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More open than open innovation?
Rethinking the concept of openness in innovation studies

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Abstract

This paper re-examines the concept of open innovation developed in organization sciences (Chesbrough, 2003a). We claim that this paradigm, which insists on the distributive nature of innovation among a wide range of heterogeneous actors, does not put enough emphasis on the condition of access to knowledge. Yet, the open dimension of knowledge is a very important feature to sustain a collective mode of innovation. We propose therefore a stronger definition of open innovation, which is based on three constitutive characteristics: (i) Firms voluntarily release knowledge; (ii) Knowledge is open, i.e. is available to all interested parties without discrimination; (iii) dynamic interactions take place among the stakeholders to enrich the open knowledge base. Examples that fit our definition of open innovation are open science, user centered innovation (von Hippel, 2005), free-libre open source software, collective invention (Allen, 1983), etc. We conclude with a discussion on the role of IPR to secure open innovation.

Keywords**:** open source, free software, intellectual property rights (IPR), open innovation, collective invention.

1) Introduction

In this paper we revisit the concept of open innovation developed in organization sciences (Chesbrough (2003a). By doing this we deal with a core topic of innovation studies, which is the condition of availability and accessibility of upstream research. This issue is central since most innovations are somehow cumulative, i.e. they build on upstream innovation and knowledge (Scotchmer, 1991; 2004; Murray and O'Mahony, 2007). The pace of innovation is therefore very sensitive to the possibility for innovation stakeholders to access and use a pool of upstream research, which serves as a springboard for further innovation. In other words, upstream research must remain open to foster economic growth (David, 2003; Nelson, 2005).

We argue that the concept of open innovation developed by Chesbrough (2003), while useful and relevant to describe the recent trend in the organization of innovation activities, does not put enough emphasis on the condition of access to existing knowledge and technology. Indeed, following Chesbrough, innovation is open because the innovation process is not retained into the hand of one single vertically integrated firm that would undertake in house

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all the steps of the innovation process (from conception to commercialization through production). Within the open innovation paradigm, innovation is distributed across a wide range of heterogeneous actors that interact through formal and informal alliances, patent pools, in and out licensing, etc. Furthermore, as opposed to a closed innovation model, within this paradigm, firms do not hesitate to use external knowledge to improve their own research. Open innovation *à la* Chesbrough is therefore synonymous with distributed innovation (Becker, 2001; Kogut, 2008), disintegrated innovation, modular innovation (Brusoni and Prencipe, 2001), network innovation, or collaborative innovation.

This open innovation paradigm does not focus on the condition of availability of existing technologies. Within this paradigm, knowledge is not necessarily available to all those who would wish to access it. It is usually kept secret by firms and diffused partly only to partners. When two firms create a research joint venture or a research consortium or when a firm outsources a part of its research or in-licenses a technology, secrecy is most of the time preserved. Only the members of the agreement can access relevant knowledge. Yet, the availability of access to new knowledge is a core feature to enhance innovation (Murray and O'Mahony, 2007).

We propose therefore to rethink the concept of openness in innovation studies. In order to do so, we draw on the work of Lessig (2001; 2004), according to whom an open world is opposed to a world of control or permission. Following Lessig one distinguishes a strong and a weak definition of openness: In a strong sense, something can be said to be open when one does not have to ask permission in order to use it, i.e. when it is not owned by someone who could control for its access. Alternatively, in a weaker sense, a resource is open if it can be accessed by all without discrimination, i.e. one may have to ask permission to access it but this permission is granted neutrally. According to this definition, open does not automatically mean free of charge.

Openness is central in the case of upstream research. Those researches must be open, in the sense that everybody should be allowed to use them without discrimination in order to create a dynamics where each stakeholder can use and enrich the open knowledge pool. The importance of this point was clearly made by Nelson (2004) who claimed that: "I do not know of a field of science where knowledge has increased cumulatively that has not been basically open" Nelson (2004, p. 463).

This discussion on the importance of openness in the innovation process leads us to propose a new definition of open innovation, which is more restrictive than Chesbrough's concept, and which is closer to the concept of collective invention raised by Allen (1983). We claim that a context of open innovation must be characterized by three constitutive conditions: (i) Firms voluntarily release knowledge (von Hippel and von Krogh, 2006); (ii) This knowledge disclosure is open, i.e. knowledge can be accessed by all interested parties (Pénin, 2007); (iii) dynamic interactions take place among the stakeholders. Examples of such situations of open innovation are open science, collective invention (Allen, 1983; Nuvolari, 2004), some cases of open source software projects (Raymond, 1999; Lessig, 2001; Lerner and Tirole, 2001; Dalle and Jullien, 2003), the human genome project, some cases of user centered innovation (von Hippel, 2005), etc.

The importance of preserving a part of openness in upstream knowledge and technology raises the issue of the protection of the open sphere. Open innovation is constantly threatened by private behaviors of actors, who may have incentives to appropriate fragments of this knowledge base through the use of aggressive intellectual property rights or secrecy. It is therefore important to implement strategies to secure the dynamics of collective invention by ensuring that upstream knowledge remains open. To do this it may be necessary to use the law, as has been done in the case of free-libre open source software (FLOSS), which are software for which open access is warranted by copyrights protection. Similarly in the case of industrial invention patents can be used to secure open innovation (Pénin and Wack, 2008). In a performance of "legal jujitsu" (Benkler, 2006) one can envisage using patent protection to prevent appropriating the invention and to preserve its open access for all.

Section 2 summarizes the concept of open innovation in organization sciences. Section 3 discusses the meaning of openness in the field of innovation and explains why it is a core issue. Specifically it shows that open innovation *à la* Chesbrough does not put enough emphasis on the condition of availability of knowledge. Section 4 introduces an alternative definition of open innovation and provides some examples. Section 5 shows how an original use of intellectual property rights, in a copyleft way, can secure open innovation.

2) Open innovation in organization sciences

An important literature has developed recently in organization sciences around the issue of open innovation (Chesbrough, 2003a; Chesbrough *et al.*, 2006). According to this stream of research, innovation is less and less undertaken in-house, in a closed and integrated way, but is "open" in the sense that many actors are involved in the different step of the innovation process. Innovating firms increasingly rely on knowledge developed outside their border. Most firms do not hesitate to outsource a part of their R&D, to collaborate in R&D, to licence in and out their technologies, to form patent pools, to buyout start-ups, etc. This trend is accurately described by Chesbrough, who is considered as the initiator of this field of research:

> "*I call the old paradigm Closed Innovation*. It is a view that says *successful innovation requires control*. Companies must generate their own ideas and then develop them, build them, market them, distribute them, service them, finance them and support them on their own. This paradigm counsels firms to be strongly self-reliant, because one cannot be sure of the quality, availability, and capability of others' ideas: "If you want something done right, you've got to do it yourself" […] For most of the twentieth century, this paradigm worked, and worked well."
>
> (Chesbrough, 2003a, p. xx and xxi; italics are mine)

> "The Open Innovation paradigm can be understood as the antithesis of the traditional vertical integration model where internal research and development activities lead to internally developed products that are then distributed by the firm […] Open Innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. 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, 2006, p. 1; in Chesbrough *et al.*, 2006)

The open innovation paradigm acknowledges that in modern economies, innovation is rarely undertaken by one single actor. A single firm, as big and dominant it can be, always represent only a small fraction of the research undertaken in a technological field. Firms have therefore strong interest to partner and to integrate external sources of knowledge. Similarly, a firm may not wish to bring to the market certain inventions developed in-house, thus having incentives to license out the technology, to support spin-offs, etc. In sum, innovation becomes a collective activity, involving a wide number of stakeholders. Not only production but also R&D can now be done in collaboration with outsiders or outsourced.

The open innovation paradigm is opposed to the closed, vertically integrated firm which does its own research and which commercializes products developed in-house and only those products. As noted by West and Gallagher (2006, p. 83): "In contrast to earlier models and 'fully integrated innovators' like AT&T (now Lucent) Bell Labs and IBM, which do basic research through commercial products, open innovation celebrates success stories like Cisco, Intel and Microsoft, which succeed by leveraging the basic research of others".

In a world-wide economy, with technologies becoming more and more complex, i.e. more difficult to understand and manage as a whole by one single individual or organization, it is indeed necessary to find partners to collaborate with. This point was already raised several decades ago by Hayek (1945), for whom the increased complexity of the world was one of the most important advantages of a decentralized mechanism (market based) as compared to a centralized mechanism. In this line, open innovation is also a way to support division of labor and specialization in knowledge intensive activities.

An important feature of this open innovation paradigm is the need for firms to access external knowledge and not to rely exclusively on knowledge developed in-house. This is often referred to as Joy's law, from Sun Microsystems cofounder Bill Joy, who would have argued: "No matter who you are, most of the smartest people work for someone else" (Lakhani and Panetta, p. 97). This joke intends to point out that whatever the R&D efforts of an organization, it can only pay to look outside the organization and to absorb external knowledge. In sum, as argued by Gassman (2006, p. 223): "The 'do it yourself' mentality in technology and R&D management is outdated".

While acknowledging the interest and relevance of this open innovation paradigm, we believe that it does not focus enough on the importance of the availability of knowledge and technology for re-use and experimentation. Chesbrough adopts indeed a very specific definition of openness. He explains that he chooses 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, 2006, p. 2 and 3; in Chesbrough *et al.*, 2006).

Open innovation *à la* Chesbrough is therefore very similar to what other authors have called "disintegrated innovation", "modular innovation" (Brusoni and Prencipe, 2003), "distributed innovation" (Kogut, 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.

Yet, an innovation can involve an important number of organisations, i.e. be open following Chesbrough's definition, and its access can nevertheless be controlled with each stakeholder keeping a tight secrecy or using aggressive patenting strategy over research results[1]. This point is illustrated by West (2006), who found that the more technologies are appropriable the more we are likely to observe patterns of open innovation (see also Laursen and Salter, 2006). It is indeed well-known that, paradoxically, strong patents allow the emergence of a market for technologies and facilitate technology transfers and R&D collaborations (Mazzoleni and Nelson, 1998; Jaffe, 2000). Put it otherwise, strong patents ease the distribution of innovation. However, strong patents also limit the access to a technology and give control to the owner of the patent over the use of the technology[2].

To summarize, open innovation in organization sciences put the emphasis on the distributive nature of innovation among a wide range of heterogeneous stakeholders. Yet, we believe that an important point on which it is necessary to insist is the condition of access to technology. A central issue of the concept of openness in innovation studies deals with the open (in the sense of "available to all interested parties" or "uncontrolled access") dimension of upstream knowledge.

3) On the meaning and importance of openness in innovation

Many authors present the free-libre open source movement (FLOSS) in software as an example of open innovation (Lakhani and Panetta 2007; West and Gallagher, 2006). Yet, one of the main features of FLOSS, if not their main feature, is the open access to anybody of 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" in organization sciences[3].

To understand this, we must first come back to the meaning of the word open. Following Lessig (2001), a resource is open if: "(1) one can use it without the permission of anyone else; or (2) the permission one needs is granted neutrally" (Lessig, 2001; p. 12). This suggests therefore that one can distinguish between two levels of openness, a weak and a strong one:

- In a strong perspective, open means that one does not have to ask for permission in order to use a resource. The resource is not owned by someone who could control for its access.
- In a weaker sense, one may have to ask permission, but this permission is not granted at the discretion of an owner, who could therefore choose arbitrarily to refuse or grant

[1] This view is clearly in line with the work of Eric von Hippel who, in is book *Democratizing innovation* (2005), always use the expression "open and distributed innovation" (p. 2, 12, 13, 177), and never the expression "open innovation" alone. Von Hippel is therefore very careful not to make confusion between the words "open" and "distributed" since obviously they have a different meaning for him. A distributed innovation may not be open.

[2] West (2006) gives the example of pharmaceuticals as a sector in which innovation is open and appropriability is strong. Yet, most empirical studies have shown that in pharmaceuticals patents are used aggressively to defend monopoly position and to exclude imitators (Mazzoleni and Nelson, 1998; Jaffe, 2000). Patented molecules are far from being open in the sense that other firms have hardly the authorization to use them before the expiration of the patent.

[3] Lakhani and Panetta (2007) acknowledge this difference between the usual meaning of open innovation and 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".

> access to others. Permission is granted "neutrally". The contrary of an open world is therefore a world of permission, of command or of control.

With respect to knowledge and technology, a piece of knowledge is open if it is available to all, i.e. all interested parties are given access to it (Pénin, 2007). It is not retained into the hand of one or several individuals who would control for its access. This implies a big difference between releasing openly a piece of knowledge and knowledge trading (von Hippel, 1987). Within a research joint venture, or a licensing agreement, firms share know-how. They do not release it openly because they do not make it available to outsiders. Conversely, publications in scientific journals, presentations at scientific conferences or knowledge released on firms' website, are really open disclosure (Hicks, 1995; Pénin, 2007). The knowledge becomes open in the sense that one cannot restrict its access. The disclosure is not limited to some well specified recipients. Everybody is potentially a recipient.

This definition of openness has one important consequence: According to our weak definition of openness, access to an open resource needs not automatically to be free of charge, as illustrated by the case of free software and the famous sentence of Richard Stallman: "Free as a free speech, not as a free beer". Of course, as stated by Cohen and Walsh (2008, p. 9) "any positive price for access to intellectual property potentially restricts access". Yet, if the price is "reasonable" and non discriminatory we consider knowledge as being open in a weak sense.

The importance of the difference between being free (concept of gratuity) and being open and why the latter is more important that the former to foster innovation and growth is acknowledged by Nelson (2005), who explains that: "With respect to patented research tools created by industry research, *my concern is less with open use at a fee, but with decisions not to make the tools widely available*" (Nelson, 2005, p. 137; italics are mine). Nelson clearly stresses the fact that to foster cumulative innovation it is important that former knowledge and innovation are easily accessible for everybody under conditions that are not too difficult to meet and not discriminatory. They must remain open, but not necessarily free of charge, if the price of access is reasonable. The famous Cohen Boyer patent on recombinant DNA provides an example of such a situation of a technology being open but not free of charge. This patent was owned and thus its access was not allowed without permission by the owner. Yet, it was widely licensed at a reasonable fee without discrimination. Anybody, if he wanted to, could be granted a license. This technology was therefore open according to our weak definition, although it was not free of charge[4].

The importance of preserving openness in the cultural world was recently emphasized by Lessig in two books "The future of ideas" (2001) and "free culture" (2004), in which he opposes a free or open world to a world of permission or control. The author explains that creativity can hardly occur in a world of permission, and that the production of novelty requires the preservation of an open platform on which creators can freely draw to feed their creativity. Upstream research must be open to foster the development of downstream innovations and applications:

> "A free culture supports and protects creators and innovators. It does this directly by granting intellectual property rights. But it does so indirectly by limiting the reach of

[4] The link between openness as we envisage it and patent is not straightforward. Patents give control to its owner over the patented technology and, in this sense, patented technology are clearly not open. Yet, if we take the weak definition of openness, a patented technology can be considered as open if only its owner gives up its control over the patent, for instance, by granting licenses without discrimination to all those who wish to.

> those rights, to guarantee that follow-on creators and innovators remain as free as possible from the control of the past. A free culture is not a culture without property, just as a free market is not a market in which everything is free. *The opposite of a free culture is a permission culture, a culture in which creators get to create only with the permission of the powerful, or of the creators from the past*"
>
> (Lessig, 2004, p. xiv; italics are mine).

The issue of openness of upstream research is not a new one. The necessity to preserve the openness of a fraction of the knowledge base, in which innovators can tap in order to generate innovations, has been acknowledged by economists and policy makers for a long time. This idea is, for instance, at the heart of the existence of the open science model, a central dimension of which is the openness of scientific knowledge. Open science is and has always been considered as a central element of national systems of innovation. It is believed to provide the basis to follow-on innovations, which are built upon scientific knowledge and which would not be implemented should this scientific knowledge not be available. The main feature of science in most countries is that it is intrinsically open. It is based on non-monetary incentives and rapid, free and wide dissemination of the research results. Yet, the recent trend is for public research organisations to patent most of their results, which may induce a privatisation of the "republic of science". Concerned by this trend, many voices speak for the necessity to keep science open, to preserve access to this common good in order to foster the pace of innovation. Fragmentation and appropriation of the scientific common may indeed increase the cost of accessing it and therefore impede the development of follow-on innovations. Even though first studies point out that actors manage to set up arrangements to solve the patent problem (Walsh *et al.*, 2003), doubts remain and many scholars still warn against the risk of rendering science proprietary (David, 2003; Nelson, 2004).

To summarize, we argued here that the notion of openness deals with the availability and condition of access to a resource. A resource is open if it is available to all without having to ask permission or, in a weaker sense, if the conditions of access are « reasonable » and non-discriminatory.

This definition of openness is more restrictive than Chesbrough's one. It is likely that, although most innovations that fit our definition of openness are also open according to Chesbrough[5], many examples of open innovation *à la* Chesbrough do not meet our criterion. For instance, when two firms collaborate in R&D, set-up a research joint venture or a research consortium, exchange technologies through licensing agreements, in most cases the underlying knowledge is kept secret and does not flow beyond the partners involved in the collaboration. Knowledge is not available to all. It flows only within closed circuit.

[5] In some extreme cases, innovation that we consider as open may not be open for Chesbrough. This is because the latter insist on the importance of the business model whereas we don't. An innovation that has no business model is not considered as open according to Chesbrough (Chesbrough, 2006). For instance, as explained by West and Gallagher (2006), some free-libre open source software are not cases of open innovation *à la* Chesbrough because they have no business model. Yet, they are open innovation for us.

4) Open innovation: definition and examples

4.1 A suggested definition of open innovation

We propose here a new definition of open innovation, which is close to what Allen (1983) and other authors refer to as being collective invention. According to us, open innovation must encompass three constitutive elements: (i) Voluntary knowledge disclosure from "participants"; (ii) knowledge being open (which is equivalent to say that "spillovers are not controllable", West and Gallagher, 2006, p. 94); and (iii) continuous and dynamic interactions among "participants" (I put participants in inverted commas since, open innovation being by definition open, it means that anybody can participate and is therefore potentially a participant)[6].

The first characteristic implies that firms and individuals involve in open innovation really intend to share and to release knowledge. Knowledge flows cannot therefore be attributed to undesirable spillovers and externalities. Many authors have recently emphasised the fact that firms, far from trying to keep tight secrecy over their research, often disclose widely their results, including to rivals (Hicks, 1995; von Hippel and von Krogh, 2006; Pénin, 2007).

The second characteristic has already been discussed above. It is the main distinction with the open innovation definition *à la* Chesbrough. The knowledge exchanged must be open, i.e. it must be available to any interested parties without discrimination. As we will show below it is only under this condition that one can guarantee an optimal use for this knowledge. 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). Again, 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. This open dimension as being constitutive to open innovation is clearly acknowledged by von Hippel and von Krogh (2006) who write:

> "In our view, free [in the sense of open] revealing of product and process designs is a defining characteristic of 'open innovation'. Free revealing is the feature that makes it possible to have collaborative design in which all can participate – as is famously the case in open source software projects"
>
> Von Hippel and von Krogh (2006, p. 295)

The third requirement to qualify a situation as being open innovation deals with the interaction among participants. It is indeed important to differentiate between a situation in which firms would just disclose knowledge at a point in time (spot disclosure) and a situation in which firms regularly disclose knowledge, use knowledge disclosed by other firms, etc. In short, it is important that participants develop dynamic interactions in order to continuously

[6] Our definition of open innovation is also 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, we think that 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.

improve 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 open innovation is restrictive enough to exclude most of the strategic behaviors described by Chesbrough (such as alliances, research joint ventures, etc.). Yet, it is possible to find examples that fit our definition of open innovation in the past as well as in recent history. For instance, the phenomenon of "user centered innovation" introduced by von Hippel in the past two decades often satisfies our three conditions of open innovation. Indeed, 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.

Open science, as it has been implemented after the Second World War, is clearly an attempt to develop an open innovation model for the production of upstream knowledge. The human genome project (HGP) is also an example of research undertaken within an open innovation context. Similarly, collective invention (Allen, 1983) and the free-libre open source software movement are also in line with our definition of open innovation.

4.2. Collective invention as open innovation

In his seminal contribution, Allen (1983) proposed a new mode of knowledge production that he called collective invention. As explained by McLeod and Nuvolari (2008, p.7), "In collective invention settings, *competing firms freely release to one another pertinent technical information* on the construction details and the performance of the technologies they have just introduced". Allen illustrated his point by an example taken from the case of the blast furnace industry at the end of the XIXth century. Allen points out that in this particular industry many knowledge exchanges occurred among firms in the industrial district of Cleveland (UK) between 1850 and 1875. He notices further that these exchanges led to important technological improvements regarding the size of the furnaces (from fifty feet to eighty feet) and their temperature (from 600°F to 1400°F), which in turn led to an important decrease of production costs. This was perceived as a quite puzzling finding then because, against the common belief of the period, this example suggested that behaviours of voluntary and open knowledge disclosure did contribute to increasing firms' profitability or at the very least did not undermine this profitability. Allen writes that:

> "If a firm constructed a new plant [more specifically, a blast furnace] of novel design and that plant proved to have lower costs than other plants, *these facts were made available to other firms in the industry and to potential entrants*. The next firm constructing a new plant built on the experience of the first by introducing and extending the design change that had proved profitable. *The operating characteristics*

of the second plant would then also be made available to potential investors. In this way fruitful lines of technical advance were identified and pursued"

(Allen, 1983, p.2, italics are mine)

Further, he adds:

> "Formal presentations through papers presented to engineering societies was the second channel through which information was released […] Papers were presented which disclosed considerable detail about the design and efficiency of different plants. The papers and the subsequent discussion were printed in the proceedings of the society. […] Since most of these ironworks contained furnaces of several vintages and the authors of the papers tried to use the resulting data to estimate the impact of increasing height and temperature on fuel consumption, *an impressive amount of useful information was made available to potential entrants*".
>
> (Allen, 1983, p. 8-9, italics are mine)

All three constitutive elements of open innovation defined in the former section are thus present in Allen's example. First, firms decided voluntarily to release knowledge to existing rivals and to potential entrants. According to Allen (1983, p. 2): "The essential precondition for collective invention is the free exchange of information about new techniques and plant designs among firms in an industry"; second, this disclosure was open, since it was not limited to well specified recipients but was made available to anybody through publications in scientific journals. Specifically, the openness of the knowledge disclosure may have fostered the emergence of new entrants in the industry. Yet, as acknowledged by Allen, this release of technical information to actual and potential competitors was necessary to allow cumulative advance; and third, this knowledge disclosure occurred within a framework of ongoing exchanges and interactions among firms, which triggered continuous improvements in the performance of the furnaces.

Episodes of collective invention have also been identified and discussed by Meyer (2003) and Nuvolari (2004). The latter raises the case of the Cornish steam pumping engine at the beginning of the XIXth century. Mining activities in Cornwall (as well as in other regions) faced serious problems of flooding at this time. Miners needed therefore engines to pump the water out of the mine. At the end of the XVIIIth century most miners in Cornwall used the Boulton and Watt engine to drain their mines. Yet, this was made very expensive due to the many patents Watt had on the engine and that he used aggressively to defend his monopoly position. After Watt's patents had expired, miners in Cornwall developed their own pumping engines. The peculiar feature with the development of this high pressure engine, as explained by Nuvolari (2004), is that it was clearly conceived under a collective invention framework. The new engine was improved and developed collectively in the sense that participants did not try to patent their improvements. On the contrary, they released openly their research to other miners through a monthly journal ("the *Lean's Engine Reporter*"). Through this channel, similarly to the blast furnace story, inventors made valuable information and best practices available not only to incumbents but also to potential entrants that may have been unknown to the sender at the time of the disclosure. This open mode of developing pumping engines led to important improvements in the performance of the engines within a short lapse of time.

4.3. The case of free-libre open source software

The recent surge of literature around the issue of open innovation finds its roots to some extent in the success of free-libre open source software (FLOSS). Indeed, the importance of openness to foster innovation and the emergence of novelty can hardly be better understood than through this example, which has been extensively analysed in the economic literature (Lerner and Tirole, 2001; Dalle and Jullien, 2003).

During the 70s software were conceived within an open environment. Basically, firms were releasing software with their source codes, which enabled other firms to adapt or improve them. Without the source code it is indeed very difficult to modify software. This tradition of collaboration and code sharing within the developers' community can partly be explained by the leading role of AT&T which, due to a consent decree (1956), was not allowed to sell software. Yet AT&T needed software in its business and employed teams of developers to design software. The birth of UNIX was, for instance, the fact of AT&T developers. Since they could not sell UNIX, AT&T decided to let it free to anybody, which triggered a formidable context of code sharing and rapid improvement of this operating system (Lessig, 2001)[7].

Yet, at the turn of the 80s, the sale of software grew into a business in its own. Firms were therefore more reluctant to release source code with their software. This surge of appropriation (mainly through copyrights but also through patents[8]) prompted a reaction from the developers' community, which was afraid that this closure of the source code would inhibit the tradition of collaboration and exchange that had prevailed in the past. Worried about the consequences of this surge of appropriation, Richard Stallman founded in 1985 the Free Software Foundation (FSF). The purpose of this foundation was to promote the design and development of free software, an important feature of which is the release of the source code. To preserve the openness of source code was considered as highly important since it is a necessary condition to favour collaborations and interactions among software developers, i.e. to create and develop software on a bazaar mode (Raymond, 1999).

In order to ensure that everybody can access the source code and modify and improve software without having to ask for permission from an "owner", the FSF developed an original exploitation license: The General Public License (GPL), also known as copyleft. The GPL ensures that everybody can use, modify, copy and even distribute software "protected" by the license at the unique condition that these changes are kept under the copyleft regime, which means that improvements must remain accessible and free for modifications by everybody (i.e. the source code of the improvements must also be released). This license spreads therefore like a virus. Any user of copylefted software must keep improvements and modifications under the copyleft regime.

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[7] As stated by Lessig (2001, p. 52, italics are mine): "No one needed permission from AT&T to learn how its file system worked or how the OS handled printing. Unix was a trove of knowledge that was made available to many. *Upon this treasure, many built*"

[8] The 1980s saw the emergence of the first patents on software. Initially software were considered as depending exclusively on the copyright legislation due to their algorithmic content. But following the Diamond vs. Diehr case (1981), patents began to be granted to software designers who could also continue to be granted copyrights (since patents and copyrights protect two different parts of a software). Software can hence be protected by a triple layer of protection: A patent for its design, a copyright for the source code and secrecy law also for the source code since copyright laws do not contain any requirement to disclose the source code.

This way of developing software, by systematically releasing the source code, has proved to be very efficient. Sendmail, which underlies the routing of e-mails over the Internet, and Apache, which is a free server program that runs more than half all web servers, are prominent examples of successful free software. But doubtless the most famous success of free software is the development of the GNU-Linux operating system, which was completed in 1991. GNU-Linux is the direct descendant of UNIX. It is often associated with the name of Linus Thorvalds but it represents the work of hundreds of persons before him, who participated in the GNU project. Nowadays it is viewed as a major threat for Microsoft in the domain of operating systems for networks.

FLOSS cumulate three properties, technical, legal and organisational:

- From a technical point of view, FLOSS are released with their source codes, thus enabling other developers to use, understand and improve them and contributing to a fast and steady advance in the resolution of technical problems that are encountered.
- From a legal point of view, FLOSS are software protected by original viral licenses, on a copyleft mode (but not exclusively. Other types of licenses, less demanding, exist also), that prevent the appropriation of the software and of its subsequent modifications.
- From an organisational point of view, FLOSS are software developed following a mode bazaar or agora (Raymond, 1999). This mode of development is opposed to the traditional, in-house conception of software, which is compared by Raymond to the building of Cathedrals. Within the bazaar mode, hundreds of developers constantly improve the code released by others and, in turn, release their improvements so that other developers can validate or change them. This collective mode of developing software has proved very efficient. In 1998 an internal Microsoft note stressed that the free software ability to gather the collective knowledge through the Internet was simply fascinating.

It is therefore obvious that FLOSS encompass the three elements that we identified as being constitutive of open innovation. First, within FLOSS projects developers disclose voluntarily lines of code to other developers. Second, the disclosure is not restrained to members of the project but participation is open to all. Third, participants in FLOSS projects intensively interact and exchange information, so that FLOSS are rapidly designed and debugged. According to Lakhani and Panetta (2007, p. 98): “OSS communities are the most fully developed example of the appearance of distributed innovation systems characterized by decentralized problem solving, self-selected participation, self-organizing coordination and collaboration, “free” revealing of knowledge, and hybrid organizational models [...] The achievements of OSS communities have brought the distributed innovation model to general attention, but it is rapidly taking hold in industries as diverse as apparel and clothing, encyclopedias, biotechnology and pharmaceuticals, and music and entertainment”.

In order to extend the FLOSS model beyond the software industry, it is important to understand why FLOSS cumulates the three properties that were presented above. In our view, those three properties follow a logical order that can be explained as follow: The aim of the FLOSS movement is to favour the development of software on a bazaar mode, which is perceived by FLOSS participants as more efficient than the cathedral mode. This specific organization is therefore the objective. Yet, to achieve this objective it is necessary that the source code is open, i.e. is released with the software. It is indeed not possible to improve and modify software, and therefore to design software on a bazaar mode, without its source code[9]. The technical dimension of FLOSS is therefore a consequence of the organisational dimension. And then, the legal dimension is a further consequence, since it aims at ensuring the openness of the source code. It is the legal weapon that enables the bazaar mode of software development to survive. In short, the collective and collaborative development of FLOSS is the aim while the legal protection is part of the solution. Let us now explore how this model may work in other industries, as suggested by Lakhani and Panetta in the above quotation.

5) How to secure open innovation?

Open innovation may in some cases be a powerful mechanism of peer production of knowledge, as illustrated by the FLOSS example. It may be a formidable lever to harness the power of mass collaboration –the so-called Wikipedia effect (Tapscott and Williams, 2007), and to “democratise innovation” (von Hippel, 2005). The open dimension implies that anybody can participate and contribute. Yet, open innovation is fragile and continuously threatened by, among other things, aggressive intellectual property rights strategies which, by definition, are designed to close the knowledge space, to create proprietary regimes, i.e. to put a brake to the collective production of upstream knowledge (David, 2003)[10]. It may therefore be necessary to implement mechanisms to secure the open innovation process, as has been done in the case of FLOSS.

5.1 Intellectual property rights to secure open innovation

Preserving the openness of the upstream knowledge base by preventing its appropriation can be done either by releasing knowledge without any IPR on it (through defensive scientific publications for instance, see Parchomovsky, 2000; Johnson, 2004) or by using IPR in a specific way, in a copyleft style. This second possibility has the advantage of controlling the use of the released knowledge and therefore of ensuring the freedom of follow-on research. Merely releasing knowledge without any IPR on it ensures that this knowledge cannot be appropriated but do not secure the openness of improvements. It entails the risk that innovators appropriate follow-on research and therefore control their use. Whereas, by using copyrights or patents in a copyleft style, one can ensure that nobody appropriates either the protected piece of knowledge, or its improvements or modifications.

It is therefore possible to use IPR in such a manner that, far from impeding open innovation, they favour collaboration and collective innovation. Much as copyright in software has been turned to copyleft, patents and other IPR can be used in such a way as to ensure the accessibility of upstream research. As David (2006) proposes, one can envisage hijacking the traditional role of patents by “using intellectual property rights to expand the commons for

[9] The importance of openness to foster incremental contributions and cumulative advances is stressed, among others, by Murray and O’Mahony (2007, p. 1008): “Motivation is not enough to spur contributions. It is only with open access to a community’s source code and development process that contributors can make accumulative contributions”. Von Hippel also outlines the needs of openness to foster interactions and ongoing improvements (2005, p. 99).

[10] Yet, recent works have emphasised that this view is too simple. Intellectual property rights do not always impede openness. A patent is a complex instrument that does not always lead to strategies of exclusion and monopolisation (Bureth *et al.*, 2005). For instance, one of the main objectives of the patent system is also to encourage the diffusion of knowledge within society.

science". Patents can mimic copyleft type licenses by adopting a "grant back mechanism", which would imply that users of patented research may be granted a license only if they agree to put further improvements under the free regime (Boettiger and Burk, 2004). Such a license would therefore stipulate that users are required to grant back the rights on follow-on inventions to original inventors. Given that the original inventor chooses to license freely his research, this viral clause effectively guarantees that the sequence of innovation arising from the original research will be enduringly open, i.e. available to re-use to all those who agree with the licensing terms.

The rationale in using patents to secure open innovation can be understood through the analogy with jujitsu (Benkler, 2006; David, 2006), which is a martial art oriented towards active self defence. Once attacked, Jujitsu practitioners 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 open innovation, patent owners use the strength of the patent system against its primary purpose. In line with the state of mind of martial art practitioners, open innovation therefore suggests to use the patent system to prevent that entire streams of research are closed down by patent thickets. In this sense, the use of IPR to prevent appropriation is a "legal jujitsu" (Benkler, 2006).

To summarise, one can reproduce in other industries the model that has proved efficient in software and which is based on three pillars: organisation on a bazaar mode, openness of the source code and licensing on a copyleft style. The generalisation of these three pillars in other industries may work as follows: First, the objective is to encourage peer production, i.e. bazaar mode of knowledge production. Second, to achieve this aim one needs to preserve the openness of the underlying knowledge. It is indeed by ensuring as large and as cheap an access as possible that one can make people participate and enrich the platform. Allowing someone to control the access to innovation can only diminish the performance of the collective mode of knowledge production. The value of openness and crowd-sourcing to foster knowledge production has been demonstrated recently by Lakhani *et al.* (2007), who studied the InnoCentive case. And third, to secure openness one may need to use IPR in a copyleft way. In other words, to make the bazaar mode of knowledge production works one needs openness, and to protect the open dimension one may need to use IPR.

The transposition of copyleft type of licences outside software has been the subject of several recent papers, focusing essentially on the case of biology research tools (Burk, 2002; Maurer, 2003; Hope, 2008; Pénin and Wack, 2008). The following example of the BIOS initiative illustrates the use of IPR to secure open innovation. The BIOS initiative – BIOS as Biological Innovation for Open Society- aims at developing open plant transformation research tools with a view to re-use them to create applications such as improved strains of crops. The BIOS initiative currently covers 12 research tools including the techniques of Transbacter and the popular GUS gene reporter. Those research tools are all patented and can be used only under specific conditions. In order to use them, a third party has to agree to the BIOS license that adopts a copyleft style "grant back mechanism" forcing the licensors into agreeing to share back to the BIOS initiative the rights to re-use the improvements that are made to BIOS research tools as well as all the information concerning that improvement. 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[11]). Furthermore, although the use of a BIOS

[11] http://www.bios.net (accessed [09/17/06]).

patent is open it may not necessarily be free of charge. Private members of OECD countries are required, in addition to agreeing with the licensing terms, to pay a participation fee.

This viral clause of licensing implies that research tools that build on a technology patented by BIOS cannot be appropriated. Yet, this 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 frontier put to the open environment is linked to the specific features of innovation in biotechnology. 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. Indeed, although prices for equipment in biotechnology may be declining, there remain large costs in the development of biotech applications, such as the testing of drugs. Those costs mean that an organization that is based solely on the decentralized contributions by a community of private, garage-based scientists with intrinsic and, limited, extrinsic motivations, is unlikely to reach the commercial success of FLOSS projects. The BIOS initiative aims therefore at preserving the openness only of upstream research tools, without impeding the commercial exploitation of their direct applications.

5.2. Beyond intellectual property rights

Patents can be used in a performance of “legal jujitsu” to secure the open dimension of upstream technologies. Yet, this possibility must not hide the other impediments to access knowledge. Patents are only one side of the problem and even without patents open innovation is not straightforward.

Following Cohen and Walsh (2007 and 2008) in order to understand the impediments to the sharing and diffusion of upstream knowledge, it is necessary to go beyond IPR. One must indeed make a distinction between legal excludability (which is operated through patents) and practical excludability, which may have little to do with patents (Cohen and Walsh, 2008). Specifically, Cohen and Walsh show that patents are not the main impediment to access scientific knowledge in biomedical science. They found that “access to knowledge inputs is largely unaffected by patents” (Walsh, Cohen and Cho, 2007, p. 1184). Out of the 381 academic scientists they have interviewed “none reported having to stop their research due to the existence of third party patents” (Walsh, Cohen and Cho, 2007, p. 1190). Hence, “although patents may confer a legal right to exclude, it does not confer “practical excludability” in academic research sittings” (Cohen and Walsh, 2008, p. 13).

In the case of biomedical science access to upstream research is mainly restricted due to the use of secrecy or to the control firms have over their materials and not due to aggressive patenting strategies. For instance, researchers may merely refuse to share intermediary results and materials to reproduce experiments. Those central inputs to do science, such as private data, protein, drugs, research tools, although not patented, are therefore made unavailable to other scientists. This is especially true when these intermediary materials are difficult to replicate. Cohen and Walsh find that most researchers in the biomedical field have already made request to other colleagues that have been denied.

In sum, it is not because upstream technologies are not patented or are copylefted that they become easily available and that a context of open innovation can emerge. As argued by Walsh et al. (2007, p. 1201): “debates that focus on the effects on academic research of the patenting of upstream biomedical discoveries may not be addressing the most pressing policy question". It is therefore important to expand the discussion about open innovation beyond the patent issue. Open innovation also requires that firms are willing to share their research. With this respect it is necessary to set up incentives schemes that induce researchers to openly diffuse their knowledge. This point is especially relevant in modern science, where incentives have changed dramatically during the past decades (Stephan, 2008).

6) Conclusion

The recent patent upsurge in almost all countries and all domains has at least one merit: It has put the notion of openness in the forefront. Indeed, a major part of the worries regarding this patent outburst deals with the substitution of an open and collaborative way of doing research for a world of control and exclusion. Indeed, although proprietary and exclusive strategies are essential features of our modern economies, openness, sharing and freedom of use have also proved to be important elements of the innovation process (McLeod and Nuvolari, 2006; 2008)[12].

The success of open source software tends to demonstrate that openness is a sustainable strategy and can foster innovation in some cases. Open innovation frameworks in which competitors share knowledge and information are not specific to software. They have always existed and often proved to be efficient. Allen (1983) and more recently Nuvolari (2004) illustrated this point through examples drawn from the early phases of industrialisation. Contemporary examples, such as the sequencing of the human genome, also support this view. Similarly, open source or free/libre biotechnology is an attempt to transpose the open source model to biology (Burk, 2002; Maurer, 2003).

In this paper we tried to provide a definition of open innovation. We identified three constitutive elements of a context of open innovation: (i) Voluntary knowledge disclosure; (ii) Openness of knowledge and; (iii) ongoing interactions among stakeholders. Our definition is therefore more restrictive than the one provided by Chesbrough (2003) which, according to us, does not put enough emphasis on the importance of openness of the knowledge and technology. In a sense Chesbrough provided a weak definition of open innovation and in this paper we propose a stronger one. An innovation can be distributed or dispersed among a wide number of stakeholders but still closed because firms keep tight secrecy over their research or aggressively patent their results. Strategic behaviours such as R&D collaboration and outsourcing define only weak forms of open innovation. Our aim in this work was to stress what is really at stake with open innovation, i.e. the issue of the availability of innovation.

For sure, not everything can be open and closed behaviours will always be necessary to innovation. Yet, we believe, like Nelson (2004), that any innovation is somehow built upon something that is open and thus, that this something must remain open. Open and closed dimensions are two complementary facets of innovation that are equally important. Open innovation does not substitute for corporate innovation but co-evolve with it. This was already the case in the linear innovation model which made a distinction between public and open research on the one hand and corporate and closed research on the other hand (The "republic

[12] 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".

of science” vs. the “kingdom of industry”). 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 will have to establish new strategies to build and secure the open knowledge base on which they can tap. The open dimension today is not left in 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 reality.

A central issue for the next years will be to secure this open platform and to make it coexist with the closed world. In the pursuit of ensuring openness of upstream research, organizational designs and numerous licenses analogous to those used in FLOSS can be ported from the software sector to other sectors. Patents, for instance, can be used in a performance of legal jujitsu (Benkler, 2006), as illustrated by the example of BIOS developed in the last section of the paper. Yet, this example also emphasizes the problems posed by the co-existence of two worlds characterised by different needs and requirements (Hope, 2004; 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 by all parts.

Similarly, firms’ motivations to participate in and to enrich the open platform will have to be studied. Public good literature suggests that such collective construction is undermined by free riding. And the more the participants, the higher the incentives to free-ride. Yet, so far, it seems that in many cases free riding behaviours are made difficult by the fact that in order to tap into the reservoir one needs to actively participate. Von Hippel and Von Krogh (2006), for instance, propose a model of “private-collective” incentives to participate, in which free-riding is limited by the specificities of the good. O’Mahony (2003) also discusses the strategies that participants in open innovation can implement to prevent appropriation and therefore to foster participation. On this issue, the works already done in the case of the software industry may be helpful to understand why firms actively contribute to an open platform of knowledge. It is likely that business models viable in software can also work in other industries.

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