaining the dimensions of openness and interactivity, which constitute the core of the open source model.

Generalizing those broad principles of FLOSS enables us to propose a definition of OSI which relies on two pillars: Openness and interactivity. In order to be qualified as open source we suggest that an innovation process[1] must exhibit, during a significant period of time, the three following features:

(i) Actors of the innovation process voluntarily disclose the knowledge (technical or not) they produce (i.e. knowledge in our general setting corresponds to code source in the specific case of FLOSS);

(ii) This disclosure is open in the sense that disclosed knowledge is not restricted to some well specified beneficiaries but potentially benefit to all without discrimination (i.e. once they are produced, spillovers are not controllable by the sender, West and Gallagher, 2006)[2];

(iii) Actors of the innovation process interact on a bazaar mode, meaning that open knowledge disclosure triggers an enduring chain of exchange and collaboration in order to enrich the open knowledge base (i.e. open knowledge disclosure is continuous and is not the fact of a single individual at a single point in time).

The first requirement in our definition implies that firms and individuals involved in OSI really intend to share and to release knowledge, so that knowledge cannot be attributed to

[1] It is important to keep in mind the central distinction between process and product. Both can be open source but here we are clearly interested in the process, which is much more important than products. To quote (Weber, 2004, p. 14): "Linux will not last forever […] Remember what is potentially durable and possibly deserving of the term "revolutionary" – not a particular manifestation of a process but the process itself" (p. 14) […] "The essence of open source is not the software. It is the process by which software is created […] If I were writing this book in 1925 and the title was *The secret of Ford* I would focus on the factory assembly line and the organization of production around it, not about the cars Ford produced. Production processes, or ways of making things are of far more importance than the artifacts produced because they spread more broadly" (Weber, 2004, p. 56).

[2] As has been shown in the software case, this open dimension is an efficiency condition. It is only when knowledge is open that one can guarantee its optimal use. Everybody must have the opportunity to use knowledge in order to improve it, enrich it and put it back into the open pool. Barriers that would impose some control over the pool or over elements of it would decrease the efficiency of this process of knowledge enrichment (Lakhani *et al.*, 2007).

undesirable spillovers and externalities. In other words, spillovers are endogenous (Katsoulacos and Ulph, 1998).

The second requirement has been discussed extensively in a previous paper, in which we proposed a definition of openness for knowledge and technology (Pénin, 2009). We argued that a piece of knowledge is open if it is made available to all either for free (this condition is what we call the strong definition of openness) or under conditions that are not discriminatory and not prohibitive (this is what we called the weak definition). All interested parties must be given access to the knowledge, which is therefore not retained into the hand of one or several individuals who would control its access. In other words, an open technology is one for which there is no owner or for which the owner has waived his right to discriminate access. This open dimension is somehow different from knowledge being accessible without fee. It is possible that a technology is open but not free of charge, if the fee to access the technology is considered reasonable (Pénin, 2009).

The third requirement to qualify an innovation process as being open source deals with the interactions among participants. It is important to differentiate between a situation in which actors would just disclose knowledge at one point in time (spot disclosure) and a situation in which firms regularly disclose knowledge, use knowledge disclosed by other firms, re-disclose again their improvements, etc. In short, in OSI frameworks participants develop dynamic interactions in order to continuously improve and enrich the open knowledge base. This requirement is in line with Maurer *et al.* (2004), who tried to define open source biology and argued that it should be a "decentralised web-based, community-wide effort, where scientists from laboratories, universities, institutes, and corporations could work together for a common cause" (Maurer *et al.*, 2004, p. 183). Clearly behind this definition is the necessity of frequent interactions and collaborations among as diverse participants as possible.

Our definition of OSI focuses therefore on two central dimensions: openness of the produced knowledge and constant interactions among actors of the innovation process[3]. OSI defines a deeply open and interactive process. Actors in this process develop a dynamics of collaboration in order to build an open resource (a technology, a software, etc.). The three conditions that we have introduced are thus equally necessary: An innovation process that would not exhibit those three conditions cannot be considered as open source[4].

Many examples in the past as well as in recent history fit our definition of OSI. First of all, obviously FLOSS is consistent with OSI. Similarly, "user centered innovation" introduced by

[3] Our definition of OSI is very similar to what von Hippel (2005, p 93) calls "innovation communities" and to what Shah (2005) calls "community based innovation": "In stark contrast to the proprietary model, the community based model relies neither on exclusive property rights nor hierarchical managerial control. The model is based upon *the open, voluntary, and collaborative efforts of users*" (Shah, 2005, p. 2, Italics are mine). Yet, the word "community", although adequate to stress the multiple and ongoing interactions among participants, does not emphasize the open nature of the process. It suggests a frontier between insiders and outsiders of the community. The expression "open innovation communities" or "open information communities" may therefore be more adapted.

[4] This implies that, in practice, many FLOSS projects do not fit with our definition of OSI. It is indeed well-known that in many cases, FLOSS projects do not interest more than a couple of isolated developers, if not only one of them. Therefore, the source code is made open under copyleft, but the dynamics never starts. In this case, the innovation is potentially open source but this potentiality does not become effective.

von Hippel in the past two decades often meets the criteria of OSI[5]. Open science, as it has been implemented after the Second WW, is also an attempt to develop and to institutionalize an OSI model for the production of upstream, fundamental knowledge (Stephan, 1996). Finally, collective invention as introduced by Allen is also clearly in line with our definition of OSI (Allen, 1983; Nuvolari, 2004; Osterloh and Rota, 2007).

To conclude, actors involved in a process of OSI develop a dynamics of collaboration in order to build an open resource (a technology, a software, etc.). According to the context, OSI may emerge on a long period (as it is the case in software) or only punctually, for a specific project, at the end of which the innovation process then becomes closed again, because the project stops or because participants decide to exit the community. However, in any case, attempts to develop OSI frameworks cannot neglect the issue of IPR which, as has been shown in the case of software, might play a critical role in order to secure the open dimension of the process.

2.2) Open source innovation and IPR's legal jujitsu

The FLOSS example suggests indeed that it may be possible to secure OSI frameworks by adopting a peculiar use of IPR, on a copyleft way. Far from being only a threat to openness, IPR, and patents in particular, may thus be necessary to sustain OSI (Pénin and Wack, 2008). Patents are indeed flexible tools that can serve heterogeneous purposes, according to the objectives of their holders: They can exclude imitators but they can also, at the other extreme of the spectrum, prevent exclusion (Cohendet *et al.*, 2009). Patents may thus become important instruments for OSI participants in order to secure the openness of the process, i.e. in order to make sure that produced knowledge and technologies are made available to all and that their subsequent improvements remain accessible.

More precisely, it may be necessary to rely on copyleft types of licenses in order to ensure that nobody can appropriate fragments of the open knowledge base. OSI assumes indeed that those who use the open stock of knowledge will voluntarily grant back new knowledge into the pool. Yet, knowledge being open and thus accessible to all, it is possible that outsiders try to appropriate new pieces of knowledge designed upon the open platform. Those outsiders cannot in theory patent the knowledge created within the open source project because it is in the public domain. Yet, what they are allowed to do is to improve this knowledge and to appropriate the improvements, thus introducing closure in the open space. Such behaviors clearly threaten the dynamics and therefore the viability of OSI.

To prevent this from occurring, one can envisage using IPR and, among others, patents in a performance of "legal jujitsu" (Benkler, 2006)[6], as it is done in software (David, 2006; Hope,

[5] Within a user centered context of innovation, users voluntarily disclose knowledge, this disclosure is most of the time open, and it triggers an ongoing chain of feedbacks and improvements among users and manufacturers. As acknowledged by von Hippel (2005, p. 10): "Users who freely release what they have done often find that others then improve or suggest improvements to the innovation, to mutual benefit". Examples of such user centered innovation are the development of high performance windsurf techniques and equipment in Hawaii, the free-libre open source software movement, the development of mountain bikes, etc.

[6] This analogy with jujitsu has been made by Benkler (2006). Jujitsu is a martial art oriented towards active self defence. Jujitsu practitioners are never offenders but once they are attacked they practice a pro-active and offensive defence. Having developed several skilful techniques, they are experts in using the strength of their adversaries to their advantage. Similarly for OSI patent owners use the strength of the patent system against its

2008). IPR can indeed prevent the appropriation of a technology or at least allows the control of the use of a technology. This original and counterintuitive use of IPR may thus prove necessary to ensure that improvements are not individually appropriated and that every single modification is granted back into the open pool. It may be a necessary condition to foster the enrichment effect of OSI.

Practically, and as it is done in the case of FLOSS, an open source use of patents is based on licenses that contain grant-back mechanisms. Depending on the content developed by the community, the open knowledge base would be protected by patents, copyrights or other kinds of IPR. Yet, unlike the traditional use of IPR, the community would waive its right to discriminate by granting licenses, either for free or for a small fee, to all those who wish to. The only requirement to access the knowledge would be to commit to grant-back any improvements into the open pool. To put it differently, users of open source technologies may be granted a license only if they agree to put further improvements under the free regime, so that the knowledge and technology remain enduringly open and available to all those who agree with the licensing terms. In the case of patents, this solution is equivalent to creating an open patent pool (Pénin and Wack, 2008). Compared to such viral licensing agreements, releasing merely the knowledge into the public domain or granting an open access license without grant-backs cannot ensure the freedom of the entire stream of knowledge. Those strategies entail the risk that follow-on innovators appropriate some part of the set of the open knowledge base and therein control their use.

The Insulin patent applied for in 1922 by the University of Toronto is a perfect example of the possibility for a patent to ensure the openness of a technology and of its improvements (Cassier and Sinding, 2008; Pénin, 2010). Against the norms of the scientific community at the time, the University of Toronto decided to patent Insulin. It did so not in order to favor the emergence of a monopoly. On the contrary, it aimed at ensuring the quality of Insulin and its large availability[7]. The University of Toronto decided therefore to grant a non-exclusive license to all firms who agreed to follow specific good manufacturing practices. Furthermore firms had also to accept to grant back improvements (with respect to manufacturing processes) into the open patent pool setup and controlled by the university. This open patent pool remained active for almost 30 years, from 1923 until the second WW. It guaranteed a large access to the substance and to its improvements. The Insulin patent is therefore, to some extent, the ancestor of the copyleft practices that are now common in software.

How would such viral, copyleft licenses perform in their objective of securing OSI? This issue has been studied by Gambardella and Hall (2006), who stress two opposite effects. On the one hand those licenses may trigger more participation to the development of the OSI because some contributors, who may have envisaged contributing under a privatized regime, are now constrained by the term of the license to contribute in an open way. But on the other hand, since the license restricts contributors' rights, it may also deter some of them to contribute at all, whereas they would have agreed to contribute in a more closed, proprietary

---

primary purpose. In line with the state of mind of martial art practitioners, open source tenants use IPR to prevent that entire streams of research are closed down by aggressive appropriation strategies.

[7] According to Cassier and Sinding (2008, p. 156): "In addition to its role of preventing a commercial monopoly, the patent gave the university the authority to set the standards of the new drug, control the quality of its industrial production, and regulate the condition of its marketing. In the university's hands the patent was a tool to discipline the industrial world, to organize the distribution and use of the new drug, and to guarantee its accessibility".

regime. The desirability of such copyleft type licenses is thus the outcome of those two counterbalancing forces. In particular, the negative effect emphasized by Gambardella and Hall stems from the fact that some contributors may be frightened by the restrictive terms of the license which, in the end, may decrease the overall rate of participation and harm the development of the innovation. For instance, in the case of software, it seems that the more restrictive the open license, the lower the probability to achieve a stable mature version of the software (Comino *et al.*, 2007).

3) Open source innovation versus open innovation

OSI is often mistaken for open innovation, a concept introduced and popularized by Chesbrough (2003) and which has triggered an abundant literature in organization sciences. Yet, open source mode of knowledge production entails very different properties[8]. In this section, we show that OSI and open innovation differ at least with respect to two central dimensions: The degree of openness and the degree of interactivity.

Open innovation advises firms to open up their boundaries and encourages them, on the one hand, to acquire knowledge and technology developed elsewhere (through in-licensing, firms' acquisition and alliances) and, on the other hand, to export knowledge and technologies developed inside (through out-licensing, spin-offs and alliances)[9,10]. The practice of open innovation relies therefore on two types of knowledge flows: Outside-in and inside-out. Firms absorb technology developed by other organizations (outside-in) and export technology developed inside (inside-out).

Isckia and Lescop (2010) argue that open innovation can be considered as a new concept only with respect to the inside-out idea. Here, open innovation goes hand in hand with other trends that have emerged recently: The development of markets for technology (Arora *et al.*, 2001) and a more strategic use of patents by firms (Rivette and Kline, 2000). Yet, open innovation can hardly be considered as a new concept with respect to outside-in. The need for firms to absorb relevant knowledge developed elsewhere had already been well documented in the economic literature long before Chesbrough's work (Cohen and Levinthal, 1989).

Open innovation is obviously a loose concept. Taken broadly, and not withholding the fact that many firms still behave in a very secret and self-reliant way, everything can be considered as being open innovation. As soon as a firm does not do everything by itself (when

[8] For instance, Eric von Hippel, in his book, *Democratizing innovation* (2005), is very careful to draw a clear distinction between open innovation *à la* Chesbrough, which he calls distributed innovation, and open source like phenomena.

[9] Chesbrough considers open innovation as the antithesis of the closed innovation model which he defines as: "the traditional vertical integration model where internal research and development activities lead to internally developed products that are then distributed by the firm" (Chesbrough, p. 1, in Chesbrough *et al.*, 2006). More precisely, Chesbrough adds that: "Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology" (Chesbrough, p. 1, in Chesbrough *et al.*, 2006).

[10] Open innovation has many points in common with other concepts developed recently by other scholars, be it "disintegrated innovation", "modular innovation" (Brusoni and Prencipe, 2003), "distributed innovation" (Kogut and Meciu, 2008; McKelvey, 1998), "dispersed innovation" (Becker, 2001) or "collaborative innovation". All these concepts emphasise the fact that useful knowledge being increasingly dispersed, innovative activities are not the fact of one single entity but are distributed over a wide spectrum of heterogeneous actors.

it acquires a start-up, licenses in or out a patent, creates a spin-off, crowdsources some of its research activities, etc.) it behaves in accordance with open innovation principles. It is therefore essential, for the sake of clarification, to locate OSI with respect to open innovation. We argue here that it is possible to rank closed innovation, open innovation and OSI on a spectrum, according to their degrees of openness and interactivity.

Closed innovation is located at the extreme left of the spectrum. It defines a framework in which knowledge is not open and firms weakly interact with each other. Firms are strongly self-reliant. They rely on appropriation strategies such as secrecy and exclusive IPR. Knowledge and technologies are not shared and still less made available to other firms. Furthermore, firms do not collaborate with other organizations, even selectively and for a given spell of time. To use a simple metaphor, within a closed innovation environment, firms' research labs have no doors through which knowledge could circulate inflow or outflow.

Open innovation is in the middle of the spectrum. It refers to a situation that is weakly open and modestly interactive. It is not very interactive because firms, although they allow knowledge to flow in or out, do not develop a pattern of continuous and regular exchanges. Interactions occur only at one moment in time and then stop. Open innovation is about firms who grant licenses to other firms or who create spin-offs. It considers therefore bilateral (market) deals and not communitarian-like interactions.

Furthermore, open innovation is weakly open because it assumes that firms still keep considerable control over their knowledge and technology (even though control is less tight than in the closed innovation case). Conversely to closed innovation, open innovation acknowledges the possibility of knowledge flows, but these flows are tightly controlled by firms, who continue to rely on secrecy and aggressive patenting strategy with other firms who are not part of the deal. Open innovation means therefore permeable organizational boundaries[11]. To use the same metaphor as above, it means that there is a door but this door can be open or closed according to the willingness of the firm, who still controls entries and exits.

Open source innovation, as it has been defined above, is located at the extreme right of the spectrum. It is both more open and more interactive than open innovation. It is more interactive, because firms continuously exchange knowledge over a significant period of time. Hence, whereas open innovation is about spot knowledge transaction, on a market of technologies for instance, OSI is clearly about collective and communitarian mode of knowledge production. OSI involves community and peer production, while open innovation most of the time relies on bilateral exchanges (in and out-licensing, merges, spin-in and out, etc.).

Furthermore, OSI is more open because firms abandon their right to discriminate. They waive any possibility to control knowledge flows in the sense that anybody can use the knowledge once it has been disclosed. Conversely to open innovation, participants in OSI settings do not rely on exclusive appropriation strategies. Therefore, while Chesbrough envisages openness

[11] Chesbrough adopts indeed a very specific definition of openness. He used the words open and closed because in a case (the closed innovation paradigm) "projects can only enter in one way, at the beginning, and can only exit in one way, by going into the market" and in the other case (the open innovation paradigm) "there are many ways for ideas to flow into the process, and many ways for it to flow into the market" (Chesbrough, p. 2 and 3; in Chesbrough *et al.*, 2006).

as a situation in which a firm has permeable boundaries (information and technologies can come in and out but remain controlled to some extent), in OSI contexts knowledge and technology are not controlled by an owner who could restrict arbitrarily their access. For instance, one of the main features of FLOSS, if not their main feature, is that anybody can access the source code. With respect to this characteristic, FLOSS are not only a distributed process, they are also fundamentally open. At least, far more open than what is usually meant by open innovation (Lakhani and Panetta, 2007)[12]. To use again the metaphor of the door, in the case of OSI there is a door and this door is open (some entrance conditions can be setup but they are reasonable and similar for all).

To summarize, with respect to the degree of openness, it is possible to illustrate the differences between closed innovation, open innovation and OSI by considering the case of a patented technology: Once a firm develops a technology and patents it, it can adopt the following strategies: (1) Closed innovation: Exclusivity and secrecy are preserved. The technology is not licensed at all. (2) Open innovation: The technology is eventually licensed or cross-licensed but only to some firms that have been previously selected. (3) OSI: The firm waives its right of control over the patent. Everybody, if he wishes to, can use the patented technology (eventually at reasonable a fee) (Example: The Cohen-Boyer patent applied for by Stanford University, see Pénin, 2010).

4) OSI and the dynamics of innovation

Isolated examples suggest that OSI can perform quite well in some instances. However, proprietary and exclusive strategies are essential features of our modern economies. Everything cannot obviously become open source. Nevertheless, we believe, as Nelson (2004) does, that any innovation is somehow built upon "something" that is open and thus it is important that this "something" remains open[13]. Open and closed dimensions might therefore be two complementary facets of innovation that are equally important. In particular, OSI may be especially promising when envisaged as providing an upstream platform of open knowledge in which firms can tap in order to develop downstream applications. This point can be easily understood when considering the dynamic framework of innovation built by Callon (1993; 1999).

[12] Lakhani and Panetta (2007) acknowledge this difference between open innovation and the open source software movement: "*OSS communities represent the most radical edge of openness* and sharing observed to date in complex technology development. *OSS communities are open in the sense that their outputs can be used by anyone* (within the limits of the license), and anyone can join by subscribing to the development e-mail list" (Lakhani and Panetta, 2007, p. 107, italics are mine). West and Gallagher (2006, p. 94, italics are mine) also conclude that: "*an open source model is inherently more 'open' than a typical R&D consortium*, both in terms of exploiting information from outside the consortium, and sharing this information back out to nonmember organizations and individuals".

[13] Openness, sharing and freedom of use have always proved to be important elements of the innovation process (McLeod and Nuvolari (2006; 2008). Mc Leod and Nuvolari (2008), p. 15) stress for instance that: "As a final consideration, it is important not to dismiss these cases of collective invention as "curious exceptions". It is worth stressing, once more, that key technologies that lay at the heart of the industrialization process, such as high pressure steam engines, steamboats, iron production techniques, etc. were at times developed in a collective invention fashion, and consequently *outside* the coverage of the patent system".

4.1) The Callon model[14]

Callon distinguishes two distinct phases of the innovation process: An emerging phase and a stabilised phase. Whereas in stabilised situation knowledge is easily reproducible and the primary will of inventors is therefore to protect their inventions from imitation, in emerging phases it is the opposite. Knowledge is sticky, market perspectives are uncertain, players in the field unknown[15]. In such emerging frameworks firms aim mostly at not excluding other firms but at “including” them, i.e. finding collaborators, suppliers, customers, financers, etc. This will of collaboration is made all the more relevant as the technology is complex and modular and as network effects are strong.

This argument developed by Callon refers to an essential aspect that was underestimated by Arrow (1962): The exploration of innovation development conditions. In order to underline the dilemma between incentives and diffusion, Arrow simplified the innovation process to a two phase process: Invention and then diffusion of the invention. All the aspects related to the complex dynamics linked to the genesis of the invention were neglected thus reducing invention to a static two step game.

During the first step of the creation of technological trajectories, the traditional arrovian framework underestimates the need for common knowledge between actors. For Arrow, the knowledge producer is a single individual. Nothing is said about any need for external knowledge required to invent, nor about any community of agents that would help throughout the process of creation (the so called knowing communities). The solitary hero is therefore the only one who should be able to claim any ownership on his invention. Yet, still according to Arrow, the public good nature of knowledge decreases his incentives to innovate. The dissemination of knowledge is indeed considered here as being isotropic: The diffusion of an innovation is not intended to follow a particular path. The possibility that first inventors are able to choose the individuals, groups or communities with whom they will develop a common knowledge base is not recognized. On the contrary, the inventor is supposed to face anonymous agents who are looking for any opportunity to steal his creation. And this free riding can easily happen since any potential imitator is supposed to be able to reproduce the knowledge at zero cost immediately.

For Callon, this scenario can occur, but only in extreme circumstances, corresponding to stable situations in which languages and competences are already shared among actors of innovation. The traditional framework (non rivalry and non excludability of knowledge) only prevails when the technological trajectories and languages have been developed and shared among individuals and organisations.

Callon (1999) shows that during the first phase of the creation of an innovation, when common languages and schemes do not yet exist, it is the exact opposite that happens. Innovation generally occurs in an environment of strong uncertainty about the actors, their objectives, their capacities, etc. Knowledge in this context is marked by strong rivalry (it is hard to reproduce it outside the local context where the discovery has been made) and strong exclusivity (the invention is linked to the tacit knowledge of the inventor). The inventor is less likely to encounter a problem of free-riding and imitation than a problem of misunderstanding

[14] This section is drawn from Cohendet, Farcot and Pénin (2009).
[15] This emerging phase corresponds in a sense to what Anderson and Tushman (1990) call the “era of ferment”.

from other actors, leading to his marginalisation (Callon, 1993). Differences of language, of cognitive models or simply the existence of a tacit dimension imply indeed that knowledge exchanges are difficult. The same applies to language that can constitute a barrier between different disciplines. And the more heterogeneous are the actors involved in the innovation development, the more relevant those problems of communication and exchanges.

In other words, in emerging phases the inventor does not face a problem of leaky knowledge (which would decrease its incentive to invent) but rather a problem of sticky knowledge, which undermines its ability to interact with the other actors of the innovation process[16]. For the actors, it is hence necessary during the first stages of the construction of a technological trajectory to exchange knowledge and information, to cooperate in order to develop common cognitive grounds and above all to converge on shared objectives. Technological trajectories cannot develop by themselves unless public or semi-public common knowledge ground is defined and created in order to enable the reproduction, enlargement, and development of the first creative ideas.

To sum up, the first stages of innovation development are a complex and mostly collective process during which agents need to exchange and cooperate. This view of innovation stands in sharp contrast to the traditional framework and its theory of knowledge spillovers, which considers that once knowledge is created, it is available for anyone to use. It is indeed the complex dynamics of evolution of technological trajectories that is underestimated by the traditional framework. The main weakness of the Arrow model is to reduce the complexity of technological trajectories to a two phase process. At one extreme, there is one single individual that has a creative idea. At the other end lies a universe where all individuals have the same knowledge and are able to exploit the innovation. This reduction has an advantage: It fixes all the attention on incentives considerations. But it also has a major weakness. It lessens the needs of coordination between agents, especially during the early stages of the creation of an innovation.

Callon's view of the dynamics of innovation has important implications for open source and the strategic use of IPR. Among others, it suggests that OSI might be especially promising in upstream, emerging situations, when coordination problems overcome incentives ones. Consequently, in those contexts actors of the innovation process need less to exclude than to include and collaborate, which might explain the attractiveness of OSI in order to build common languages and knowledge base.

4.2) Platform, co-opetition and incentives

The implication of the Callon model is in line with other studies which underlined the advantages of OSI in the case of cumulative innovations (Pénin and Wack, 2008; Bessen and Maskin, 2009). It is indeed in those situations that the incentive-diffusion dilemma (Arrow, 1962) is the most relevant: Innovators need both strong incentives to innovate and as wide as possible an access to existing knowledge[17].

---

[16] This point is also raised by Gibbons (1994) in its distinction between mode 1 and mode 2 of knowledge production: "In mode 2, knowledge production and knowledge appropriation converge. The outcomes are likely to be commensurate with the degree of involvement. Only those who take part in knowledge production are likely to share its appropriation" (Gibbons, 1994, p. 165).

[17] Yet, those two objectives are often opposed (Scotchmer, 1991; 2004; Murray and O'Mahony, 2007). For instance, strong appropriation regimes (via strong patents for instance) may increase incentives to develop first

It is hence appealing to envisage OSI as an industry platform (Gawer and Cusumano, 2002)[18], a springboard which business firms can tap into to improve their innovative ability. Within OSI frameworks, firms and communities of individuals collaborate to feed an open pool of knowledge, which can then serve as a basis for corporate competition. Considered this way, OSI may illustrate a case of co-opetition (Brandenburger and Nalebuff, 1996) but in an open way, i.e. which would not be limited to a few enterprises but may potentially concern all the actors of a given field and beyond. Actors of the innovation process may collaborate upstream, in order to develop a strong reservoir of open knowledge, but may continue to compete on downstream markets. This obviously suggests, and the examples that we provide in this paper are in line with this view, that OSI may be especially promising to produce far from the end-market technologies, when collaboration needs overcome competition effects.

Consequently, OSI may not substitute for corporate innovation but rather co-evolve with it. A parallel can be drawn with the linear model of innovation which considers open science as devoted to provide industry with a reservoir of public, basic knowledge that firms use in order to do applied research (The "republic of science" vs. the "kingdom of industry", Nelson 1959; Polanyi, 1962). In this model, public and open research on the one hand, and corporate and closed research on the other hand, are also viewed as perfect complements. The sphere of open science is considered as a platform for industrial competition. That this model is not considered as relevant anymore does not prove the unimportance of openness, on the contrary. It only means that actors of the innovation process may have to establish new strategies to build and secure the open knowledge base into which they can tap. The open dimension today is not left into the hands of the public sector alone (which more and more adopt closed behaviours, patent its research, etc.) but is a concern for all the actors involved in innovation. Many corporate actors have already understood this need to rely to some extent on OSI frameworks and have changed some of their behaviours accordingly.

This is particularly true in creative industries (see section 5.2 below). Similarly, the example of BiOS that is detailed below is perfectly in line with this view of OSI as providing a platform of knowledge and technology that firms can use in order to compete on downstream markets. The emergence of the airplane industry just before the first WW, as described by Meyer (2010), fits also perfectly this co-opetition model. Based on a detailed bibliometric analysis from 1860 to the first WW, Meyer distinguishes two phases in the emergence of this industry: A pre-market phase, in which individuals did not hesitate to collaborate and share their discovery in a way that is quite similar to OSI. This phase lasted until 1907. Then, when opportunities of profit became apparent, we enter the market phase and the behaviors of the actors of innovation were completely reversed: They protected their discovery by strong patent and tried to release a minimum of information to competitors.

If OSI may constitute a platform on which competitive firms may rely, it is important to investigate why firms and individuals may participate in the construction of this open platform. This is indeed an important issue in economics: Why may rational economic actors

stages innovations but limit the access to these innovations, thus endangering the emergence of second stages innovation that are built upon first stages innovations. Conversely, weak appropriation regimes may ease the access to existing knowledge but reduce the incentives to develop first stage innovations.

[18] Gawer and Cusumano (2002) argue that an industry platform provides a common foundation or core technologies that firms can reuse. They also stress the fact that industry platforms have relatively little value to users unless they are combined with in-house complementary assets.

be willing to contribute to the construction of a public good? Economic literature suggests that such collective construction of a pure public good is undermined by free riding. And the larger the number of participants, the higher the incentives to free-ride. Here again, lessons from the software sector can help to understand why firms and individual may actively contribute to build an open platform of knowledge.

First, at the individual level, many studies have underlined the complex mix of motivations that induces individuals to devote time and resources to develop FLOSS (Lerner and Tirole, 2001; Bonaccorsi and Rossi, 2002; Dalle and Jullien, 2003; Lakhani and von Hippel, 2003; Lakhani and Wolf, 2003). Among others, all those studies emphasize that, although extrinsic motivations are important, intrinsic types of motivation dominate. And there is no reason to consider that this result is specific to software. Intrinsic types of motivations can boost individual participation in many different fields in which firms can therefore envisage to rely on a community of individuals, who can be users (von Hippel, 2005) or not. This is true in video-game, for instance (Cohendet and Simon, 2007), and more generally in all creative industries (Lessig, 2001). It is also true in biology, and more generally in all science-based industries, in which scientists may, for an heterogeneous set of reasons (gold, reputation, puzzle-solving), be willing to devote time to feed a platform of upstream knowledge (in the pharmaceutical sector for instance).

Furthermore, at the firm level, another result of empirical studies on participants' motivation in FLOSS projects is that, in many cases, individuals participate during their work hour with the consent of their employers (Lakhani and Wolf, 2003). This clearly suggests that firms may also find it profitable to participate (O'Mahony, 2003). For instance, it seems that in many cases free riding behaviours are rendered difficult by the fact that in order to tap into the open reservoir one needs to actively contribute. In particular, the absorption of the tacit dimension of knowledge requires that the firm develops tight links with the community, which in turn forces it to participate. Von Hippel and Von Krogh (2006) propose therefore a model of "private-collective" incentives to participate, in which free-riding is limited by the specificities of the good. Firms may also base their business model on activities that are complements to the open platform. They may rely on complementary assets which are protected (Teece, 1986; 1998), thus being more willing to work hand in hand with the OSI actors and to enrich the open knowledge base. Finally, it is also important to mention that copyleft type of intellectual property may oblige some firms to grant-back, thus also participating to the enrichment of the platform.

To summarize this discussion, according to Osterloh and Rota (2007), firms and individuals are more willing to contribute to OSI settings if: (i) The learning potential is important, i.e. the sharing of information of knowledge leads to more than the sum of each pieces of knowledge; (ii) Opportunity costs are weak and (iii) benefits are linked to the degree of participation. Clearly, those three conditions are more likely to hold in upstream, far from the market situations, which may induce firms and individuals to participate in OSI settings.

In conclusion, we have suggested here that OSI may be specifically promising in emerging, pre-competitive phases. In those situations participants in OSI can build a platform of open knowledge that firms can use in order to develop end-market products. In the next section we provide two examples that underline this dynamic view of OSI: We consider the case of BiOS, which is an attempt to develop open source biology for upstream research tools (Hope, 2008; Pénin and Wack, 2008) and the case of creative industries which rely on underground, creative communities in order to continuously introduce novelty.

5) Two examples of open source innovation

5.1) Open source biotechnology: The case of BiOS[19]

BiOS constitutes an attempt to setting up a framework of open source biology in the field of agronomics (Hope, 2008; Pénin and Wack, 2008). BiOS stands for Biological Open Source. It is a sub-part of a wider project entitled BIOS, for Biological Innovation for an Open Society. This initiative was launched by Cambia (for Centre for the Application of Molecular Biology to International Agriculture), a non-profit organization (Hope, 2008).

In the domain of agricultural biotechnology, BiOS aims at developing open -easily available for re-use, research tools. A research tool is used only for research purposes. It is not considered as an application that can be commercialized on the end-market, but it serves as a springboard for those downstream innovations (Walsh *et al.*, 2003). Research tools are therefore part of a sequential process of innovation, being situated upstream from the development of applications such as new drugs or new crops. These follow-on innovations rely on the invention, diffusion and usage of research tools. Research tools are therefore a typical example of a “platform technologies” (Pray and Naseem, 2005).

The early position of research tools within the innovation process in modern biotechnology makes their mode of appropriation a core issue. Since they are inputs in the development of further applications it is highly important that they remain easily available for reuse. Furthermore, since research tools are far from the end market, firms may be more willing to collaborate at their development. Hence, research tools might be good candidates for developing a context of OSI. And this is exactly what BiOS endeavors to do. BiOS seeks to develop a set of research tools that would operate freely from current patents on plant transformation methods. To do so BiOS relies on the principles that have been emphasized earlier in this work: An open patent pool protected by copyleft types of licenses.

Concretely, BiOS has set-up a patent pool with its own patents and agrees to grant non-exclusive licenses only to those who accept the viral terms of the BiOS license. Hence, in order to use the technologies patented by BiOS, a third party has to agree to grant-back any improvements and modifications into the open patent pool. In a dynamic perspective, this creates an environment: “in which a material or invention can be improved by the ideas of many, but access is maintained for all who agree to the terms, without exclusive capture by anyone” (BiOS homepage)[20]. This viral clause of licensing implies that research tools that build on a technology patented by BiOS cannot be appropriated. They remain available for reuse. This creates a favorable environment for collaborations, exchanges and cumulative inventions. Furthermore, although the use of a BiOS patent is open, it may not necessarily be free of charge. Private members of OECD countries are required, in addition to agreeing to the licensing terms, to pay a participation fee.

[19] This section is drawn from Pénin and Wack (2008).
[20] http://www.bios.net (accessed [05/07/2010]).

Yet, BiOS acknowledges that producers of downstream application need to make money out of their investments. Hence, openness regards only upstream research tools. The treatment of applications derived from those research tools is completely different. Developers of potential applications of the BiOS research tools have the liberty to individually control new strains of plants, through patents if so wished. This limit put to the free environment is linked to the specific features of innovation in biotechnology. As emphasized by Maurer *et al.* (2004), there has to be some appropriation in the innovation process so that, at the end, firms are encouraged to put end products on the market. The development of biotech applications is costly, which means that an organization that is based solely on the decentralized contributions of a community of private, garage-based scientists with intrinsic, and limited extrinsic, motivations is unlikely to reach the commercial success of FLOSS projects. BiOS aims therefore at preserving the freedom only of upstream research tools, without impeding the commercial exploitation of their direct applications.

To date it is unclear whether the BiOS initiative will succeed or fail. Discussions with actors in the field suggest that many firms are reluctant to participate due to the restrictive conditions of the license (especially the requirement to grant-back improvements), which is in line with the prediction of the model of Gambardella and Hall (2010). Nevertheless the BiOS initiative illustrates the platform nature of OSI and puts forward the potential of OSI as being a complement to corporate activities, thus offering firms infrastructures and technologies at a minimum cost.

5.2) OSI and the IPR dilemma in creative industries[21]

The emergence of the *creative industries* as one of the main drivers of growth in the knowledge based economy has important implications for IPR and the concept of OSI. Innovation in creative industries is generally a collective effort that necessitates the interaction and coordination of a multitude of heterogeneous economic actors. For instance, the production of a videogame requires the participation of hundreds, sometimes thousands of different contributors: Artists, musicians, game designers, etc. Hence, in creative industries the determination of IPR has to be examined as a fundamentally *dispersed* phenomenon. Basically, stakeholders of the creative process can be gathered into three broad categories: Talented individuals, firms and creative communities.

A specific attention must be paid to creative communities. In creative industries firms are not backed by a regulated and institutionalized universe which could be compared to the *open science*, nor is it the result of a single individual process. Creative ideas emerge and develop in an informal universe that is sometimes called *underground* (Cohendet and Simon, 2007). The locus of creation is thus rooted within the diverse informal communities with which firms and individuals must somehow maintain links in order to keep introducing novelties. By *creative communities*, we refer here to informal groups of individuals who accept to exchange voluntarily and on a regular basis in order to create knowledge in a given field.

The role played by these communities in the creative process is essential: As the knowledge-based economy expands, such communities take in charge some significant parts of the *sunk costs* associated with the process of generation or accumulation of specialized parcels of knowledge. They achieve the progressive building of a common base of knowledge, a model

[21] This section is drawn from Bach, Cohendet, Pénin and Simon (2010).

and a “grammar” (a ”codebook”, according to Cowan *et al.*, 2000), allowing the creative idea to be equipped with sufficient shared understanding and codes to become economically viable. As a result, these communities are the places for the accumulation of innovative micro-ideas, which may be potential sources of future creativity. In other words, creative communities are the main constituents of the “underground” from which creative industries extract their innovative efforts. They channel promising ideas and concepts developed in the underground and bring them progressively to market.

The emergence of creative industries raises new questions, and two paradoxes are notably at stake. A first one, analyzed by Cohendet and Simon (2007), puts forward the issue of the compatibility between traditional rules of corporate governance and creative communities. In short, is it possible for firms to manage, drive and harness creative communities without sterilising them?

A second paradox, linked to the first, deals in an explicit way with IPR and OSI: How can the three categories of actors of the creative process reconcile their different wants and needs in terms of IPR? Basically, individuals desire strong individual IPR, firms aim at strong “corporate” IPR, whereas creative communities require weak IPR, or even not IPR at all, in order to easily use and recombine existing art, which is the raw material of the activity of creation. Creative project can only flourish under weak IPR because they entail integrating, cutting and pasting, assembling creative elements dispersed among a vast array of technical and cultural activities carried out by diverse and distinct actors. Thus, in order to foster the production of novelty, firms, individuals and communities must rely on some kind of open spaces (Lessig, 2001; 2004). A minimum of openness (which might not mean an absence of property) is necessary to enable creative communities to work properly.

These different logics that drive individuals, firms and communities are what we call the “IPR dilemma” in creative industries. For firms, this dilemma can be stated as follows: On the one hand they need strong IPR to exclude imitators, prevent copying and therefore secure some market power. The main instruments to do so are copyrights, trademarks, patents, trade secrets, or some combination of the above. Yet, on the other hand firms also need to extract the creative potential of the creators. And with respect to this need, a systematic abuse of exclusive contracts on the type of “work for hire contracts” can lead to a risk of erosion of creativity. With respect to this aspect it is therefore important for firms to moderate their use of exclusive IPR in order to preserve privileged links with creative communities.

To summarize, creative industries illustrate well the promises of OSI as providing a platform of new ideas that firms can then use, but they also pinpoint the tensions that may arise in this peculiar relationship between corporate actors and underground communities. In particular, it suggests that a critical issue deals with the strategies that are implemented to handle the IPR dilemma. Firms involved in the creative process might be obliged to adopt specific arrangements in order to optimize their links with creative communities. For instance, they might agree to weaken their intellectual property and to accept to some extent new uses of IPR, in particular those based on copyleft strategies, creative commons, etc. The two examples of the music industry and of the video-game industry studied by Bach *et al.* (2010) illustrate that IPR in creative industries can only be the outcome of a delicate balance between exclusion and openness. Building an ongoing creative dynamics requires the preservation of this fragile equilibrium which ensures the co-evolution of individuals, firms and a creative underground.

6) Conclusion

This paper proposed a general definition of OSI, valid not only in software but also beyond, and investigated when such OSI settings may emerge. Our definition relies on two pillars: openness and interactivity. OSI is both an open and deeply interactive process. Actors in OSI settings release openly the knowledge they produce and develop ongoing exchanges with each others', favouring therefore a bazaar mode of knowledge production (Raymond, 1999). Furthermore, we have argued that such OSI settings are more likely to emerge in emerging phases, where collaboration needs overcome competition ones.

This work, by proposing a clear definition of OSI, contributed to emphasize the difference between open source-like mode of knowledge production and open innovation as it has been defined by Chesbrough (2003). Those two concepts, although often confused, are quite different. They differ both with respect to their degrees of openness and interactivity. In particular, most cases studied by Chesbrough do not meet our definition of openness because firms do not make relevant information available to all but only to a small number of partners.

OSI is a recent concept. A lot of work remains to do both on the theoretical and empirical sides. Here are some "hotspots" that appear specifically important to us:

A first central issue deals with the viability of OSI in competitive settings. The point we have made in this document is that OSI might be a complement to more closed behaviours based on exclusion. We have argued that in many situations, OSI can be considered as a platform on which firms might rely in order to develop downstream applications that are then commercialized. According to this view, OSI may be especially promising in upstream, pre-competitive phases, i.e. in which firms may be more willing to collaborate. Here, we have argued that OSI may correspond to a new way to frame competition, a case of open co-opetition (Brandenburger and Nalebuff, 1996). Yet, a more interesting issue would be to explore whether or not OSI can succeed in competitive phases and under which conditions. To our knowledge there is today no example of OSI initiative in such competitive context (except software).

Linked to the former point, from a managerial perspective it will also be important to improve our understanding of the business models that allows firms to exploit and use the strength of OSI. Is it possible to develop business model that are fully compatible with OSI? More modestly, is it possible for firms to elaborate hybrid strategies in between exclusive and open access in order to reconcile their need of appropriation and of creation? If yes, under which conditions? For instance, crowdsourcing is often presented as such hybrid strategy (a mix of strong appropriability and peer production) (Howe, 2006). Yet, we know that crowdsourcing in the case of inventive and complex activities raises many problems and is likely to work only in limited contexts (Burger-Helmchen and Pénin, 2010).

Furthermore, a central issue for OSI to succeed depends upon the possibility to secure this open platform and to make it coexist with the closed world. In the pursuit of ensuring openness, numerous licenses analogous to those used in FLOSS can be transferred from the software sector to other sectors. Patents, for instance, can be used in such a way as to prevent appropriation and exclusion, as illustrated by the BiOS case. Yet, this example also emphasizes the problems posed by the co-existence of two worlds characterised by different needs and requirements (Hope, 2008). Unlimited viral licences, for instance, can hardly be accepted by firms and one will have to develop, according to the different contexts, licenses acceptable to all parts (de Laat, 2005).

This leads us to the most important issue to ensure the exportation of open source beyond software: The creation and development of communities who will imagine and diffuse the norms that are necessary to regulate the behavior of all the heterogeneous actors (ensure that all have incentives to participate among others). Indeed, one of the first and major tasks in order to favor the emergence of OSI in a given field might be to design formal and informal rules (about the sharing of intellectual property, for instance, which supposes to design adequate IP licenses) that are likely to be accepted by most players in the field and to fit the specificity of each technology[22]. This implies that implementing open source beyond software will require an important preparation time. For instance, the success of FLOSS nowadays can to a large extent be attributed to the long lasting work of the free software foundation which, since the mid-eighties, has largely designed the rules of the game. Hence, since norms and rules are mainly situated within communities, the adoption of OSI is likely to be localized in communities. How this may spread through from community to community of different typologies is a fundamental research question to be pursued.

References

Allen R. C. (1983), “Collective Inventions”, *Journal of Economic Behavior and Organization*, 4, p. 1-24.

Anderson P., Tushman M. (1990), “Technological discontinuities and dominant designs: A cyclical model of technological change”, *Administrative Science Quarterly*, 35, p. 604-633.

Arora A., Fosfuri A., Gambardella A. (2001), *Markets for Technology: The Economics of Innovation and Corporate Strategy*, MIT Press, Cambridge, Mass.

Arrow K. J., (1962) “Economic Welfare and the Allocation of Resources for Invention”, in *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton university Press, 609-625.

Bach L, Cohendet P., Pénin J., Simon L. (2010), “Creative industries and the IPR dilemma between appropriation and creation: some insights from the videogame and music industries”, forthcoming in *Management International*.

[22] For instance, the case of BIOS license is very much tailored to the fact that the mother owner CAMBIA owned valuable intellectual property to build on, and that the domain allows to make easily a separation between the applications and the research tools (basically, new plants are applications and everything to make a new plant possible is research tool). In this way, BIOS, through a well-designed license, is able to guarantee that the research tools and continued development are enduringly free. But other contexts will be different and will require subtle modifications to the license. It may not be so easy to separate a free layer from the controlled layer as other situations may require more upstream appropriation due, for instance, to the necessary investments to develop the technology.

Becker M.C. (2001), “Managing Dispersed Knowledge, Organizational Problems, Managerial Strategies, and their Effectiveness”, *Journal of Management Studies*, 38, p. 10-38.

Benkler Y. (2006), *Freedom in the commons: A political economy of information*, Yale University Press.

Bessen J., Maskin E. (2009), “Sequential innovation, patents, and imitation”, *The RAND Journal of Economics*, 40, 611–635.

Bonaccorsi A., Rossi C. (2003), “Why open source software can succeed”, *Research Policy* 32, p. 1243-1258.

Brandenburger A. M., Nalebuff B. J. (1996), *Coopetition.* New York: Currency / Doubleday.

Brusoni S., Prencipe A. (2001), “Unpacking the Black Box of Modularity: Technologies, products and organizations”, *Industrial and Corporate Change*, 10, p. 179-205.

Burk D.L. (2002), “Open Source Genomics”, *Journal of Science and Technology Law*, 8, p. 254.

Boettiger S., Burk D.L. (2004), “Open Source Patenting”, *Journal of International Biotechnology Law*.

Cassier M., Sinding C. (2008), “Patenting in the public interest: Administration of insulin patents by the University of Toronto”, *History and Technology* 24 (2), 153-171.

Chesbrough H. (2006), “Open Innovation: A New Paradigm for Understanding Industrial Innovation”, in Chesbrough et al., 2006, *Open Innovation: Researching a New Paradigm*, Oxford: Oxford University Press, p. 1-12.

Chesbrough H. (2003), *Open innovation: The new imperative for creating and profiting from technology*, Boston: Harvard Business School Press.

CohenW.M., Levinthal D.A. (1989), “Innovation and learning: the two faces of R&D, *The Economic Journal* 99, 569–596.

Cohendet P., Farcot M., Pénin J. (2009), “Intellectual property in a knowledge-based economy: Patents to include vs. patents to exclude” , WP BETA 2009 – 15.

Cohendet P., Simon L. (2007), “Playing across the playground: paradoxes of knowledge creation in the videogame firm”, *Journal of Organizational Behavior* 28 (5), 587-605.

Comino S., Manenti F., Parisi M-L (2007), “From Planning to Mature: On the Success of Open Source Projects, *Research Policy*, 36, p. 1575-1586.

Cowan R., David P. A., Foray D. (2000), “The Explicit Economics of Knowledge Codification and Tacitness”, *Industrial and Corporate Change* 9, 211-253.

Dalle J. M., Jullien N. (2003), "'Libre' Software : Turning Fads into Institutions", *Research Policy*, 32, p. 1-11.

David P.A. (2006), "Using IPR to expand the research common for Science: New moves in 'legal jujitsu'", a Presentation to the Conference *Intellectual Property Rights for Business and Society*, London, September 14-15 2006.

De laat P.B. (2005), "Copyright or Copyleft? An Analysis of Property Regimes for Software Development", *Research Policy*, 34, p. 1511-1532.

Gambardella A., Hall B.H. (2006), "Proprietary versus public domain licensing of software and research products", *Research Policy*, 35, p. 875-892.

Gawer A., Cusumano M. (2002), *Platform leadership: How Intel, Microsoft and Cisco drive industry innovation*, Harvard Business School Press.

Henkel J. (2006), "Selective revealing in open innovation processes: The case of embedded Linux", *Research Policy* 35(7), p. 953-969.

Von Hippel E., von Krogh G. (2006), "Free revealing and the private-collective model for innovation incentives", *R&D management*, 36, p. 295-306.

Von Hippel E. (2005), *Democratizing innovation, MIT Press.*

Hope J. (2008), *Biobazaar: the Open Source Revolution and Biotechnology*, Cambridge, Mass.: Harvard University Press, forthcoming.

Howe J. (2006), "The rise of Crowdsourcing", *Wired*, 14 (6).

Isckia T., Lescop D. (2010), "Les fondements de l'innovation ouverte", paper presented at the AIMS workshop "Les modèles d'innovation ouverte: quelles pratiques pour quells enjeux", Caen, March 26, 2010.

Katsoulacos Y., Ulph D. (1998), "Innovation Spillovers and Technology Policy", *Annales d'Économie et de Statistique*, No. 49/50, p. 589-607.

Kogut B., Meciu A. (2008), "Open source software development and distributed innovation", in *Knowledge, Options and Institutions,* Kogut B., Oxford University Press.

Lakhani K., Panetta J.A (2007), "The principles of distributed innovation", *Innovations*, p. 97-112.

Lakhani K., Jeppesen L., Lohse P., Panetta J.A (2007), "The value of openness in scientific problem solving", Harvard Business School working paper 07-050.

Lakhani, K. R., von Hippel, E. (2003), "How open source software works: 'free' user-to - user assistance", *Research Policy*, 32, p. 923–943.

Lakhani, K. R., Wolf, R. G. (2003), "Why hackers do what they do? Understanding motivation effort in free/open source software projects", MIT Sloan School of Management Working Paper 4425-03.

Lerner J., Tirole J. (2001), "The Open Source Movement: Key Research Questions", *European Economic Review,* 45, p. 819-826.

Lessig L. (2004), *Free Culture: The nature and future of creativity*, Penguin books.

Lessig L. (2001), *The Future of Ideas*, Vintage Books, New York.

Maurer S. M. (2003), "New institutions for doing sciences: From databases to open source Biology", paper presented at the EPIP conference in Maastricht, November 24-25, 2003.

Maurer S. M., Rai A., and Sali A. (2004), "Finding Cures for Tropical Diseases: Is Open Source an Answer?", PLoS Medicine, pp. 183-186.

McKelvey M. (1998), "Evolutionary innovations: Learning, entrepreneurship and the dynamics of the Firm", *Journal of Evolutionary Economics*, 8, p. 157-175.

Mc Leod C., Nuvolari A. (2006), "Inventive activities, patents and early industrialisation. A synthesis of research issues", working paper DRUID 06-28.

Mc Leod C., Nuvolari A. (2008), "Inventive Activities, Patents and Early Industrialization. A Synthesis of Research Issues", presented at the DIME-OIDE workshop, Strasbourg, 22/02/2008, 23 p.

Meyer P. B. (2010), "The transition from airplane invention to airplane industry", paper presented at the "open source innovation" workshop, February 25-26, 2010, Strasbourg.

Meyer P.B. (2003), "Episodes of collective invention", BLS working papers 368.

Murray F., O'Mahony S. (2007), "Exploring the foundations of cumulative innovation: implications for organization science", *Organization Science*, 18, p. 1006-1021.

Nelson R.R. (2004), "The market economy, and the scientific commons", *Research Policy*, 33, p. 455-471.

Nelson R.R. (1959), "The Simple Economics of Basic Scientific Research", *Journal of Political Economy*, 67, p. 297-306.

Nuvolari A. (2004), "Collective invention during the British Industrial Revolution: The case of the Cornish pumping engine", *Cambridge Journal of Economics,* 28, p. 347-363.

O'Mahony S. (2003), "Guarding the commons: How community managed software projects protect their work", *Research Policy*, 32, p. 1179-1198.

Osterloh M., Rota S. (2007), “Open source software development – Just another case of collective invention?”, *Research Policy*, 36(2), 157-171.

Pénin J. (2010), “Quelle politique de licence de brevet pour les organismes publics de recherche ? Exclusivité versus modèles plus ouverts”, Forthcoming in *Management International*.

Pénin J. (2009), “Open source innovation: Rethinking the concept of openness in innovation studies, submitted to *Revue Economique*.

Penin J., Wack J-P. (2008), “Research Tools Patents and free-libre biotechnology: A suggested unified framework”, *Research Policy*, 37 (10), p. 1909-1921.

Polanyi M. (1962), “The Republic of Science: Its political and economic theory”, *Minerva*, 1 (1), p. 54-73.

Pray C.E., Naseem A. (2005), “Intellectual property rights on research tools: incentives or barriers to innovation? Case studies of rice genomics and plant transformation technologies”, AgBioForum 8, 108–117.

Raymond E. (1999), *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*, Sebastopol, CA: O’Reilly.

Rivette K.G., KlineD. (2000), *Rembrants in the attic: Unlocking the hidden value of patents*, Harvard Business School Press.

Scotchmer S. (2004), *Innovation and Incentives*, Cambridge, MA. MIT Press.

Scotchmer S. (1991), “Standing on the Shoulders of Giants: Cumulative Research and the Patent Law”, *The Journal of Economic Perspectives*, 5, p. 29 -41.

Shah S. (2005), “Open beyond software”, in *Open sources 2*, Dibona, Cooper and Stone, O’Reilly Sebastopol, CA.

Stephan P. (1996), “The Economics of Science”, *Journal of Economic Literature*, 34 (3), 1199-1235.

Teece D. (2000), *Managing intellectual capital*, Oxford University Press.

Walsh J.P., Arora A., Cohen W.M. (2003), “Research tool patenting and licensing and biomedical innovation”, in *Patents in the Knowledge Based Economics*, 285–340.

West J., Gallagher S. (2006), “Patterns of Open Innovation in Open-Source Software”, in Chesbrough et al., 2006, *Open Innovation: Researching a New Paradigm*, Oxford: Oxford University Press, p. 82-106.