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Patenting practices within the Upper-Rhine Biovalley network : Exclusion and cooperation rationales.

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I. Introduction

This contribution aims at analysing the role of patents in an emergent network in the field of biotechnology[1], namely the cluster of Upper-Rhine Biovalley. We examine the traditional rationale for firms to apply for a patent, which focuses on the protection against competition as the basic motive of application and we claim that another, complementary motive should be explicitly taken into account: The role of patent as a negotiation and/or cooperation instrument.

A patent has two main properties or functions: A function of protection of innovations and a function of disclosure of the knowledge underlying the innovations. The strategic dimension of patenting only relies on the coupling of these two functions and not upon one or the other taken separately. Indeed, we show that the combination of protection and disclosure can support two different patenting logics: A logic of excludability (exploitation of a monopoly position and preservation of a minimal diffusion of knowledge), which is usually put forward by economic textbooks, and a logic of coordination (signalling of competences, transfer of licence, R&D collaboration, etc.) which until very recently was widely neglected by scholars.

Life sciences and mainly pharmaceuticals has been pointed out by most empirical studies as sectors in which a strict logic of exclusion dominates (Levin, Klevorick, Nelson and Winter, 1987; Cohen, Nelson and Walsh, 2000; Federal Trade Commission report, 2003). The pricing of medicines, for instance, reflects perfectly this logic of rent seeking, i.e. of exploitation of a commercial monopoly position. Yet, we believe that biotechnologies have

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[1] Biotechnologies companies are defined as those using modern biological techniques to develop products, services or knowledge. An indicative (but not exhaustive) list of biotechnologies is the following: DNA coding and sequencing, proteins and molecule sequencing, culture and engineering of cells and tissues, process biotechnologies (fermentation, biofiltration, bioprocessing, bioreactors, etc.), gene therapy, etc. (see the OCDE website). Domains in which those technologies may be used are essentially human healthcare, animal health, agriculture productivity, food processing, renewable resources and environmental affairs (Federal Trade Commission report, 2003).

induced some organizational ruptures in the innovation process. Due to the increasing specialization in research activities, it is now impossible for a single agent to master the complete chain of innovation, neither from a financial point of view, nor in terms of competences. The production of novelty is more and more rooted in collective processes of interactions based on moving, heterogeneous networks.

Three types of agents perform innovation within those collective, organizational devices: New Biotech Firms, Public Research Centers and Big Pharmas. In such a context, patents are crucial in order to overcome their strongly differentiated bargaining power and their diverging incentive schemes. Start-ups and small sized firms have generally no alternative means to extract a rent from their capabilities and know-how. Furthermore, considering the multiplication of the players, patents provide the opportunity to signal competences and to facilitate the valorization of complementarities, both in terms of financial and of technological resources. In this context it is therefore interesting to explore whether the emergence of biotechnologies has led to a new utilization of patents portfolios, more focused on coordination concerns.

Patenting strategies in biotechnologies are empirically explored through a study conducted by a team of the BETA within the Biovalley network. The Upper-Rhine Biovalley Association masters around 600 members in France, Germany and Switzerland. Among them, we focus especially on the 20% of firms conducting R&D activities. Information about patenting activities has been collected mainly through a postal survey. Additional, complementary information has been gathered via several extensive interviews of private and academic players of the Alsatian biotech field and via queries in patent databases. The aim of the study is to grasp the intensity and the incentives for patenting, compared to other strategies of knowledge protection and signalling. The questionnaire entails also items concerning some related activities, for instance the use of patent databases for technological survey and economic intelligence, or the role of patents in establishing collaborations. Overall, we obtained detailed information and interesting qualitative insights about 18 Biovalley companies.

The structure of this paper is the following: In the first part we explain how the theory about the role of patents has evolved from an approach that used to view patents as a way to both appropriate the return of innovation and preserve a minimal diffusion of knowledge towards a vision that regards patents as devices to ensure coordination and collaboration among actors of innovation. Then, in the second part, we present the insights brought by our

questionnaire-based inquiry in the field of biotechnology. We conclude with remarks and with suggestions for further studies.

II. From a logic of exclusion towards a logic of coordination

> "Instead of being driven by a desire to win strong legal rights to a stand alone price, these firms are driven by broader motives […] The classical role of patents seems to be dominated by this broader use of patents as "legal bargaining chips" that enable the firms to avoid being excluded in a particular field of use, to obtain more favourable terms to their licensing agreements, to safe guard against costly patent litigation or to gain access to external technologies or more favourable terms of trade"
>
> Hall and Ziedonis (2001, p. 104)

A patent has two main properties or functions: A function of protection of innovations and a function of disclosure of the knowledge underlying the innovations. In terms of protection, a patent provides its owner with an exclusive property right over his patented innovation. This protection is always accompanied by the disclosure of some information about the innovation, since a description of the patented innovation is automatically published by the patent office.

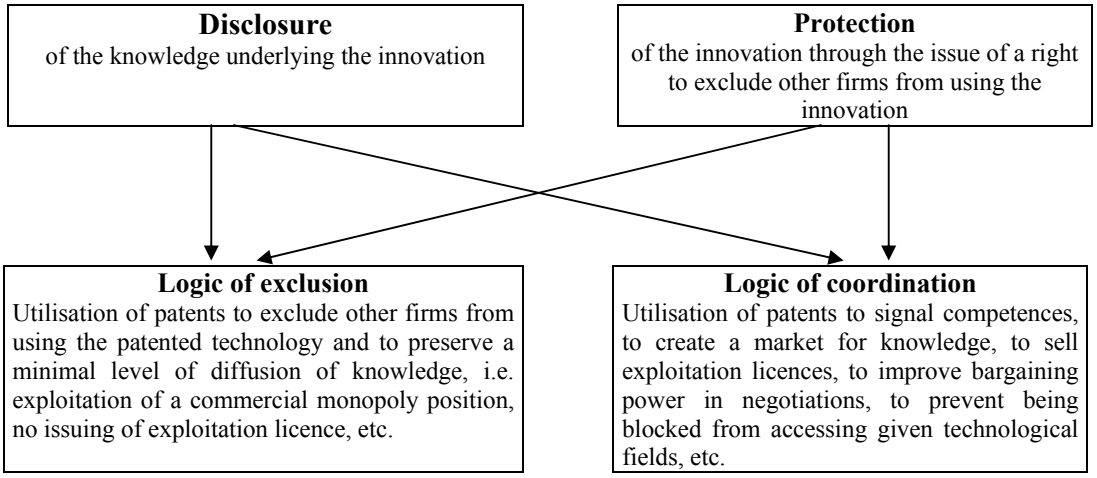
Traditionally economic scholars have been essentially interested in the monopoly power granted by a patent, i.e. in the protection function. However, we argue here that it is the combination of the two functions of a patent, the disclosure one and the protection one, that gives its strategic importance to a patent. Depending on how these two functions are tuned, they can lead to two different logics of utilisation of the patent system: A logic of exclusion or a logic of coordination. Indeed, more than a simple guarantee of a monopoly position, in some industries where innovation is strongly systemic and the risk of patent overlap is high (it is the case of the semi-conductors but also more and more of biotechnologies), patents can play a fundamental role of coordination in the innovation process, by easing the exchanges of knowledge and R&D collaborations for instance.

II.1. Protection and disclosure in a logic of exclusion

Economic scholars usually describe patents as devices that can reconcile two apparently opposite but equally necessary goals: To provide innovators with a high level of incentives to innovate and to ensure a wide dissemination of the results of their research.

Indeed, knowledge is traditionally considered as a non-rival, non-appropriable and cumulative good. On the one hand, non-appropriability is not desirable, since it decreases firms' incentives to invest in knowledge production but on the other hand, non-rivalry and cumulativeness imply that the produced knowledge must remain as much as possible non-appropriable (Arrow, 1962). A direct consequence of this dilemma is that non-market mechanisms must be implemented in order to increase both the incentives to invest in knowledge production and the dissemination of the produced knowledge. This statement is at the origin of the implementation of the patent system.

Figure V.1: Patents: A combination of two properties that can serve two different logics of utilisation



In theory, a patent ensures its owner with a monopoly position, limited in time and in space, over the applications of the patented innovation. This issue of a monopoly position aims at increasing firms' expected returns of innovation, which in turn should increase their incentives to innovate. Moreover, in theory patents ensure a wide diffusion of the knowledge (codified) underlying the patented innovation. Indeed, when firms apply for a patent they must provide a detailed description of the innovation they want to patent, which must be detailed enough to allow a person aware of the state-of-the-art to reproduce the patented innovation. Once the patent is granted, and in some countries even if the patent is not granted, this description is published, meaning that everybody has free access to it. Whether the

knowledge disclosed in patents is really valuable to other firms is not well established yet. But, at the very least, even if patents do not disclose important technical results, they still remain an indicator of which field may be worth exploring and which one may not. Such information about the map of the technological field is also quite valuable[2].

This traditional view of the patent system calls for one essential remark: It assumes that innovation and commercialisation are two distinct steps and that patents stand at the frontier between them. Firms innovate, apply for patents and then commercialise their patented innovation. Furthermore, this view also assumes that innovations are not embodied in a wider system and hence that they can easily be sold on a market. What would be the role of patents in a more complex context in which innovation is the outcome of a cumulative and interactive process and in which it is integrated within a wider system and cannot be considered independently of this system? Does the view that considers patents as providing exclusive monopoly rights of exploitation over innovations make sense in a context in which innovations are not completed and not ready to be exploited? In such a complex, systemic context the traditional view of patents may be useless.

To summarize, within a traditional framework patents are considered as major instruments of innovation policy. They restore the incentives to invest in knowledge production, since they allow to some extent the appropriation of the innovation, and they ensure the necessary dissemination of the research results, since the knowledge enabling the reproduction of the patented innovation is published.

Yet, empirical works on the topic underline contradict this classical explanation of the economic role of patents. In most industries, firms do not rely on patents to protect their inventions. This conclusion holds for many industries regarded as high-tech, such as computers and semi-conductors (chemicals and pharmaceuticals are exceptions)[3]. Moreover, this conclusion is quite robust in the sense that it is based on several empirical studies, concerning different periods, countries and industries, that all converge to similar results (Scherer *et al.*, 1959; Taylor and Silberston, 1973; Mansfield, Schwartz and Wagner, 1981; Levin *et al.*, 1987; Arundel and van de Paal, 1995; Goto and Nagata, 1996; Cohen *et al.*, 2000; Sakakibara and Branstetter, 2001). Similarly, concerning the role of patents as

[2] Patents signal to other firms the state of the art in a given technological field, they indicate the potentially fruitful domains of research that may be worth exploring and they set aside these domains from those that have already been explored. And, as David (1999) puts it, the knowledge that something can be done is itself an important step toward discovering how it may be done.

[3] It is worth mentioning that most empirical studies identify the pharmaceutical industry as an exception. In this industry patents seem essential to spur innovation and firms could hardly be innovative without the patent system (see, for instance, the report of the *Federal Trade Commission,* 2003).

knowledge carriers, empirical evidence indicate that patents do indeed convey some technical information but they nevertheless mitigate the optimistic view that patents disclose the knowledge underlying an innovation perfectly (Levin *et al.*, 1987; Jaffe, Fogarty and Banks, 1998; Jaffe, Trajtenberg and Fogarty, 2000).

To put it plainly, the logic of exclusion does not seem to be relevant in most cases. It is therefore argued in the following that patents must be understood through a logic of coordination. Indeed, the knowledge production process does not involve so much an appropriation failure than a coordination failure (Pénin, 2003a). In this context, we believe that patents can play a central role, not necessarily because they increase incentives and ensure a minimum level of diffusion of knowledge, but because they facilitate cooperation and knowledge exchanges among agents who are part of the innovation process.

II.2. Protection and disclosure in a logic of coordination

Considering patents as a means to ensure coordination among agents may help to explain a curious paradox, which was underlined by many authors (Hall and Ziedonis, 2001). On the one hand, results displayed in the previous section suggest that firms do not rely on patents in order to protect their innovations but on the other hand, the number of firms who apply for patents has sharply increased since the mid-eighties[4]. Yet, if firms do not rely heavily on patents then why are they patenting so much?

Kortum and Lerner (1999) identified and tested four assumptions that may help to explain the recent patent application surge[5]. After a thorough check they concluded that the recent patent application surge is due to a change in firms' management of their patent portfolios. It is also the conclusion we propose here: In a knowledge based economy, in which coordination problems may be more important than appropriation ones, firms may value patents not because they give them strong legal rights to exclude others but rather because they ease coordination among organizations by signalling where competences are located, by enabling firms to negotiate, etc. There are many ways through which patents may facilitate the coordination among agents involved in the innovation process:

[4] The USPTO received 60,000 patent applications in 1983 and more than 120,000 in 1999see www.uspto.gov

[5] *(i)* Their first explanation attributes the recent patent application surge to new legislations that favour patent holders and make it more profitable to patent innovations; *(ii)* The second explanation attributes this surge to the emergence of new knowledge intensive technologies such as biotechnologies and software that widened the technological opportunities set; *(iii)* The third assumption they tested ascribes the surge to incumbents' over patenting strategies aiming at increasing the barriers to potential entrants; *(iv)* Finally, the last hypothesis attributes this surge to a change in the way firms manage their patent portfolios. It is to be noted that other motives not explored by Kortum and Lerner can be added to these four reasons, such as a shift to more applied research (which could be more easily patented) or a higher R&D efficiency.

(i) Patents can help to free innovations. First, it must be stressed that firms can apply for patents merely in order to be sure that nobody will appropriate their innovations. To patent an innovation without any intention to use the exclusive property right associated with the patent is equivalent to placing this innovation into the public domain. In a sense, firms who apply for patents without any claim liberate their innovation[6].

(ii) Patents signal where competences are located. The disclosure function associated with a patent also allows signalling to industrial and scientific communities that the owner holds given competences. As argued by Mazzoleni and Nelson (1998), the focus here is on the advertising value of patents. This signalling dimension of patents enable patentees to find partners with whom to collaborate, to collect funds, to hire bright students, etc. Furthermore, patents encourage firms to publish their results in the scientific literature and, in this sense too, they help to break secrecy and to signal competences. Firms are usually reluctant to let their researchers publish before they have been granted a patent, i.e. patents, by protecting the disclosed knowledge encourage the publication of research results, which in turn also improves the coordination among agents[7].

(iii) Patents help technology trading. The existence of the patent system also plays a key role in facilitating the purchase and sale of technologies, i.e. patents contribute to the creation of a market for technology. Firms specialized in research can produce knowledge, patent their results and then sell them as licensing contracts that specify the price and the terms of the transaction. Such a market for technology could hardly emerge without the existence of the patent system since only the combination of the two properties of a patent permits it. On the one hand, the property of knowledge disclosure of patents allows firms to advertise their products and on the other hand, the exclusive right of exploitation ensured to patentees supports this disclosure by dismissing problems of free rider. Empirically, there is evidence of such markets for technology in chemicals (Arora and Fosfuri, 2000), semiconductor, biotechnologies or electronics (Arora, Fosfuri and Gambardella, 2000).

(iv) Patents as "legal bargaining chips". In many sectors firms gather strong patent portfolios mainly in order to be able to trade those patents with other patent holders (Levin *et al.*, 1987; Grindley and Teece, 1997; Cohen *et al.*, 2000). In this way patents are defensive

[6] Theoretically, one may not need to apply for a patent in order to liberate knowledge. To publish this knowledge in a scientific journal should be sufficient to prevent other firms from appropriating it. However, in practice firms may prefer to patent, although it is more expensive, because in case of litigation a patent may give them more strength than a publication in order to defend their claim in court.

[7] This point was clearly stressed in a report of the *Federal Trade Commission* (2003), which concluded that in the field of biotechnologies: "the information transfer happens in the scientific literature rather than in the patent literature, but quite a bit of the scientific literature is enabled by the fact that there has been a patent filed on it" (p. 18).

devices that aim at protecting their holders from uncertain and risky lawsuits. In sectors in which technologies are overlapping and in which innovations are most of the time incremental firms are likely to be blocked during their research by other firms' patents. Expecting such situation, firms are therefore induced to gather important patent portfolios that will serve as "legal bargaining chips" and will be traded when firms need to use technologies that are protected by patents held by other firms. To amass patent portfolios enables therefore firms who are notified that they are infringing other patents to propose cross-licensing agreements rather than engaging costly and uncertain patent litigations. Many empirical studies support this view of patents as defensive devices (Hall and Ziedonis, 2001; Lanjouw and Schankerman, 2001; Somaya, 2003; Harhoff and Reitzig, 2004). Yet, those empirical studies also suggest that in industries with simple and discrete technologies, such as pharmaceuticals, the primary role of patents remains to exclude rival firms.

(v) Patents ease collaboration among firms. More than a defensive use that aims at protecting firms' against lawsuits and at exchanging technologies through licensing agreements, patents can be used in an explicit cooperative way, in order to ease collaborations among firms. For isolated actors who need to develop collaborations with other firms, patents can be precious devices to signal competences and to bargain favourable agreements. In this respect, patents clearly play a role at an early stage of the innovation process. They are used in a perspective of knowledge creation and not only in a perspective of allocation of resources. In the process of inter-firm or inter-organisation collaborations, patents may play a role at three stages:

Before the collaboration, patents signal the competences of their holders to other firms and hence help to identify potential partners. Patents may therefore help to decrease the adverse selection problems that may impede the collaboration among different organizations (Pénin, 2003b). Furthermore, R&D cooperation is a risky process in the sense that participants must often share parts of their most important intellectual assets. Since patents protect the knowledge held by a firm from plundering by her partners, they decrease the risk of opportunistic behaviours and of hold up of competences. It follows that firms protected by patents may be more willing to be involved in R&D cooperation (Ordover, 1991).

At a later stage, patents are important devices during the negotiations aiming at setting up the terms of the collaboration. Indeed, patents are a way to assess the competences of each partner, i.e. they provide a benchmark that allows firms to compare their relative competences. Without patents firms would have difficulties to evaluate their relative competences and therefore could hardly agree on the terms of the entente. Moreover, not only

patents allow evaluating the competences of the different partners but, since they represent a credible threat to block the entente, they also allow firms to enforce their claim. In this sense patents are central devices to determine the bargaining power of each part and, as such, they can entail a distortion of the terms of the entente in favour of the firm who holds the most important patents.

After the collaboration, patents may also be used as instruments to share the outcome of the collaboration, through a joint application for instance. Hagedoorn (2003) explained that: "co-owned patents are largely the result of small scale inter-firm R&D collaborations where companies are unable to divide the invention among the partners" (2003, p. 1045). Patents may therefore encourage the collective process of innovation by facilitating the sharing of the dividends of collaborations.

Finally, patents, all along the collaboration, help the coordination between sometimes very heterogeneous actors because they represent a common language that can be understood by all of them (public labs, big multinationals, consulting agencies, financing organisations, etc). Patents are an element of culture shared by all the actors and in this sense too they may ease collaboration.

To summarize, the main reason for patenting is often triggered by other considerations than a mere appropriation and exclusion motive. The two functions of patents (protection and disclosure) can serve two very different logics: A logic of exclusion or a logic of coordination. In the remaining of the paper we investigate which logic dominates in the field of biotechnologies.

III. Patenting practices in the Upper-Rhine Biovalley

III.1. The specificities of biotechnology

In the domain of life and healthcare sciences, empirical studies carried out until very recently show that, regarding the way firms use the patent system, it is a strict logic of exclusion that dominates. In the pharmaceutical industry specifically, the propensity to patent is higher than in all the other industries (Arundel and Kabla, 1998) and patents are usually perceived as efficient to appropriate the returns of an innovation[8]. However, the technological

[8] This specificity of the pharmaceutical industry can easily be explained by its technological characteristics. The production of new drugs involves huge costs, time and important uncertainties. Yet, once a new drug is on the market its simple reproduction is very easy and cheap. This implies that incentives to invest in new drugs would be very low without non-market intervention. Furthermore, patents in the pharmaceutical industry are usually efficient to exclude potential competitors, which is often not the case in other sectors in which imitation around a patent is easy. The production of me too drugs (drugs based on different molecules, i.e. protected by different patents, but that have similar therapeutic effects) is

and organisational breakthroughs linked to the emergence of biotechnologies may bring considerable changes to these conclusions.

Biotechnologies companies strongly rely on patents[9] because they usually do not have any other tangible asset. But this does not mean that they automatically use patents in an exclusive way. Indeed, biotechnologies firms are often small companies who need to develop collaborations with other actors. Innovation in biotechnologies is typically a collective process, involving a heterogeneous network of firms and organizations (Thumm, 2001). Usually, isolated actors do not possess the financial and technological capacities required to lead a project from its beginning (basic research) to its end, which is the commercialisation of the product (Powell, 1996). Consequently, biotechnology and pharmaceutical industries experienced until the end of the 1970s an extraordinary burst of technological inter-firm collaborations, which has continued until nowadays. For instance, in 1998, collaboration agreements signed between biotechnologies and pharmaceutical companies represented approximately 30% of the total of the collaborations in all industries (Hagedoorn, 2002).

Furthermore, the academic sector and the practices related to it have a central place in the biotechnology industry. Biotechnologies companies are often founded by academic researchers who, although they enter the industrial world, keep some of their old habits and continue to publish in scientific journals, to attend conferences and to fulfil their teaching duties. The importance of the academic sector in biotechnologies, the fact that most of the basic research is still conducted by public labs must somehow influence patenting strategies. It is indeed clear that despite recent changes (the Bayh-Dole Act in the US) that allow public research to be patented, academic research is still guided by a system of open science, which relies strongly on quick knowledge disclosure, on reputation and on the validation of research by the referring by peers (Dasgupta and David, 1994). Although important pressures are exerted due, among others, to the huge financial interests at stake, many researchers from the

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difficult because the effects through which a molecule is efficient to cure a symptom remain largely unknown. After many trials firms know that a molecule has a positive effect but do not know why because the search for new molecules is made randomly, by screening, rather than rationally. This explains that, as von Hippel (1988, p. 53) puts it: "Potential imitators cannot gain much helpful insights from examining a competitor's patented product".

[9] Patents in the biotechnology industry can concern three types of innovations: One type relates to newly discovered and isolated genes or proteins or to pharmaceutical inventions based on those genes or proteins. Although one cannot patent a naturally occurring gene or protein as it exists in a plant, animal, or human, one can patent it when it has been isolated from the organism and is useful as such in that form as a pharmaceutical drug or other applications. Another class of biotechnology patents relates to methods of use of specific genes or proteins. Even if someone has already a patent on a gene, a researcher who discovers a new method for using that gene can patent the new method of use. The third class of biotechnology patent is related to research tools. A research tool is a technology that is used by pharmaceuticals or biotechnologies companies to find, refine, design and identify potential products or properties of potential drug products. As such, it serves as a springboard for follow up innovation. Users of research tools (biotechnologies firms) need to be granted a license to use the research tool but do not need to be granted a license to use the ensuing innovation (Federal Trade Commission report, 2003).

academic world are still reluctant to patent their results and to use their patent rights to prevent any research in a technological field.

Finally, the nature of the technology used may also explain why biotechnologies firms cannot exploit patents as pharmaceutical firms do. Conversely to pharmaceuticals, technology in biotechnologies is not discrete, meaning that biotechnologies firms will often need to combine several different research results, which are for most of them protected by patents. In other words, in biotechnologies, one single patent usually does not allow the production and sale of a product because it protects only a fraction of this product (for instance, a patent on a portion of a gene). All these features suggest that biotechnologies firms may seek patent protection not only to appropriate the return of their inventions but also to attract investments from capital markets and to facilitate inter-firm relationships.

III.2. The case of the Upper-Rhine Biovalley

Founded in 1996, the Upper-Rhine BioValley is a trinational network strategically located in the Upper-Rhine region, which extends over northwest Switzerland, South-Baden in Germany and Alsace in France. The network gathers approximately 600 partners subdivided according to four categories: R&D companies, service and consulting companies, supply companies and research institutions. Since we want to explore firms' patenting strategies and their effects on R&D collaborations, we focused only on R&D companies, which account for 20% of the enterprises in the network (approximately 135 companies, of which 22% are located in Switzerland, 47% in France and 31% in Germany).

We e-mailed a questionnaire, addressed either to the CEO, the R&D director or the intellectual property director of the company, to each of those 135 firms[10]. The questionnaire included three main parts: One related to general information about the firm, such as the age of the company, its activity, its type, the total number of employees, the number of employees with a PhD, the function of the respondent, etc. The second part aimed at gathering information related to firms' patenting strategy. We questioned firms about the number of patents they hold, the number of patent applications they have filed in the last three years, their main motivations for applying for a patent, the main deficiencies they attribute to the patent system, the methods they use to prevent imitation, the methods they use to signal competences and the consequences they have experienced after having been granted a patent. The third part aimed at gathering information related to firms' set of R&D collaborations and

[10] The questionnaire is available on demand to the authors. It has been written in French and in English

to the eventual role played by patents in these collaborations. Therefore, we questioned firms about the number of R&D partnerships they have been engaged in within the last three years, the types of the partnership, the types of the partner, the terms of the collaboration, and the role played by the patent system in the collaborative process.

18 firms answered the questionnaire. Most of the respondents are small (less than 50 employees) young start ups specialised in pharmaceuticals. As we can see in Table 1, which displays the general information about our sample, out of the 18 firms, 13 are start ups, 10 are located in France, 11 are specialised in pharmaceuticals and only 2 have more than 50 employees. Furthermore, it is also worth noticing that more than one half of the firms in our sample were founded within the last 6 years.

Table 1: Profile of the 18 enterprises

type	nationality	activity	number of employees	ratio phD/ employees	patent applications within the last three years	R&D collaborations within the last three years	role of patent in R&D collaborations
SME-1	France	pharmacy	1 to 10	50%	1 to 5	0	
SME-2	France	pharmacy	50 to 250	10 to 25%	>10	>5	Yes
SME-3	Germany	pharmacy	10 to 50	10 to 25%	1 to 5	>5	Yes
FIL-1	France	agriculture	10 to 50	<10%	1 to 5	1	Yes
FIL-2	France	pharmacy	>250	<10%	>10	1 to 5	No
START-1	Switzerland	expertise	1 to 10	100%	0	1 to 5	Yes
START-2	Switzerland	agro diagnostic	10 to 50	10 to 25%	0	1 to 5	Yes
START-3	Switzerland	research tools	1 to 10	>50%	1 to 5	1	Yes
START-4	France	pharmacy	10 to 50	25 to 50%	>10	>5	No
START-5	Germany	pharmacy	10 to 50	50%	1 to 5	1 to 5	Yes
START-6	Germany	not precised	1 to 10	25 to 50%	0	1 to 5	No
START-7	Germany	Bio informatics	1 to 10	not precised	1 to 5	0	
START-8	Germany	research tools	1 to 10	10 to 25%	0	1 to 5	No
START-9	France	pharmacy	10 to 50	>50%	5 to 10	>5	Yes
START-10	France	pharmacy	10 to 50	25 to 50%	1 to 5	1 to 5	No
START-11	France	pharmacy	1 to 10	100%	1 to 5	not precised	
START-12	France	pharmacy	1 to 10	50 to 100%	5 to 10	1 to 5	No
START-13	France	pharmacy	1 to 10	50%	0	1 to 5	No

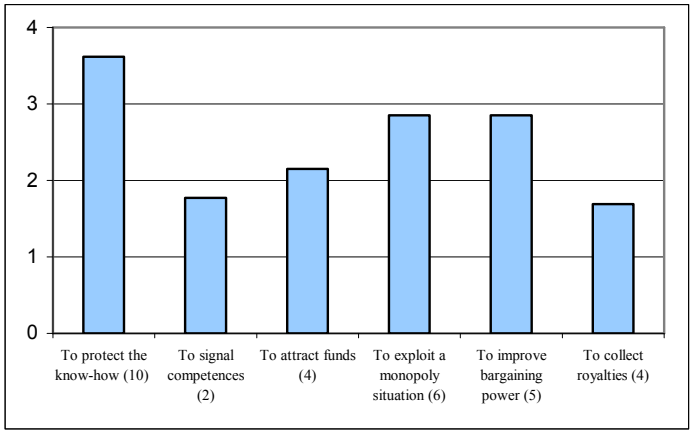
Firms in our sample all do R&D and are almost all currently engaged in patenting activities and in R&D collaborations. For 11 firms out of 18 the ratio number of employees with a PhD on the total number of employees is higher than 25%. It is lower than 10% only for 2 firms, which we interpret as a sign that firms in the sample are all currently engaged in R&D activities. Furthermore, 13 firms out of the 18 applied for at least one patent within the last three years, which means that most of the firms in our sample are actively engaged in patenting activities. This finding seems to confirm the importance of patents for biotechnologies firms. Finally, only two firms report that they were not engaged in any R&D

partnership within the last three years, which is also in line with the theoretical developments exposed earlier in the paper that biotechnologies companies are not isolated actors but are engaged in a collective process of knowledge production.

III.3. Firms' motivations for patenting

When questioned about their motivations for applying for patents, firms answer almost unanimously that, first of all, it is in order to protect their know-how from free riders. Of the 13 firms who were concerned by the question, 10 rated this motive first, indicating that it is by far the most important reason for patenting. Furthermore, on a scale from 0 to 4, the average answer is above 3.6. This finding strongly confirms the central role of the protection dimension of patents in biotechnologies.

Graph 1: Average mark given to motives to apply for a patent



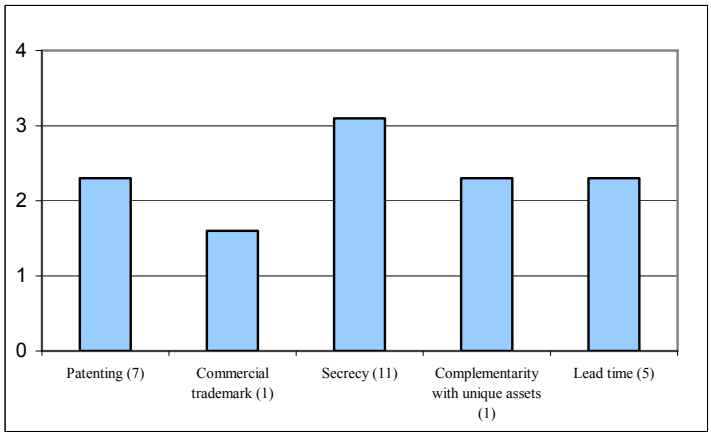
NB: *n= 13*. Only firms who had already applied for a patent were asked to answer this question. Firms were asked to give to each proposition a mark between 0 and 4. Figures in brackets beside each proposition indicate the number of time the proposition was ranked first.

However, we have seen earlier that this protection can serve two different logics, one of exclusion and one of coordination. It may hence be interesting to explore how firms use the protection provided by patents. Is this protection only aimed at excluding rivals or is it used in a more collaborative way? In this respect our results appear more contrasted. Indeed, the motives of exploiting the innovation in a monopoly position and of improving bargaining power are both ranked high with an equal average mark of 2.9. An equal number of firms (8 firms) gave a mark of 3 or 4 to these motives. Furthermore, the motive of collecting funds is

also rated rather high with an average mark of 2.2. Conversely, the motives of collecting royalties and of signalling competences are not rated high on average. Only 4 firms out of 13 consider the willingness to signal competences as an important reason for patenting (i.e. gave a mark of 3 or 4 to this item).

Graphs 2 and 3 provide further information to analyse the role of patents. Graph 2 indicates that patents are not perceived as the most efficient device to prevent imitation. Firms consider secrecy as being much more efficient than patents for this purpose. But overall patents are perceived as relatively efficient: They are ranked second with an average mark equal to that of lead-time advance and complementarities with other assets. When we compare this result with conclusions stressed by most famous innovation inquiries (Levin *et al.*, 1987; Cohen *et al.*, 2000), the importance granted to patents in our sample places it in between the pharmaceutical industry (for which patents is considered as the most efficient device to protect from imitation) and the other industries (for which patents usually come far beyond the other methods to prevent imitation).

Graph 2: Average mark given to methods to prevent imitation

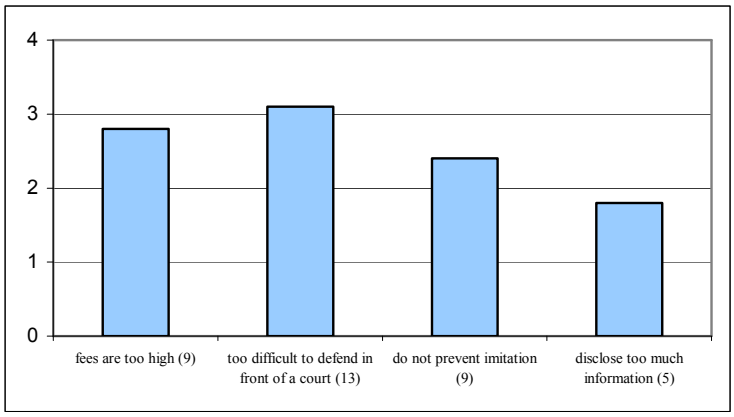


NB: *n= 18* firms. Firms were asked to give to each proposition a mark between 0 and 4. Figures in brackets beside each proposition indicate the number of time the proposition was ranked first.

Therefore, firms find patents to be a method of protection relatively efficient as compared with other means of protection. Yet, they would still like to strengthen this protection if it was possible. Indeed, figures displayed in Graph 3 indicate that firms consider the lack of protection as one of the most important problems of the patent system. Half of the firms in our sample (9 firms) consider the fact that patents do not prevent from imitation as the most important deficiency of this system. Furthermore, most firms consider that the main

deficiency of the patent system is its cost and, above all, the difficulties to defend a patent in court. This answer may be explained by the profile of the firms in our sample, constituted mainly of small firms who, for the most part of them, do not have the financial power to use the patent system in a logic of exclusion efficiently. Moreover, most firms in our sample do not consider that patents disclose too much information, which is in line with other empirical studies. This can mean, as we already explained, either that patents do not disclose key information or, if they do, that firms do not find this disclosure as being too damaging (and maybe they even appreciate it).

Graph 3: Average mark given to deficiencies of the patent system

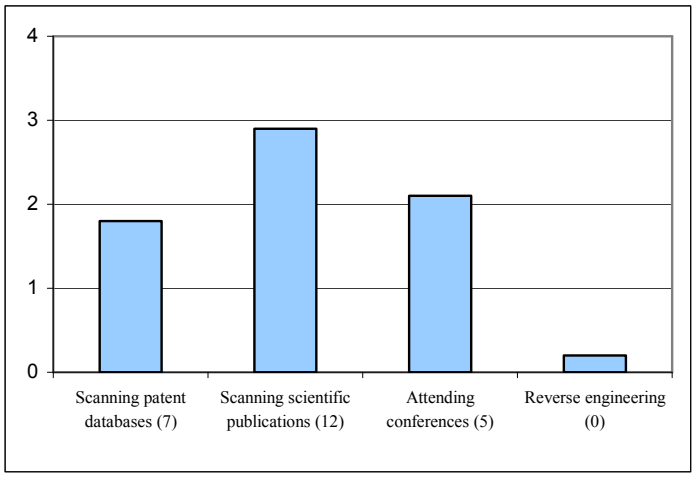


NB: *n= 18* firms. Firms were asked to give to each proposition a mark between 0 and 4. Figures in brackets beside each proposition indicate the number of time the proposition was ranked first.

Graph 4 confirms this impression. It indicates that firms' preferred strategy to achieve technological intelligence is to scan scientific publications, which obtains an average mark just below 3 and is ranked first 12 times, and to allow their researchers to participate in conferences, which obtains an average mark just above 2. To scan patent databases comes after with an average mark just below 2. However, it is interesting to observe that 7 firms ranked the scanning of patent databases first, which we interpret as an indication of the role of patents as instrument of coordination. Finally, firms do not practice reverse engineering, which may somehow be due to the fact that only few products are commercialised in the domain so far. These findings suggest therefore that patents do disclose some information but not really valuable technical results. To scan patent databases may be useful for firms in order to observe what others are doing but not to acquire complex technical knowledge. There is

indeed one major problem about the role of patents as a source of information, namely the long lag between the patent application and the disclosure of the description of the innovation. One of the firms in the sample answered that she does not scan patent databases to achieve technological intelligence because there is too important a lag between the filling of the application and the disclosure. Hence information displayed in patent description are often useless at the time they are published. This point may be specifically relevant in a sector such as biotechnology in which the technological pace is rapid[11].

Graph 4: Average mark given to methods to achieve technological intelligence



NB: *n= 18* firms. Figures in brackets beside each proposition indicate the number of time the proposition was ranked first.

To sum up, the picture rendered by the empirical study is very ambivalent: The main declared function of the patent is protection, but the declared best way to achieve protection is secrecy. It suggests that strategies of exclusion still dominate strategies of cooperation, in terms of general industrial behaviours within the Biovalley cluster. But the role of patents as collaborative instruments is profiled in the background. Indeed the protection offered by patents is often used for very different purposes: To exclude rival firms, to improve bargaining power and to attract funds more easily. In other words, biotechnologies companies do indeed use patents as coordination devices but this use has not replaced the use of patents in an exclusive way. These two logics may be complements, biotechnologies firms combining

[11] Yet this remark should also apply to scientific journals, since it is well known that the publication process is not really fast.

one with the other in a complex way. This conclusion is confirmed when looking to firms intensively engaged in collaborations, which stress the important role played by patents before, during and/or after the process of cooperation.

III.4. The role of patents in R&D collaborations

We have seen that some firms apply for patents to improve their bargaining power during negotiations with other firms, to attract funds or even sometimes to signal competences, which are signs that patents play a role of coordination in the collective process of innovation. Now we would like to explore in more depth this role, among others, by investigating at which step of an R&D collaboration patents intervene.

To investigate this point, we first questioned firms about their R&D collaborations. We can see in Table 1 that almost all firms reported that they had been engaged in R&D collaborations within the last three years. Then we asked these firms whether or not the patent system played a role at any step of their R&D collaborations. The answer was positive for more than half of them. 8 firms out of the 15 who were engaged in R&D collaborations within the last three years report that patents played a role at a given stage. This strongly suggests that, as expected, patents are important within the collaboration process.

Then we questioned these 8 firms on the nature of this role. We asked them whether or not the patent system played a role before the collaboration (if patents enabled one partner to identify the other), when firms had to define the terms of the collaboration (if patents helped to determine the term of the entente), or after the collaboration (if patents allowed a better share of the returns of the collaboration)? The answers do not enable us to pick up one stage in which patents would have played a more important role than at the other stages, although the role of patents during negotiations seem to be slightly more important than at the two other stages. Patents do play a role at the three steps of the collaboration. For instance, the fact that patents played a role before the collaboration was ranked first by 4 firms out of the 8 and obtained 4 times a mark of 3 or 4. Similarly, the fact that patents played a role after the collaboration was ranked three times first and 3 firms gave at least the mark of 3 to this proposition. Finally, the fact that patents played a role when defining the terms of the collaboration was ranked 6 times first and obtained 6 times a mark equal to or higher than 3.

These results are in line with the theoretical developments presented earlier. Patents seem to play an important role in the collaboration process by distorting the terms of the entente in favour of firms who hold central patents. Firms may therefore be induced to apply for patents just in order to obtain more favourable agreements.

Furthermore, these results give also some strength to the signalling hypothesis. Patents can sometimes play a role of signal and therefore enable firms to enter in contact with potential partners. Indeed, although firms do not regard the motive of signalling competences as a major reason for applying for a patent, some firms do apply for patents in order to signal their competences to the industrial and scientific communities (7 firms out of 13 give this reason a mark equal to or higher than 2 on a scale that goes from 0 to 4). Moreover, the importance given to patents as signaling tools increases with the size, the maturity and the level of patenting activity of the firms. It might therefore be derived that fully using the whole range of functionalities offered by patents (protection and cooperation) implies: i) a learning process in terms of strategies of codification and of disclosure of knowledge ii) important financial resources, especially in order to keep control on how competitors can use the knowledge signaled by patents.

At the very least, our inquiry allow us to stress the following point: Whereas the analysis of the role of patents within the inter-firm collaboration process is not very important in the economic literature, it seems that this question is relevant and would deserve more attention in the future.

IV. Conclusion

This paper explored the role of patents in biotechnologies. We investigated whether patents are only instruments to limit competition or whether they are also used by biotechnologies companies to facilitate coordination among agents. Indeed, whereas scholars have extensively studied the role of patents as a mean of exclusion, we claimed here that the property of coordination of patents must also be taken into consideration. In our theoretical discussion we insisted on the strategic importance of patents as tools to improve firms' bargaining power, to ease access to financing and to signal competences. We explained that it is the combination of the protection and disclosure functions of a patent that gives this instrument its strategic importance by allowing it to play a central role of coordination among the actors of innovation.

In the second part of the paper we focused on the field of biotechnologies. This enabled us to confirm the existence of a role of coordination played by patents, even though the main motive for patenting remains the protection of the firm's know-how. Yet, Biotechnologies firms in our sample report to use the protection given by a patent in two

different ways that seem equally important: To exclude rival firms and to improve bargaining power in negotiations, thus indicating that the motives of exclusion and coordination interact in a complex way. It also comes out that patents play a role at all stages of R&D collaborations between firms. A possible interpretation of those results might be that firms use patents as strategic tools devoted to different aims. One is obviously to exclude rivals and to extract rents from innovations. But in parallel patents can be seen as coordination tools, involved in the processes of diffusion and collective creation of knowledge, favoring interactions and facilitating the identification of potential partners.

Therefore, by combining the recent theoretical economic developments on the patent system with the first elements of an empirical study in the field of biotechnologies our work, although modest, provided some insights and raised interesting questions that will deserve more in depth explorations in future studies. Yet, this work is part of a wider debate about the role of the public sector and the possible changes to be brought to the patent system in life sciences. Indeed, in the current context of strengthening intellectual property rights (Coriat and Orsi, 2002; Henry, Trommetter, Tubiana, 2003) and of extending the patent domain to living organisms it is central to develop an exact vision of the role of patents in biotechnologies. Many questions regarding patents on living organisms remain unanswered so far from a legal point of view (Orsi, 2002) and before taking any decision to modify the patent legislation in this sector it would be preferable to gather a full understanding of the nature of the utilisation of patents by biotechnologies firms. Specifically, an important motive of concern is the fact that the multiplicity of patents may affect negatively the relationships between the actors of the domain (public research organisations, start ups and big-pharmas) and leads, for instance, to decreasing the rate of innovation (Heller and Eisenberg, 1998).

The central question for those who wish to foster innovation in life sciences deals therefore with the possibility to implement mechanisms in order to encourage the necessary collaborations between the actors who are part of the innovation process and to counterbalance the negative effects linked to the application of strict strategies of exclusion (Campart and Pfister, 2002; Cassier, 2002). Patents are often presented as tools dedicated to the defense of private profits. Reconsidering them as instruments of coordination allows to moderate the threat they represent towards the collective interests, and opens some promising perspectives in terms of technological policy and management of innovation.

Finally, the recognition of the twofold nature of the patent has some important policy implications. The first bears on the vital need for start ups to be accompanied and supported in the building of their intellectual property rights (IPR). Funding activities, technological

facilities, consulting services should be provided in order to improve the registering of patents by new firms. It is worthwhile to note that the implementation of such policies is not just a matter of accessibility to resources and services, but has to be designed so as to trigger learning processes related to the drafting and use of patents. The second recommendation, tightly coupled with the previous one, concerns the selection criteria of emergent projects. It underlines the need to preserve a subtle balance between favoring profitability (i.e. proper specification of property rights) on the one hand, and maintaining the scope of technological options (i.e. innovativeness) on the other hand. If priority is given, not to the most promising innovative project, but to the most strongly and clearly specified in IPR terms, then a potential danger exists to lock the region in an innovation-follower trajectory.