On the consequences of university patenting: What can we learn by asking directly academic inventors?

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Abstract

This paper examines the consequences of university patenting by using an original source of information: The point of view of French academic inventors, i.e. French university professors who are also inventors of European patents. Via a questionnaire we collected information about 280 French academic inventors. The first statistical analysis of this dataset put forward new insights with respect to the effect of university patenting on the diffusion of scientific research, incentives to do basic research, commercialization of university inventions and access to upstream knowledge. In particular, the study suggests a tradeoff between enabling the transfer of university inventions to industry and delaying the dissemination of scientific research. On the one hand, most academic inventors acknowledge a lag in their publication process directly attributable to the patent application but, on the other hand, a large majority of respondents who have had one of their inventions commercialized, believe that this would not have been the case had a patent not been there.

Keywords: University patenting, open science, intellectual property rights, technology transfer, university-industry relationships, Bayh-Dole Act.

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1. Introduction

This paper deals with the role of patents in academia. Specifically, it focuses on the consequences of university patenting on the dissemination of scientific knowledge, transfer of universities inventions to industry, access to upstream research, university-industry relationships and incentives scientists have in order to undertake basic research. Although these issues have been widely dealt with in the literature (Henderson *et al.*, 1998; Mowery *et al.*, 2001; Stephan *et al.*, 2001; Mazzoleni and Sampat, 2002; Nelson, 2004; Eisenberg, 2006; Geuna and Nesta, 2006; Sampat, 2006; Verspagen, 2006; Fabrizio, 2007; Murray and Stern, 2007), we bring new insights by using an original source of information: The point of view of French professors who have been involved as inventors in a European patent application (academic inventors in the following). Via a questionnaire, we collected information about 280 French academic inventors.

The traditional model of public research (the open science model) views universities as being devoted to provide a reservoir of public knowledge in which firms can tap to develop industrial applications. In this sense, patents had historically almost no place in the "republic of science" (Polanyi, 1962), which relied on rapid and free publications of research results (Bush, 1945; Nelson 1959; Dasgupta et David, 1994; Stephan, 1996). Yet, during the past three decades one has observed a strong and steady trend towards university patenting. If the Bayh-Dole Act[1] (1980) in the US symbolizes this rupture, nowadays this trend can be observed worldwide (Cesaroni and Piccaluga, 2002; Geuna and Nesta, 2006). Universities and public research organizations all over the world massively patent the outcome of their research.

According to USPTO statistics, US universities owned 1.1% of US owned patents issued between 1969 and 1984. Since 1984 this share has increased continuously and was equal to 4.8% in 1999 (Mazzoleni and Sampat, 2002). With respect to the number of university patents, Henderson *et al.* (1998) mention that in 1965, 28 US universities held 96 patents, while in 1992, it is almost 1500 patents that were held by about 150 US universities. This increase in university patenting has mechanically induced an augmentation of licensing of university patents[2]. Yet, Mowery *et al.* (2001) notice that most licenses granted by US universities contain somehow exclusive arrangements[3]. In parallel to this increase of patenting, US universities have also adopted a more aggressive use of their patent portfolios. Some of them do not hesitate to enforce their patents in court. Although not as aggressive as in the US yet, a similar trend can be observed in Europe. In France, most public research organizations are now engaged in an active patenting policy. In 2004 the CNRS was ranked number six with respect to French patents held by French organizations. INSERM and INRA

[1] An important literature has emerged recently around the issue of the Bayh-Dole Act and its consequences on US academic research (Mowery *et al.*, 2001; Mowery and Ziedonis, 2002; Mowery *et al.*, 2004; Sampat, 2006). It is generally agreed that although the Bayh-Dole Act has accompanied the trend, it was not the factor which triggered university patenting, since many important US universities started to patent their research in the 70s (see for instance Colyvas, 2007, for a detailed story of the Cohen-Boyer patent).

[2] An inquiry of the AUTM (Association of University Technology Managers) shows that in 1991 US universities had granted 1043 licenses to firms, while the same universities had granted more than the double (2351) in 1998.

[3] Not less than 90% of the licenses granted by University of California contained exclusive arrangements and 60% for Stanford. Similarly, the study of the AUTM shows that in 1999 50% of the licenses granted by US universities did contain exclusivity clauses. For licenses granted to start-ups this figure goes up to 90% (Mowery *et al.*, 2001).

were also ranked high (INPI, 2005). Similarly, French universities are now patenting more systematically their research (Azagra-Caro *et al.*, 2006; Carayol and Matt, 2007; Lissoni *et al.*, 2007).

Scholars have extensively discussed the effects of this trend on social welfare. On the one hand, it is argued that patenting academic invention is necessary to facilitate technology transfer and to decrease the rate of public inventions that remain on the shelves of universities (The Bay-Dole Act hypothesis). This argument relies on the assumption that universities inventions must be appropriable to induce firms to commercialise them. In the absence of property rights, universities inventions would not provide firms with any competitive advantage over their rivals, which would deter them from adopting products and processes developed within universities (Verspagen, 2006). Moreover, it is also often argued that patenting universities research is a way to close the gap between universities and corporate research. Patents would provide a common language and a common practice, which would help to develop links between universities and industry. University patents could therefore help to anchor universities within industrial networks. Finally, allowing universities to own patents may also enable them to increase their financial resources through licensing and industrial research contracts (Geuna and Nesta, 2006).

But on the other hand, university patenting can also have numerous "unintended effects" (Davis *et al.*, 2008). For instance, it is feared that it might increase the cost of accessing upstream research, decrease the incentives to do basic, non-patentable research, decrease the trust among public researchers and thus undermine the culture of open science, decrease the teaching quality of university professors, decrease the publication rate of researchers, etc. (Geuna and Nesta, 2006). Overall, it is feared that academic patents undermine the construction and availability of a platform of scientific, upstream knowledge on which applications may flourish (David, 2003; Nelson, 2004). In this sense, university patenting would seriously damage the pace of innovation in the long run.

Many empirical studies have documented some of the aspects of university patenting. There are converging results, for instance, on the fact that university patenting does not decrease the performance of researchers, measured in numbers of publications (Stephan *et al.*, 2001; Van Looy *et al.*, 2006; Carayol and Matt, 2007). It has also been demonstrated that in some specific sectors (pharmaceuticals, biotechnology) university patenting does facilitate technology transfer from university to industry. However, we lack general evidence on the social desirability of university patenting.

This paper complements the existing literature by proposing a new source of data to study the consequences of university patenting. We asked directly academic inventors. Those are indeed likely to be the best persons to know about the consequences of their patenting activities. To gather the information, we sent a questionnaire (via email) to French academic professors (not full time researchers), who had formerly been identified as inventors in a European patent application. Previous studies had identified 1228 confirmed French academic inventors (Lissoni *et al.*, 2007). Out of this number we had been able to collect 280 responses, i.e. a response rate of over 20%. This sample is reasonably representative of the mother population of confirmed French academic inventors.

The relevance of questionnaire based studies is always limited by the fact that we do not work on objective figures but on what respondents tell us. And respondents may not always tell the truth, which can lead to multiple biases in the answers. In our study we will see that most

respondents seem to be patent enthusiastic, thus exaggerating sometimes the merit of university patenting and diminishing the problems (most of the time unconsciously). Yet, in the case of university patenting, where objective figures are rare, our study has the merit of providing new and rich qualitative insights.

The first statistical analysis of the responses put forward two important results: First, university patenting induces a systematic delay in the publication process. In most cases academic researchers acknowledge a lag in their publication date directly attributable to the patent. This lag is sometimes short (less than 6 months) but in half the cases it amounts to more than one year and it can even exceed 2 years. In some extreme cases publication is not allowed at all. Some researchers also often acknowledge a control of the partner firm over the content of their publications. The second important result is in line with the spirit of the Bayh-Dole Act. It concerns the link between university patenting and the commercialization of academic inventions. Most of the researchers that are inventors of an invention that has been commercialized consider that the patent has played a central role in this commercialization. In more than half the cases they consider that, had not a patent been granted the invention would have remained on the shelves of the university. This is specifically true for pharmaceuticals, for instance, where 100% of the respondents considered that their invention would not have been transferred without the patent. With respect to the consequences of university patenting, our study suggests therefore a trade-off between easing the commercialisation of university inventions and delaying the dissemination of public knowledge.

Section 2 provides a description of our sample and compares it with the mother population of confirmed French academic inventors. Section 3 displays general results about the motivations to patent, the perception of university patenting by academic inventors and the practices of French universities with respect to patenting activities. In section 4 we develop the key findings of the study. We analyse the direct effects of university patents on the dissemination of scientific research, the transfer of university inventions to industry, the access to academic inventions, the culture of open science and the agenda of scientific research.

2. Description of the sample and representativeness

Via a questionnaire we gathered information about 280 French academic inventors[4]. This sample stems from a wider population of French academic inventors identified in a previous study (Lissoni *et al.*, 2007). By French academic inventors we mean French university scientists (i.e. Maître de Conférences [equivalent to associate professors] and University professors) active in a French university in 2004 and mentioned as inventor in at least one European patent applied for after 1993. Within a European project entitled KEINS[5], we were able to identify 1228 confirmed French academic inventors, by matching the European Patent Office (EPO) database of inventors since 1993 with the database of French university

[4] The questionnaire is available on request to the author. It contained 16 questions and was voluntarily kept short in order to increase the response rate. Questions included the following points: In how many priority patents is the professor mentioned as inventor? Who generally is the owner of the patent? What is the policy of the lab in terms of patent? What was the motivation to patent? What direct consequences, either positive or negative, have been experienced? What is the point of view of the researcher about academic patenting?, etc. Furthermore, we are able to cross this information with the scientific discipline of the researcher, his university, his gender and his age.

[5] KEINS is the acronym of "Knowledge based Entrepreneurship: Innovation Networks and Systems".

professors active in 2004. Those are confirmed academic inventors since they were all joined by telephone or email and they all confirmed being both university professors and mentioned as inventor in a European patent. This population of academic inventors amounts to 3.84% of the total population of French university scientists (Maîtres de Conférences plus University Professors) in the corresponding scientific disciplines (Lissoni *et al.*, 2007).

Out of these 1228 confirmed French academic inventors, we were able to send a questionnaire via email to 1122. For the remaining 106 scientists we were not able to find their email addresses. Moreover 104 email addresses proved to be invalid and 6 respondents answered that they were not concerned by our study, since they were inventors in a European patent before entering academia. Finally, the effective targeted population amounts to 1012 French academic inventors. Out of these 1012 inventors we collected 280 answers, which amount to a response rate of 27.7%.

Table 2.1: From the population of French academic inventors to our sample

French academic inventors identified by Lissoni *et al.* (2007)	1228
No email addresses	- 106
Invalid email addresses	- 104
Not concerned	- 6
French academic inventors who received a questionnaire	1012
Responses collected	280
Response rate: - 27.7% of the scientists to which the questionnaire was sent - 22.8% of the mother population of all the confirmed French academic inventors	

Tables 2.2, 2.3 and 2.4 give the profiles of the respondents according to their age, gender, academic ranking and scientific disciplines. It also provides similar information for the mother population, which enables us to analyze the representativeness of our sample. The statistics computed for the mother population are based on the 1228 confirmed French academic inventors identified by Lissoni *et al.* (2007).

Table 2.2: Distribution by age

Respondents			**Mother population**		
Age	**Number**	**%**	**Age**	**number**	**%**
More than 65	17	6.1%	More than 65	150	12.2%
60-64	49	17.6%	60-64	258	21%
55-59	43	15.5%	55-59	183	14.9%
50-54	36	12.9%	50-54	148	12.1%
45-49	52	18.7%	45-49	183	14.9%
40-44	48	17.3%	40-44	205	16.7%
35-39	29	10.4%	35-39	90	7.3%
30-34	4	1.4%	30-34	11	0.9%
Total	**278**	**100%**	**Total**	**1228**	**100%**

Note: Based on 278 respondents. For 2 respondents we have not been able to collect the information.

Table 2.3: Distribution by gender and academic ranking

		Respondents		Mother population	
		Number	**%**	**Number**	**%**
Gender	Male	250	89.3%	1110	90.4%
	Female	30	10.7%	118	9.6%
Academic Ranking	MCF	119	42.8%	443	36.1%
	PU	159	57.2%	785	63.9%

Note: Based on a total of 280 respondents for the gender and 278 respondents for academic ranking.
MCF=Maître de Conférences; PU=University Professor.

Table 2.4: Distribution by scientific discipline

	Respondents		Mother population	
DISCIPLINES	**Number of respondents**	**%**	**Number of academic inventors**	**%**
Biological sciences (CNU sections 64 to 69)	**44**	**15.8%**	**165**	**13.4%**
including Biochemistry and molecular biology	17	6.1%	66	5.4%
Cellular biology	12	4.3%	45	3.7%
Chemical sciences (CNU sections 31, 32, 33)	**78**	**28.1%**	**284**	**23.1%**
including Theoretical, physical, analytical chemistry	12	4.3%	50	4.1%
Organic, mineral, industrial chemistry	41	14.7%	140	11.4%
Chemistry of materials	25	9%	94	7.7%
Electronics (CNU section63)	**45**	**16.2%**	**169**	**13.8%**
Medical sciences (CNU sections 43 to 59)	**29**	**10.4%**	**235**	**19.1%**
Pharmaceuticals and drugs (CNU sections 39, 40, 41)	**27**	**9.7%**	**109**	**8.9%**
including Sciences physiquo-chemical and pharmaceutical technologies	12	4.3%	44	3.6%
Drug sciences	11	4%	51	4.2%
Engineering (CNU sections 60, 61, 62)	**37**	**13.3%**	**153**	**12.5%**
including IT engineering and signal treatment	15	5.4%	49	4%
Energy, process engineering	16	5.8%	69	5.6%
Others	**18**	**6.5%**	**113**	**9.2%**
including Materials	10	3.6%	45	3.7%
Total	**278**	**100%**	**1228**	**100%**

Note: Based on 278 respondents. For 2 respondents we have not been able to collect the information.

With respect to the representativeness of our sample, we can outline the following points:

- A huge majority of respondents are males (89.3%), which is in line with the mother population, since about 90% of French confirmed academic inventors are males.
- There is an over-representation of Maîtres de Conférences in our sample (and therefore an under representation of University professors). This is likely to be correlated with the age variable since most of the time Maîtres de Conférences are younger than University Professors.
- There is an under-representation of aged academic inventors (over 60) (23.7% in the sample of respondents vs. 33.2% in the mother population). This feature of the sample

may induce a bias since it is likely that old and young scientists do not have the same experiences and opinions about university patenting.

- There is an under-representation of medical sciences in the sample (10.4% in our sample vs. 19.1% in the mother population) and an over-representation of chemical scientists (28.1% vs. 23.1%). The under-representation of medical scientists can probably be explained by the difficulty to reach them. They are usually scientists working full time in hospitals and most of the time we did not have their direct email addresses but the one of their secretaries'.

Overall, notwithstanding the differences between our sample and the mother population (especially with respect to the age variable), it is not undue to consider our sample as being reasonably representative of the population of confirmed French academic inventors.

The issue of multiple patents and the interpretation of the responses

Before turning to the analysis of the answers and to the interpretation of our findings, it is important to keep the following point in mind. Most academic inventors in our sample are inventors of more than one patent. 80% of our respondents answer that they are inventors in more than one priority patent. Yet, for simplicity's sake and in order to facilitate the treatment of the answers, in many questions we asked respondents to give only one answer. However, it is likely that for those inventors who have been involved in many patent applications, there is not one single appropriate answer because each patent application has its own context and story. Many respondents expressed therefore their frustration of not being allowed to give several answers and considered this as a serious limitation of the questionnaire. For those questions the figure presented here must therefore be considered as being the "average" answer; the one that best takes into consideration all the contexts of the different patent applications.

3. Patent practices, motivations to patent and perception of university patents

3.1 Patent practices in academia

The first part of the questionnaire aimed at evaluating the current practices of universities with respect to patenting activities. To do so, we asked a bundle of questions related to the frequency of patent applications, the usual owner of the patent, the interactions with patent advisors and the follow-up of the patent within the years following the application. Results are displayed in Tables 3.1, 3.2 and 3.3.

Table 3.1: Patent policy of French universities

Question: In your research lab, do you apply systematically for patents when your research allows it? (only one possible answer)	Number of respondents	%
Yes, as soon as an invention is patentable we systematically apply for a patent	99	35.9%
No, we apply occasionally for patents but do not have a policy of systematic application	128	46.4%
No, a patent application remains an exceptional event	49	17.8%
Total	276	100%

NOTE: 276 responses to this question

Most public research centers do now apply regularly for patents in order to valorize their inventions. Table 3.1 indicates that only 17.8% of the respondents consider that a patent

application remains an exceptional event. Furthermore, 35.9% of the respondents consider that their research lab has a policy of systematic patenting of the research. This is especially true in the field of pharmaceuticals and drugs, where 55% of the respondents consider that their lab has a policy of systematic patenting of inventions, and less relevant in the case of electronics and engineering sciences, where only 16% of respondents consider that their lab has adopted a policy of systematic patenting of inventions.

A second point related to patent practices deals with the procedure of writing the patent. Patenting follows a complex procedure and it is likely to take time for new players such as universities to reach the level of expertise of already experienced firms (Mowery *et al.*, 2002; Colyvas, 2007). To test the degree of maturity of universities we asked two questions about the links between inventors and lawyers in charge of writing the patent and about the feedbacks inventors receive on the future of their patent. It is usually considered as a necessary condition to write a good patent that all the inventors have in depth interactions and discussions with the lawyer in charge of the writing. With respect to this criterion, only 17.2% of the respondents confess that they have never communicated with their patent lawyers. If one takes into account that some of the respondents are likely to be secondary inventors, thus less directly concerned by the writing, it seems that French universities are not far from good practices in the process of patent writing. Yet, this is less true when one considers the return of information to inventors about the status of the patent (grant, opposition, license, etc). 41.7% of inventors say that they never received any updating of information concerning the patent.

Table 3.2: Patent practices in French universities: interaction with patent lawyers

Question: During the procedure of patent application, did you interact with the lawyer who was in charge of writing the application? (only one possible answer)	Number of respondents	%
Yes, via physical exchanges and regular meetings	167	60.9%
Yes, via mail, emails and telephone but no physical meeting	60	21.9%
No, I have never communicated with the patent advisor	47	17.2%
Total	274	100%

NOTE: 274 responses to this question

Table 3.3: Patent practices in French universities information on the future of the patent

Question: Do you receive regularly information about the status of the patent (grant, litigation, licenses, etc.)? (only one possible answer)	Number of respondents	%
Yes	161	58.3%
No	115	41.7%
Total	276	100%

NOTE: 276 responses to this question

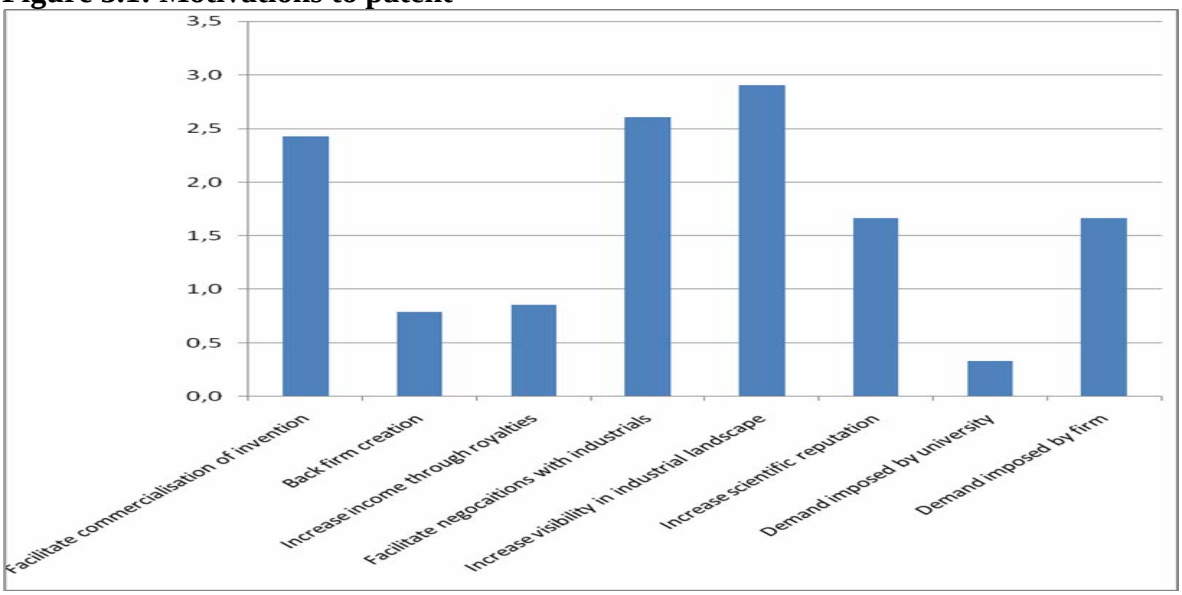
3.2 Motivations to patent: Why do scientists engage in patenting activities?

An important question deals with the motivations that led scientists to engage in patenting activities. To understand what induces scientists to become academic inventors, we listed possible motivations and asked respondents to give a mark on a Likert scale according to the importance of the motivation: 0 for a motivation not important at all and 5 for a very important motivation. Results are displayed in Figure 3.1, which shows the average mark given to each listed motivation. It should be noticed that those average results may be biased

downwards because in the absence of mark for a given motivation we assigned a 0 to this motivation[6].

Overall, it appears that the most important reasons that induce scientists to engage in patent applications deal with the willingness to get closer to industry. The statements "to improve their visibility in the industrial landscape", "to facilitate the negotiations of contracts and partnerships with industrials" and "to ease the commercialization of their inventions" obtain indeed the highest average lists.

Figure 3.1: Motivations to patent



NOTE: 273 responses to this question. Respondents were asked to give a mark on a Likert scale from 0 to 5 to each motivation according to its degree of importance: 0=not important at all; 5=very important. Results displayed are the average mark obtained for each motivation. In the absence of mark for a motivation we assigned a 0 to it.

These results are confirmed when one looks at the number of times a motivation was given a 5 (i.e. the maximum mark). The willingness "to facilitate the commercialization of inventions" received 89 times a 5, followed by the willingness "to improve their visibility in the industrial landscape" (84 times). Conversely, the willingness "to ease the creation of a start-up" (31 times) and the willingness "to increase income through royalties" (only 15 times) are ranked very low. Surprisingly, the fact that the application "was imposed by the partner firm" received 62 times the maximum mark, suggesting therefore that in many cases researchers are just forced to enter into the patenting process.

These results tend to confirm that academic inventors are most of all driven by non-pecuniary considerations. For sure, they would not refuse an increase in their salaries if there was an opportunity, but most of them are well aware of the limiting direct remunerating possibility offered by patents. Yet, this does not mean that patents cannot be rewarding, at least indirectly. By increasing the visibility of scientists, by improving their bargaining power, patents can be a powerful lever to collect corporate funds to undertake academic research and to negotiate industrial partnerships. In this way, patents can improve the conditions to do

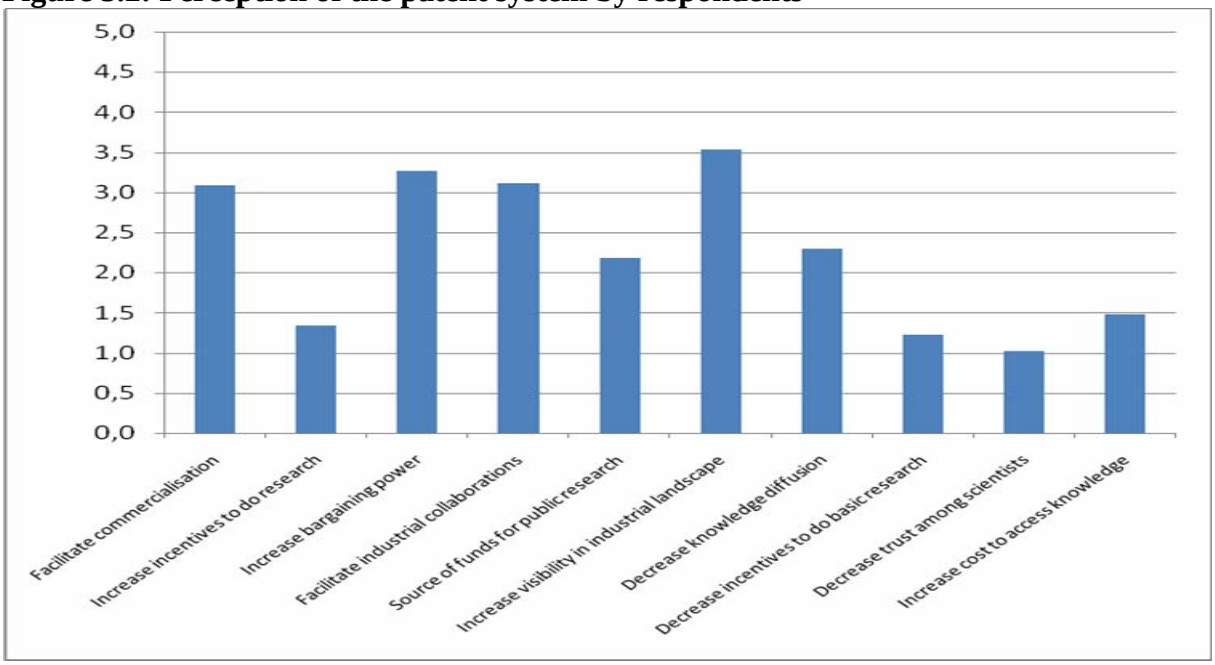
[6] This point was clearly stated in the questionnaire. Yet, probably due to lack of time some respondents still gave a mark only to one or two motivations out of the 8 motivations that were listed and left a blank for all the others. We therefore assigned a 0 for all the motivations that were not marked although it is likely that in the mind of the respondents they may have been ranked differently.

research. Many scientists, specifically in chemical sciences and in pharmaceuticals are also well aware that patents are often a necessary step to ease the corporate use of their inventions.

3.3 The points of view of the respondents about university patenting

The last question of the questionnaire aimed at collecting the perception of academic inventors about the desirability of patents in science. The question was deliberately subjective in the sense that we did not ask respondents to answer according to their experiences or to objective facts but merely to give their opinions. We provided several statements such as "patenting public research facilitates their commercialisation" or "patenting public research increases the cost to access scientific knowledge", and we asked respondents to give a mark on a Likert scale to the statement according to their degree of agreement: 0 if they totally disagree and 5 if they totally agree. We proposed two types of statements: Either very positive for academic patenting (statements from 1 to 6) or rather negative (statements from 7 to 10). Average marks are displayed in Figure 3.2. Similarly to Figure 3.1, raw figures must be interpreted with care, since we assigned a 0 when there was a blank, which can bias some answers downwards.

Figure 3.2: Perception of the patent system by respondents



Note: 278 responses. Respondents were asked to give a mark on a Likert scale from 0 to 5 to each statement according to their degree of agreement: 0=full disagreement; 5=full agreement. Results displayed are the average mark obtained for each statement. In absence of mark for a statement we assigned a 0 to it.

Four statements are given an average mark higher than 3: "patenting public research facilitates their commercialisation and their industrialisation" (average mark of 3.1), "patenting public research increases the bargaining power of universities in front of industrialists" (average mark of 3.3), "patenting public research facilitates the development of collaborations between public research centres and firms" (average mark of 3.1) and "patenting public research increases the visibility and credibility of scientists in the industrial landscape" (average mark of 3.5). All these statements are rather in favour of university patents.

Conversely, the statement "patenting public research allows financing university research" was ranked low with an average mark equal to 2.2, which tends to indicate that scientists are

not fooled by the financial perspective of university patents. This confirms the result obtained in Figure 3.1, in which the perspective to increase earning is ranked very low as a motivation to patent. Similarly, the statements "patenting public research increases the cost to access scientific knowledge", "patenting public research reduces trust and therefore diminishes interactions and collaborations among scientists" and "patenting public research decreases incentives to do basic, non-patentable research" are all ranked very low by the respondents with an average mark respectively equal to 1.5, 1 and 1.2.

To sum up, respondents have a rather positive, and sometimes enthusiastic, image of university patenting. Most of the positive statements are given an average mark higher than the negative statements. The only negative proposition that is not ranked very low is that "patenting public research slows down the diffusion of university research" with an average mark of 2.2. This feature must be kept in mind when analysing certain results of our questionnaire. It is likely that some answers are biased due to the very positive image the majority of respondents have about university patents. This possible bias is unfortunately a recurrent shortcoming of questionnaire based methodologies and is not specific to our study.

4. Consequences of university patenting: Key findings

The theoretical analysis has raised many important questions with regard to the consequences academic patenting may have on the functioning of science. This section aims at presenting the insights brought by our study concerning the main issues: The dissemination of academic knowledge, the commercialization of academic inventions, university-industry relationships, the culture of open science, the choice of their research agenda by scientists, the access to academic knowledge, etc.

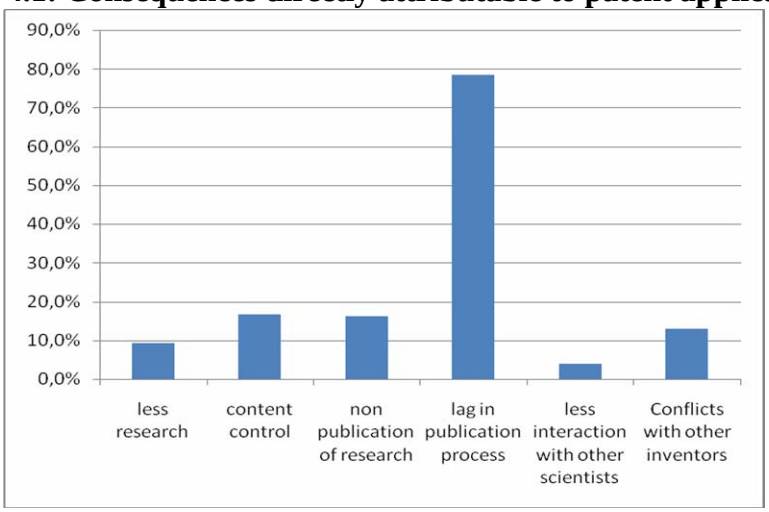
4.1 University patenting and the dissemination of academic knowledge

The impact of university patenting on the diffusion of academic knowledge is still unclear. Most econometric studies show that patents and publication are complement rather than substitutes, i.e. scientists who patent the most are also those who publish the most. Van Looy *et al.* (2006) even find that academic patenting may reinforce the publication activity of scientists. This result can be interpreted, with all the necessary reservations, as evidence that academic patenting does not reduce the dissemination of academic research, as long as one accepts to measure the latter by the number of scientific publications. But, on the other hand, the limited qualitative evidence that exist suggests that patents may delay the publication process. On the basis of a questionnaire, Webster and Packer (1997) conclude that university patenting can compromise the dissemination of academic research. Similarly, a report of the European Commission (2002) directly addresses the question of the publication delay attributable to university patenting. Results show that a majority of respondents acknowledged to some extent a publication delay (see Geuna and Nesta, 2006, for an interpretation and a criticism of the finding of the EC report).

While not denying the complementarity between patents and publications, our work suggests that patents systematically induce a lag in the publication process. In a huge majority of cases the patent application forces researchers to postpone their publications in order to proceed to the patent application. More precisely, 218 scientists out of 278 respondents (78%) acknowledge a lag in the publication process directly attributable to the patent application. Furthermore, 46 scientists out of 278 respondents (17%) acknowledge a control over the content of their publications by a partner firm, which has the right to deny the publication or

to modify the content. 45 scientists out of 278 respondents (16%) also acknowledge that the patent application led to the non publication of their research (Figure 4.1).

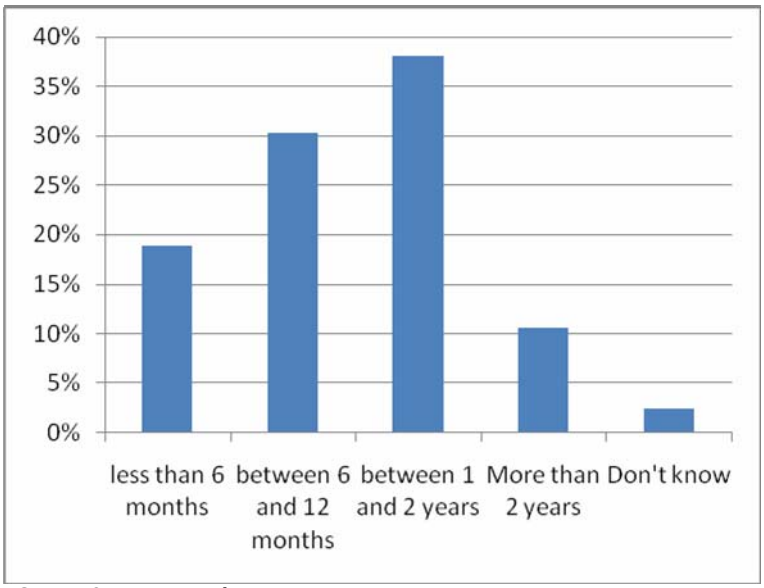
Figure 4.1: Consequences directly attributable to patent application



NOTE: 278 responses to this question.

Moreover, out of the 218 academic inventors that have acknowledged a lag in their publication process, about one half (106, which amounts to 49% of the respondents who acknowledge a delay and to 38.1% of the respondents to the question) state that this delay exceeded 1 year (Figure 4.2).

Figure 4.2: Estimated lag in publication date directly attributable to the patent application



NOTE: 218 responses to this question.

The length of the lag does not seem to be discipline specific. When one considers the scientists who acknowledge a lag superior to 1 year, the distribution of these scientists over scientific disciplines is quite homogeneous. Within each discipline, the ratio of scientists who acknowledge a lag superior to 1 year over the total number of respondents goes from 35% in engineering sciences, chemical sciences and electronics to 45% in medical sciences and biology (for the total sample of respondents this ratio is 38,1%). The difference between disciplines, if it exists, is therefore quite limited.

These findings clearly suggest that university patent may impede seriously the diffusion of scientific knowledge. It may affect the speed of the diffusion as well as the content of publications[7]. This finding is confirmed by the perception of university patent by respondents. The proposition "patenting public research slows down the diffusion of university research" received an average mark of 2.2 on a scale from 0 to 5. This is the higher mark given by respondents for a negative point of university patents (Figure 3.2).

4.2 University patenting and the commercialization of academic inventions

An important consequence of academic patenting deals with the transfer of university inventions to industry. This is the so-called Bayh-Dole hypothesis, named after the Bayh-Dole Act (1980) in the US. According to Senators Bayh and Dole, the two initiators of this law, allowing universities to patent their inventions should increase technology transfer and industrial exploitation of academic research. Without patents, many inventions developed in academia would remain on the shelves of the university because "what is available to everybody is of interest to no one" (Mazzoleni and Sampat, 2002, p. 237)[8]. Firms have no incentives to commercialize inventions from universities, to undertake important investments to bring them to the market if, once this is done, they cannot appropriate the invention. Patents give an element of exclusivity over the invention and should therefore facilitate its commercialization (Verspagen, 2006). The work of Jensen and Thursby (2001) excepted, we lack empirical test of this Bayh-Dole hypothesis. Our study attempts to fill this gap.

Table 4.1: The effect of university patents on the corporate exploitation of university research

Question: If your patented invention has been commercialized or industrialized, did the patent play a role within this technology transfer? (only one possible answer)	Number of respondents	%
Yes, without the patent application the invention would not have been exploited	62	54%
Yes, without the patent application the invention would have been exploited but the patent has facilitated this exploitation	28	25%
No, no role at all	8	7%
I don't know	16	14%
Total	114	100%

Note: 114 responses to this question. This amounts to the academic inventors of an invention that has been industrialized or commercialized (42%). The remaining 58% did not experience the commercialization or industrialization of any of their patented inventions.

42% of the respondents (114 out of the 270 respondents to this question) stated that one of their patented inventions had been industrialized or commercialized by a firm.
Out of these 114 respondents, more than one half considered that the patent played a fundamental role in the process of transferring the technology. More precisely, 54% answered

[7] Yet, this finding must be taken carefully since one of the primary goals of patents is also to help knowledge dissemination. For instance, one of the respondents mentioned that: "In the field of chemical sciences, a patent is a genuine publication. Some of my patents in the past have not been followed by publications in scientific journals because they were so complete that a publication would not have helped to diffuse more knowledge […] 95% of the content of publications in scientific journals could not have been patented, not due to the lack of industrial application, which is the argument usually put forward, but due to a lack of real novelty". This comment was corroborated by many other scientists with whom we had the chance to talk.

[8] This argument derives from a statement of a pioneer academic inventor, the chemist F.G. Cottrell who said in 1912: "what is everybody's business is nobody's business" (Sampat, 2006).

that without the patent application their invention would not have been exploited (see Table 4.1). Furthermore, 25% considered that although their invention would have been exploited should a patent not have been applied for, the patent application helped the commercialization or the industrialization of the invention. Overall three quarters of the respondents consider therefore that patents played a positive role for the industrial exploitation of university research and only 7% think that the fact that their invention was patented did not play any role to help the transfer of the invention.

Table 4.2: Distribution by scientific disciplines of scientists who consider that their invention would not have been exploited should a patent not have been granted

	Number of 'yes'	% of 'yes'	Number of invention exploited	Ratio 'Yes' over number of invention exploited	Total number of respondents	Ratio of 'yes' over number of respondents
Biological sciences	14	25.9%	19	73.7%	44	13.6%
Chemical sciences	15	27.8%	34	44.1%	78	23.1%
Electronics	7	13%	16	43.8%	45	20.0%
Medical sciences	8	14.8%	14	57.1%	29	10.3%
Pharmaceuticals and drugs	11	20.4%	11	100%	27	33.3%
Engineering	4	7.4%	14	28.1%	37	13.5%
Others	3	5.6%	6	50%	18	22.2%
Total	62	100%	114		278	

This issue of the corporate exploitation of university research is very discipline sensitive. Table 4.2 shows the results displayed by sectors. The first column indicates the number of respondents who considered that their invention would not have been exploited by a firm without a patent. Then, we divided this number by the total number of respondents who said that one of their inventions had been exploited by a firm. The result is displayed in the fourth column. This ratio is particularly high for biology and pharmaceuticals. With regard to the former, according to the respondents three quarters of the inventions exploited in industry would have remained on the shelves of university without patents. This ratio goes up to 100% in pharmaceuticals and drugs. This means that according to the respondents, in this sector all the academic inventions that have been transferred to the industry would have remained on the shelves of the university had they not been patented. This is a well known specificity of the pharmaceutical industry, where patents are essential to ensure the development of new drugs (Mansfield, 1986; Levin *et al.*, 1987; Cohen *et al.*, 2000)[9]. The ratio is much lower in engineering sciences, where almost three quarters of the commercialized inventions would have been transferred even without patents.

To sum up, our work brings new insights with regard to the Bayh-Dole hypothesis, which assumes that patenting university research helps the commercialization and use of these researches in industry. This hypothesis seems to be especially relevant in life science sectors such as biology, pharmaceuticals and medical sciences, but less so in engineering.

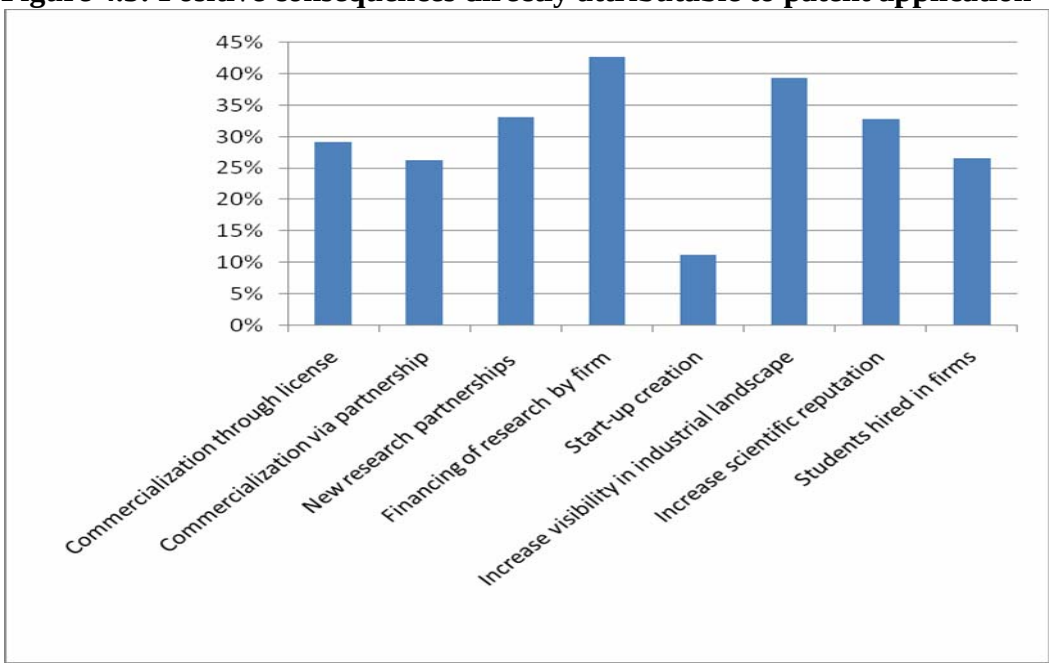
4.3. University patenting and university-industry relationships

Related to this issue of corporate use of academic inventions, it is often argued that letting university patent their research may help to improve relationships between universities and

[9] For instance, Sampat (2006, p. 773) asserts that: "Patents and licenses are considerably more important channels in pharmaceuticals that in other industries".

industry. University patents would be a way to help university researchers going out of their "ivory tower" and getting closer to the "kingdom of industry". University patents would ensure that academic scientists share norms similar to those of corporate scientists, which could only improve the links between the two worlds. To explore this hypothesis, we provided respondents with a list of possible consequences directly attributable to the patent application and we asked them to indicate all those that they experienced. Results are displayed in Figure 4.3.

Figure 4.3: Positive consequences directly attributable to patent application



NOTE: 274 responses to this question.

43% of the respondents mention that their participation in a patent application led to the financing of a part of their research by a firm. This finding is very important and must not be neglected by policy makers when evaluating the efficiency of university patents. For instance, it is not because a patent does not yield royalties to a university that it was not worth applying for. The subject is much more complex than usually believed. There are many ways through which a patent held by a university can increase or decrease welfare. Evaluation of university patents must carefully consider all the indirect costs and benefits of those patents.

39% of the respondents also mention that the patent application helped to increase their visibility and their credibility in the industrial landscape; 33% consider that it helped to establish new research partnerships with firms or other public labs; 33% also consider that it increased their scientific reputation, which raises again the question of the place of patents in the scientific evaluation of public researchers; 29% acknowledge that the patent led to commercializing the invention through a license and 26% through a partnership with a firm; Finally, 11% of the respondents mention that the patent led to the creation of a new venture.

Overall these answers suggest that patents may be an important element to anchor universities within industrial partnerships and networks. This is confirmed by the motivations of scientists to apply for patents (Figure 3.1). The most important reasons to apply for patents are "to improve their visibility in the industrial landscape", "to facilitate the negotiations of contracts and partnerships with industrials" and "to ease the commercialization of their inventions". In a sense, this means that academic scientists apply for patents in order to get closer to industry,

to improve links with corporate scientists. This is also confirmed by the opinion of academic inventors about university patents (Figure 3.2). In their vast majority, respondents consider that university patent is a device that can improve university-industry relationships.

4.4 University patenting and the "open science" culture

One possible consequence of the rise of patents within academia is to diminish the interactions between scientists, thus decreasing the efficiency of scientific communities. Here, university patenting would threaten the culture of open science at its heart. Since around a patent there may be important amounts of money at stake, or at least since scientists may believe that there are important amounts of money, university patenting may decrease the willingness of scientists to share their results and research materials. In this sense, scientists may become more "selfish" and less willing to collaborate and to help colleagues. Yet, as asserted by Verspagen (2006, p. 616), open science "works in an atmosphere of openness and sharing of knowledge, data and research results. It is exactly this open nature of the scientific process that is responsible for much of its success […] Patents may turn this open culture into a more closed one".

Only a very low proportion of respondents consider that their participation in a patent application decreased the rate of their interactions with the rest of the scientific community (Figure 4.1). Only 11 scientists out of 278 respondents (4%) consider this to be true. The fact that academic patenting does not seem to affect significantly interactions among researchers also emerges when one asks researchers directly about their perception of university patents. The proposition "Patenting academic research decreases trust and diminishes interactions among scientists" is ranked very low. It received only an average mark of 1 on a Likert scale from 0 to 5. This is the lowest average mark given to a proposition, which means that respondents mostly disagree with this statement (Figure 3.2). Yet, according to Figure 4.1, 36 scientists out of 278 respondents (13%) confess that their participation in a patent has somehow triggered some conflicts with other members of the scientific community or with industrial partners. This last finding suggests therefore that patents are not always neutral and that they can be a potential source of tension within scientific communities, decreasing the necessary trust to foster collective research.

Table 4.3: Perception of academic inventors by scientific colleagues

Question: How was your participation to a patent application perceived by your scientific colleagues? (only one possible answer)	Number of respondents	%
Rather positive image	148	53%
Indifference	77	28%
Rather negative image	15	5%
I don't know	38	14%
Total	278	100%

Note: 278 responses to this question

Furthermore, within the academic community patents are surrounded by ideological considerations, which lead an important part of the community to reject them. Minds are evolving but slowly, and it is still frequent to hear academic inventors complaining about the low consideration that their colleagues give to their patent attempt. In this sense, scientists who apply for patents may be ostracized within scientific communities, thus also decreasing the rate of exchanges and interactions among communities. Our study does not provide evidence to sustain this hypothesis. Most scientists think that their patent application was

positively considered by their scientific colleagues (53%). Only 15 inventors out of the 278 respondents (5%) think that their implication in a patent application was badly perceived within their scientific environment (Table 4.3).

4.5 University patenting and incentives to do basic research

Patents reward applied research. Theoretically basic research cannot be patented[10] since, by definition, they consist of research undertaken without any application in mind, while an invention must have an industrial application in order to be patentable. It is therefore possible that the possibility to patent university research induces an eviction effect of basic research in favor of more applied research. Since the latter becomes more rewarded, scientists may prefer to engage more resources to do applied, patentable research and less to undertake basic, non patentable research. This eviction effect could seriously damage long term growth rate, since a platform of good basic research is a necessary springboard to foster long run economic growth.

This problem is part of a wider issue in economics of science which is the "problem of problem choice" (Carayol and Dalle, 2007), i.e. the choice by scientists of their research agenda. One of the pillars of the "the republic of science" is that scientists must be free to choose the problem they want. To ensure the efficiency of the process, no central regulator should oblige scientists to work on some specific topic (Polanyi, 1962). Yet, another pillar of the "republic of science" is that scientists decide their research agenda according to the effect on their reputation. This induces scientists to choose not the more remunerating problems to solve but the ones that will increase their reputation, i.e. the more challenging from an intellectual point of view. This, in turn, intends to encourage scientists to devote time and resources to undertake basic research, which is highly valued by the scientific community, and less time and resource to undertake applied research, less valued by the community. Hence, the "republic of science", although likely to do it imperfectly, ensures that scientists have incentives to do basic research although this kind of research yields weak monetary benefits. By introducing patents within the "republic of science", one may reduce those incentives and increase incentives to do applied research.

If we measure the outcome of basic research by the number of publications (which is a poor proxy but also the only serious one that exists) the existence of such an eviction effect is rejected. As already mentioned above, researchers and labs who patent the most are also those who publish the most, which tends to indicate that researchers who are engaged in patentable activities do not do less basic research. Yet, the few questionnaire based studies that exist tend to confirm the risk of an eviction effect. Gulbrandsen and Smeby (2005) found, for instance, that in Norway professors who have links with industry tend to describe their research as more applied (see also Geuna and Nesta, 2006).

Our study provides a new element in this debate. We asked academic inventors whether or not the possibility to be granted patents had any influence over their research agenda. Results are displayed in Table 4.4. Almost 20% of the respondents acknowledged that they tend to orient their research in areas where they know they will be able to get patents. This may indeed suggest that, at least for some researchers, the possibility to get patents encourages them to do less basic research and more applied research. Furthermore, consequences of academic patenting on the nature of academic research are very sector specific. Table 4.5 shows that this issue may be specifically relevant in chemical sciences and in pharmaceuticals and drugs.

[10] This is less and less true in some scientific disciplines where the frontier between applied and basic research is blurred (In genomic for instance).

Table 4.4: Influence of university patents over scientists' research agenda

Question: Did the possibility to be granted patents influence the nature of your research? (only one possible answer)	Number of respondents	%
Yes, I try to orient my research in fields where I know it will be possible to apply for patents	54	19.4%
No	215	77.3%
I don't know	9	3.3%
Total	278	100%

Note: 278 responses to this question. We voluntarily did not use the words "applied research" and "basic research" in this question in order to dismiss any misunderstanding from respondents.

Table 4.5: Distribution by scientific disciplines of scientists who acknowledge orienting their research towards patentable activities

	'yes', patents influence research agenda	% of 'yes'	Number of respondents	Ratio of 'yes' over number of respondents
Biological sciences	6	11.1%	44	13.6%
Chemical sciences	18	33.3%	78	23.1%
Electronics	9	16.7%	45	20.0%
Medical sciences	3	5.6%	29	10.3%
Pharmaceuticals and drugs	9	16.7%	27	33.3%
Engineering	5	9.3%	37	13.5%
Others	4	7.4%	18	22.2%
Total	54	100%	278	

Yet, we must be cautious with this interpretation since, as noticed by some respondents, behind patent application there is very often an important amount of basic research. Another finding urges us to interpret this finding carefully: When researchers are asked whether or not university patents "decrease incentives to do basic research" they almost unanimously disagree with this statement. It is granted an average mark of 1.2 on a scale from 0 to 5, which is among the lowest mark given to the 10 listed statements (Figure 3.2). This may suggest that whereas some researchers indeed decide their research agenda according to patent possibility, they do not consider that this induces a reduction of their activity in basic research. Again, a possible explanation is a reduction of the frontier between basic and applied research in some technological fields.

Related to the question of the effect of academic patenting on the research agenda of scientists, 26 respondents (9,4%) also considered that the patent application led them to reduce the amount of time spent to do research (see Figure 4.1). Although we did not ask researchers to explain this reduction of their activity of research, open comments made by some respondents suggest that this is mainly due to the administrative burden and to the necessity to follow the invention after it has been patented (bargaining with industrialists, time spent to explain the invention, etc.).

4.6 University patenting and access to upstream research

A central issue with respect to university patenting, and more generally with respect to the patenting of any upstream research, deals with the availability and the condition of access to academic research. Since innovation is somehow a cumulative process, knowledge is an input

in the process of producing knowledge, which means that it is highly important to preserve as large as possible an access to existing knowledge in order to foster the production of further inventions. This is the basic argument that underlies the existence of the "republic of science", which is based on a quick and free release of scientific knowledge through publications.

Yet, patenting university research gives automatically an element of control to these researches, which may decrease their availability to other researchers. It is feared here that patents might increase the price of access to university inventions, thus decreasing their availability to build on and impeding the cumulative process of knowledge production. In fields where many patents are granted, such as biotechnology and electronics, some authors warn against the risks induced by a "patent thickets" (Shapiro, 2001), by the emergence of a potential "tragedy of the anticommons" (Heller and Eisenberg, 1998) or by a "privatization of the commons" (Nelson, 2004). All these expressions suggest that the proliferation of patents in some specific fields may increase the cost of accessing knowledge and of doing science, which in turn would reduce research in these fields.

With respect to the access to scientific knowledge by academic scientists, another potential damage caused by university patenting was raised by Eisenberg (2003), who analyzed the recent rejection by the CAFC in the US of an "experimental use defense" or a "research exception" to Duke University[11]. Historically, and even in the States, academic researchers have always been considered as being unconcerned by patent infringements. As long as their research was undertaken for non-profit motives, for purpose of "idle curiosity" or "philosophical inquiry", they could use patent held by others without having to ask for permission and without having to pay royalties. Yet, this situation may change as shown by the recent Madey vs. Duke decision, which "did not extinguish the experimental use defense entirely, but eviscerated it to the point that it is essentially useless to research universities" (Eisenberg, 2003, p. 1019).

Yet, this decision is in a sense a direct consequence of university patenting. Now that universities are using their patent portfolios more and more aggressively, one may indeed expect to see firms trying to secure their patents and starting to sue universities for patent infringements. By patenting massively and by using their patent portfolios aggressively, universities become a normal player in the patent game and there is no reason to grant them a "research exception" or an "experimental use defense". This unanticipated consequence of university patenting may seriously damage scientific research, which is inherently a cumulative process in which scientists need to reuse pieces of knowledge invented by others.

Recent studies in the field of biomedical sciences do not find that patents may impede access to upstream research. They rather put forward other impediments such as control over materials necessary to do research or secrecy. Following Cohen and Walsh (2008) 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, Walsh *et al.* (2007, p. 1184) found that "access to knowledge inputs is largely unaffected by patents". Out of the 381 academic scientists they 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

[11] *Madey* v. *Duke University*, 307 F.3d 1351 (3 October 2002).

confer “practical excludability” in academic research sittings” (Cohen and Walsh, 2008, p. 13)[12].

Our results are not as optimistic as Cohen and Walsh’s. We find that a significant share of scientists acknowledge having been obliged to reorient their research due to patent problems. Almost one quarter of the respondents (68, which represents 24% of respondents) acknowledge having been obliged to change their research agenda to get round patents held by other inventors. Moreover, 14% of the respondents also confess having already been involved at least once in a patent litigation. These results are displayed in Table 4.6 and 4.7.

Table 4.6: Access to upstream research

Question: Have you already been disturbed in your research by patents held by other inventors?	Number of respondents	%
Yes, I have already been obliged to reorient my research in order to get round a patent held by another inventor	66	24%
Yes, my lab has already been obliged to buy licenses to other inventors in order to be allowed to pursue research in a given technological domain	2	0.7%
No	207	75.3%
Total	275	100%

Note: 275 responses to this question.

Table 4.7: Academic inventors involved in patent litigations

Question: Have you already been implied in a patent litigation (Trial, etc.)?	Number of respondents	%
Yes	39	14%
No	240	86%
Total	279	100%

Note: 279 responses to this question.

Again, the issue of patents as impeding access to existing knowledge is very sector specific. Table 4.8 indicates that this question is particularly relevant in electronics and pharmaceutical and drugs, while it is less important in Biology. In this latter field we find nevertheless that 15.9% of respondents acknowledge having been obliged to reorient their research in order not to infringe patents held by others. In electronics this shares goes up to 33.3% and in pharmaceuticals up to 37%.

Overall, these results suggest that patents may in some cases be serious impediments to upstream research. This stands in sharp contrast with the work of Cohen and Walsh in the field of biomedical sciences. Yet, respondents in our sample do not seem to worry too much about the consequences of university patenting on the access to existing inventions. The statement “patents increase the cost of access to existing knowledge” was ranked quite low with an average mark of 1.5 on a Likert scale from 0 to 5 (Figure 3.2).

[12] In the case of biomedical science, the authors argue that 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, proteins, 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 requests to other colleagues that have been denied.

Table 4.8: Distribution by scientific discipline of scientists involved in patent litigation and disturbed in their research by patents held by other inventors

	'yes', reorientation of research (1)	Number of Respondents (2)	(1) over (2)	'yes', involved in patent litigation (3)	(3) over (2)
Biological sciences	7	44	15.9%	5	11.4%
Chemical sciences	21	78	26.9%	11	14.1%
Electronics	15	45	33.3%	6	13.3%
Medical sciences	6	29	20.7%	5	17.2%
Pharmaceuticals and drugs	10	27	37%	5	18.5%
Engineering	8	37	21.6%	1	2.7%
Others	1	18	5.6%	6	33.3%
Total	68	278		39	

5. Conclusion

This paper used a new source of information to explore the consequences of university patenting. Via a questionnaire we asked questions directly to academic inventors, i.e. to scientists who have been involved in patenting activities. Those are indeed the best persons to know about the effects their patents have had on their research and publication activities, the commercialization of their inventions, the granting of funds, etc. Overall we collected information on 280 academic inventors. Of course, like all questionnaire based studies, results must be taken with care due to multiple possible biases. Our results are not based on perfectly objective facts but on what respondents have told us. Yet, in the case of university patenting, where objective figures are rare, this nevertheless allows us to provide a rich bundle of new insights. Relying on this original and, to our knowledge, unique dataset our work outlines the following results:

- University patenting almost systematically induces a lag in the publication of academic research. About 80% of the respondents acknowledge a delay in their publication directly attributable to the patenting process. Furthermore in half the cases this lag is longer than 1 year. Some respondents also explain that their patenting activities led to a control by industrial partners over the content of their publication.
- University patenting can be helpful to transfer inventions from universities to industry (the so-called Bayh-Dole Hypothesis). About 40% of the respondents say that one of their inventions has been used by a firm. More than half of these respondents who have experienced technology transfer also think that the transfer would not have been realized without the existence of the patent. Patents are specifically helpful to enable the transfer of university inventions to industry in fields such as pharmaceuticals and biology.
- Our study provides only limited evidence with respect to the effect of university patent on interactions and exchanges within the scientific community. Yet, the little evidence we have suggests that university patenting does not seem to interfere too much with the open science culture. For instance, a huge majority of respondents think that their patenting activity is rather well perceived by their colleagues.
- University patenting can increase the cost of accessing upstream research and can block research in some technological fields. About 25% of the respondents confess

that they have already been obliged to re-orient their research because of risks of infringements.

- University patenting can in some cases lead to a modification of the research agenda of scientists and encourage some of them to do more applied, patentable research and less basic, non-patentable research. 20% of the respondents acknowledge that university patents affect their research agenda. More specifically, the possibility to be granted patents induces them to undertake research in patentable areas rather than in non-patentable areas. Yet, this result must be taken with care since patentable research may not necessarily be done to the detriment of basic research.

The purpose of this paper was to display the first descriptive statistics of our questionnaire based study on the consequences of university patenting. These raw statistics provide very interesting and new insights. Yet, more work still needs to be done in order to obtain more robust results. An econometric analysis should allow us to deepen the analysis. This may enable for instance, to study the links between scientific disciplines and the consequences of university patenting, or between the age of the respondents and the motivations to patent.

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