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Auteurs

Antonio Della Malva, Francesco Lissoni, Patrick Llerena

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Faculté des sciences économiques et de gestion
Pôle européen de gestion et d'économie (PEGE)
61 avenue de la Forêt Noire
F-67085 Strasbourg Cedex

Secétariat du BETA
Géraldine Manderscheidt
Tél. : (33) 03 90 24 20 69
Fax : (33) 03 90 24 20 70
manderscheidt@cournot.u–strasbg.fr
http://cournot2.u–strasbg.fr/beta

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
Nancy-Université
Université Nancy 2
UNIVERSITÉ LOUIS PASTEUR STRASBOURG

Institutional Change and Academic Patenting: French Universities and the Innovation Act of the 1999

Antonio Della Malva*, Francesco Lissoni†, Patrick Llerena‡

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* Maastricht University (The Netherlands)

† CESPRI, Universitá Luigi Bocconi, Milan (Italy)

‡ BETA, Universitè Louis Pasteur, Strasbourg (France)

Abstract

Recent empirical work in the field of university-industry technology transfer has stressed the importance of IPR-related reforms and university patenting has major forces behind the success of US high-tech industry. European policy-makers have been tempted to explain the poorer technological performance of their countries with the lower propensity of their academic institutions to get engaged in patenting and commercializing their research results. As a consequence, a number of measures have been taken to promote academic awareness of IPRs, as part of more comprehensive policies in favour of academic commercialization and entrepreneurship.

This paper explores university patenting, and the related policies, in France. We provide evidence that university patenting in that countries has been underestimated by policy-makers' perceptions: French academic scientists are in fact responsible for no less than 3% of patents by French inventors at the European Patent Office. However, only 10% of academic-invented patents are owned by domestic universities, with the remainder assigned both to firms and to Public Research Organizations (PROs).

We then explore the impact of the Innovation Act, passed in France in 1999. We find that the Act has significantly increased the likelihood an academic patent to be assigned to a university rather than to a business company. We also find, that the opening of a technology transfer office in a university appears to have a stronger and more significant impact than the Act on the decision of universities to retain IPRs over their scientists' discoveries.

JEL Classification: L31, O31, O34.

* Corresponding author: pllerena@cournot.u-strasbg.fr

1. Introduction

National governments have increasingly considered academic institutions as key drivers of economic growth. In Europe several initiatives have been taken in order to strengthen the links between the Academia and the Industry and to increase technology transfer efforts by academic institutions and faculty members. Many of those initiatives have touched upon intellectual property rights (IPRs) legislation and its relationship to university policy ranging from the abolition of the professor's privilege in Germany, Austria and Denmark, to various initiatives to obtain more patenting disclosures and entrepreneurial initiative by the university faculties (OECD, 2003; Mowery and Sampat, 2005).

These IPR-related reforms have been mainly informed by the US experience, where universities have always been a major actor in the national system of innovation, one whose contribution to inventing and patenting has been recognized as central by a number of reforms introduced in the early 1980s..

The reforms have also relied on the assumption that encouraging patenting of inventions stemming from academic research may enhance the universities' contribution to innovation and economic growth. To the extent that inventions stemming from academic research mostly appears as prototypes and proofs of concepts, they need further investments to be commercialized; as a consequence, the argument goes, they need strong IPR protection in order to set the proper economic incentives in place to induce industrial partners to pay for exclusive licenses and undertake expensive development investments1.

Recent studies have shown European policy-makers, by imitating US policies, may have failed to pay proper attention to the legal and institutional differences between European (especially Continental) universities and US ones. In particular, too much attention has been paid on patents owned by universities (university-owned patents) as opposed to patents covering inventions by academic scientists, and assigned not only to universities, but also to the same scientists, public research organization or business companies (university-invented patents; surveys by Geuna and Nesta, 2006, and Verspagen, 2006).

Recent studies have proved that common statistics on university-owned patents, which are most often called in to support the above-mentioned policy initiatives, underestimate drastically the patenting activity by academics, and the under-estimation is much more severe for Europe than for the US. Lissoni et al. (2008) suggest that university-owned patents in France, Italy and Sweden are no more than 11% of all university-invented patents (69% in the US), as opposed to 60%-80% business-owned patents (25% in the US).

In this work we build upon Lissoni et al. (2008) in order to assess the impact of IPR-related reforms in terms of patent ownership. In particular, we explore the consequences of the introduction, in France, of the Innovation Act in France, in 1999. Among other things, the Innovation Act promoted a more aggressive patenting activity by French universities. In particular, we test whether the Innovation Act has significantly increased the likelihood of a patent to be assigned to a university rather than to a business company or a public research organization. We also assess, in the same respect, the effect of a university establishing its first technology transfer office.

The study is organized as follows. In section 2 we provide a brief review of the IPR-related reforms of university policies introduced in France over the past 10 years, with special emphasis on the Loi Allegre and some comparisons with similar policies in the US and Europe. In section 3 and 4 we present the data and the econometric model used to examine the effect of the new law.. Section 5 contains the discussion of our results. Section 6 concludes, and outlines our directions for further research.

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[1] The evolution of patenting activity by US universities has been investigated, among others, by Henderson et al. (1998), Jensen and Thursby (2001), and Mowery et al. (2004).

2. IPR-related reforms of university policy

Nowadays the importance of the role the universities and public research organizations (PROs) have in producing, exploiting and commercializing technological applications based on knowledge stemming out of their research facilities is diffusely recognized.

2.1 The international experience

The USA was the first country to reconsider the role of universities and to amend a set of reforms aimed at improving the integration of these organizations in the national system of innovation. This process of reform began in the late '70s and saw its realization in the 1980, with the introduction of Public Law 96-517, better known as Bayh-Dole Act. The Act, among other things, allows universities to retain intellectual property rights over the inventions resulting from federally funded research, and establishes the government's march-in right, that is the right to arrange for licensing of patents left unexploited by academic administrations. This legal initiative was meant to provide a unique set of rules for universities that, until then, had to cope with several funding agencies (NIH, DoD, NASA, NSF, etc.), each of which with different policies in terms of IPRs assignment (Mowery et al. 2001). It was also meant to provide universities with both stick and carrot incentives to commercialize their inventions (as a matter of fact, the stick, that is the march-in right, was hardly, if ever , used). More generally Bayh-Dole Act belonged to a wave of policies aimed at reinforcing the IPR regime in the USA, such as the extension of patentable matters to living organisms and to software, two fields where the academic contribution to invention stands out as prominent (Kortum and Lerner, 1999; Jaffe, 2000).

After the passage of the Act, the number of patents issued to universities increased tremendously, from 264 in 1979 to 2436 in 1997 (NSF, 2006), representing now 5% of the total of patents issued to US assignees. In addition, the number of universities with a technology transfer office has grown from 150 in 1991 to 400 in 1997 (AUTM, 2004).

The context for academic patenting in Europe differs from the US case. The British government was the first to emulate the US initiative: it introduced in 1985 the right for universities to patent and to commercialize the results of their own faculty. Previously, the British Technology Group, a public agency, had the exclusivity on the inventions by academics (Clarke, 1995).

Shortly after, at a time of constant or decreasing level of public financing of universities in Continental Europe, the latter were encouraged (or took the initiative) to look at markets for technologies as an complementary funding source (Geuna, 2001)[2]. Such strategic reorientation was accompanied in some countries by sets of reforms in IP laws, which allowed the granting of intellectual property rights to universities. Between 2000 and 2002 Germany, Austria, Denmark passed a set of reforms on the ownership of the results stemming out of the research conducted at universities: they abolished the so-called professor's privilege, which allowed professors to retain IPRs over their research results and not to leave them to the employer (the university in this case)[3]. On the other hand, Italy introduced the professor's privilege in 2001 and slightly modified in 2005[4].

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[2] In Europe the system of government structural funds has been partially replaced by a more competitive manner of financing the public research system: indeed, since the late 1980s, the subvention of universities has relied more and more on problem-oriented and industry-oriented public programs rather than on public budgetary channels. This switch in sources of funds could be considered as the result of the shrinking of the public research budgets and the change in the rationale for science support occurred in Europe.

[3] National IP Laws state that the employers own the IPRs of the results from research conducted by employees.

[4] From 2005 the professor's privilege is not applied whenever the patent is the result of research financed by a non-academic organization. In this case the owners of the patent are the university and the non-academic organization.

2.2 The French experience

In the case of France, the interest of government in a more participative role by the public research system had its roots in the 1970s and saw its early realization at the beginning of the 1980s, when the government led by François Mitterand passed the Research Act (Loi d'Orientation et de Programmation) which introduced the valorization of the results of research and its diffusion (art. 14, Public Law 82-610). The same indications were extended to universities two years later (Public Law 84-52). Indeed, the French public research system has been often criticized to be unable to transfer the excellent results of research to the industry. It has been longly characterized by a strong intervention of the central government, which, through the large programmes, indicated and promoted the national independence of some strategic sectors such as electronics, defense and nuclear technologies. These programmes were put in practice by ad hoc agencies (CEA for atomic energy, INRA for agricultural research, CNES for telecommunication), which were under the direct control of the government. Besides these research agencies, the CNRS (National Scientific Bureau) and INSERM (National Institute of Health) were created with the target of supporting the weak and unstructured academic system, which had mainly tasks of teaching, and had the responsibility to develop, orient and coordinate all scientific activities in France.

In the mid 1990s the government was still concerned about the cooperation and the knowledge transfer between PROs and the Industry. Several consultations and proposals (Fillon in 1994 and d'Aubert in 1997) led to the approval of the Public Law 99-597, also known as Innovation Act. This piece of legislation has been profoundly influenced by the Guillaume report in 1998, which stressed the barriers that hampered the flow of knowledge between public research and industry. Briefly the Guillame Report suggested to adapt the public research system to the issues of technology transfer and to simplify the institutional context in which it would occur. It proposed a clear IPRs policy in public research institutions, the creation of specific entities devoted to manage industrial relationships, more researchers' mobility and a set of measures to foster firms' creations by researchers.

Thus, the Innovation Act cannot be reduced to a change in the IP Law, nor it contains specific provisions on the matter. Rather, it aims, among other things, at increasing the awareness toward IPRs among the public research system and to facilitate their commercialization. It completes the 1982 and 1984 acts by explicitly adding among the missions of such organizations the commercial exploitation of patents and licenses (art. 1, IV comma for PROs and art. 2, IV comma for universities). It also regulates the creation of technology transfer offices (TTOs), in order to administer research contracts with industrial partners (art. 2, I comma for universities).

2.3 The Innovation Law in perspective: a short note on French universities

In order to appreciate the full extent of the institutional differences between the US universities (to which most available studies on university patenting refer) and the French ones, we find it useful to provide a few historical and institutional information on the latter.

Differently from their US counterparts (but also from the British or the Dutch), French universities have always struggled to establish themselves as central actors in the public research systems, let alone to gain the necessary autonomy to the purpose. After all existing universities had been closed under the Revolutionary regime at the end of the XVIII century, a new university (one for the entire country) was established by Napoleon at the beginning of the XIX. Under the name of Imperial University, the latter had exclusively teaching tasks, for the provision of medical doctors, teachers and lawyers[5]. Such university was organized in regional faculties under tight State's control along rigid disciplinary lines. It was only in 1896 the regional faculties gained the status of local universities and acquired some prominence in research. Still, research activities were conducted in small personal laboratories by a professor with a few assistants, and these laboratories constituted the body of academic R&D. The professors responsible for these specialized laboratories negotiated directly with external partners to raise extra funds to carry on research projects (e.g. Pasteur in Lille). Those labs had limited chances to grow due the lack of autonomy of the universities that hosted them; in fact, it was only in the 1970s that universities gained some rights to self organize their activities (but not yet any freedom in terms of finance and real estate management, or faculty recruitment and career management).

The responsibility of research, in France, has been traditionally assigned to specialized public institutes, often created around a new discipline or mission. In 1939 the Centre national de la recherche scientifique (CNRS) was established with the expressed goal of supporting academic research and/or performing research through its own labs. During the 1960s both demographic factors and a call for democratisation of education took to a massive enrolment to universities which caused the isolation of larger and better endowed laboratories from teaching; in the meanwhile the CNRS and INSERM (the National Institute of Health) established a system of partnership between universities personnel and its research groups, on the basis of a periodic evaluation by its committees. This kind of mechanism, which has been extended over time, has led on one hand to split the academic environment between teaching vs. research departments, and, on the other hand, to the integration of the agencies personnel in university research groups: larger and better connected laboratories received financial and material assistance from CNRS and INSERM. Thus a vertical hierarchy of labs exists: those staffed only by CNRS personnel and funded directly by CNRS and the Ministry of Education; those staffed by both CNRS and university personnel; and finally those exclusively staffed by university personnel, with no to little access to CNRS funds (Laredo and Mustar, 2001). In the last decade the whole system has witnessed several changes: the number of faculty members increased to more than 50000 researchers, whereas the totality of PROs employs less than 35000. As a matter of comparison, during the 1970s the sole CNRS had as many researchers as the entire university system. Moreover, a second trait of the academic system, the elite educational mission of the grandes écoles and its separation from research, seems to be disappeared. As Laredo and Mustar (2001) state, one out of five Ph.D. theses across all disciplines is produced in the research centres of these schools, even though they only account for 6% of all teacher researchers.

These historical remarks have a number of implications for our study. They suggest that the Innovation Act is one of many steps taken in France to promote more autonomy for universities, and less dependence on CNRS and INSERM. Therefore we test whether its introduction helped universities to retain the property a higher share of university-invented patents, in particular by subtracting them to the exclusive control of large PROs. In the same perspective, we do not expect universities to have gained IPR control at the expenses of business companies, whose cooperation was possibly made easier by the Act.

3. Data

[5] Besides universities, higher education is the task of the Grandes Ecoles, which enjoy more prestige than universities and take care of the formation of the technical and administrative elites, with very limited involvement in research activities (Chesnais, 1993).

The core data employed in this study come from the KEINS database, which is part of a broader database, EPO-INV database[6]. The French KEINS database on academic inventors provides detailed information on faculty members in France who appear to be among the inventors of one or more patents applied for at EPO – European Patent Office – between 1994 and 2002. It is the result of the match of the names of scientists and engineers with tenured positions[7] in 2005 with names of inventors of EPO patents. The faculty name were provided by BETA (Bureau d'Economie Théorique et Appliquée), a research unit of Université "Louis Pasteur" in Strasbourg, contains Ministerial records for both medical and non medical disciplines (32006 associate professors and full professors in hard science disciplines).
In order to obtain the KEINS database, we firstly matched inventors from the EP-INV database with professors in the national list of professors, by name and surname; we then filtered out incongruous inventor-professor matches by employing "age" and "discipline" filters. The "age filter" implied that by the moment of the first patent claim by a "suspected" matched professor, the latter was older than 21. The "discipline filter" was based on a list of incompatible disciplines and IPC 3-digit codes.
After matching the two databases, and obtaining pairs of professor-inventor, we checked for homonymy by contacting the professor-inventor matches by e-mail or by telephone. Given the large numbers of professor-inventor pairs, we chose to focus only on those pairs wherein the inventor's last patent had been filed after 1993, since we considered them more likely to be still active and reachable. This choice left us with 3951 inventor-professor pairs 'To be checked'. For 2400 pairs information was collected either through direct contact or by examining the professors' CV (when available), her publications and/or the patent applicants' websites (2400); for 484, the required information was provided by their academic co-inventors. For 1067 pairs, corresponding to 587 professors no information was available, nor the professors ever answered to our e-mails or telephone calls[8].
More than 1700 patent applications have 1208 French faculty active in 2005 among the inventors. They respectively represent 3.27% of all French patents and 2.33% of domestic inventors. Most of the patents are in the fields of Instruments, Chemistry and Pharmaceuticals, respectively 20.07%, 25% and 28.5%. Their authors come mainly from academic disciplines related to the life sciences and electronics.

Table 3.1: French academic patenting activity between 1994 and 2002

	Patents	Number of Inventors	Patent Productivity
Total Inventors	53285	51839	1,028
Academic Inventors	1744	1208	1,444
Share of Accademia	3,27%	2,33%	

6 Lissoni et al. (2006) describe in detail the methodology of patent classification for inventors of the EP-INV database and the methodology applied to construct the KEINS database on academic inventors.
7 By tenured position, we refer to all "maitre de conferénce" and "professeur"
8 Additional information on the universities employing our academic inventors was collected from the database of CURIE, the French network of technology transfer offices.

Table 3.2: Distribution of academic patents in DT-7/OST technology classification

	PATENTS				INVENTORS			
TECHNOLOGY CLASSES	Total A	%	Academia B	%	Total C	Academia D	B/A	D/C
ELECTRONICS	12991	24,38%	251	14,39%	14448	218	1,93%	1,51%
INSTRUMENTS	6823	12,80%	350	20,07%	9189	341	5,13%	3,71%
CHEMISTRY	6729	12,63%	436	25,00%	8951	343	6,48%	3,83%
PHARMACEUTICALS	5363	10,06%	497	28,50%	6352	399	9,27%	6,28%
PROCESS ENGINEERING	6784	12,73%	138	7,91%	7941	145	2,03%	1,83%
MACHINERY AND TRANSPORT	9431	17,70%	58	3,33%	10456	44	0,61%	0,42%
OTHERS	5164	9,69%	14	0,80%	4889	11	0,27%	0,22%
TOTAL	53285	100,00%	1744		62226	1501		

As explained by Lissoni et al. (2008), these values do not differ much from those of Italy and Sweden. These findings are in line with Owen-Smith and Powell (2001), who found that universities with medical schools and school of engineering are the most likely to conduct patentable research.

Table 3.3: Distribution of academic patents by aggregated disciplines

AGGREGATED DISCIPLINES	Patents (X)	Inventors (Y)	Professors (Z)	Y/Z	X/Y	% Patents
MATHEMATICS	72	35	6270	0.56%	2,06	3.77%
PHISICS	125	67	2660	2.52%	1,87	6.54%
CHEMISTRY	545	321	3829	8.38%	1,7	28.50%
EARTH SCIENCES	2	1	1090	0.09%	2	0.10%
BIOLOGY	356	228	5445	4.19%	1,56	18.62%
LIFE SCIENCE	397	246	6181	3.98%	1,61	20.76%
ENGINEERING	32	31	2052	1.51%	1,03	1.67%
ELECTRONICS	383	279	4324	6.45%	1,37	20.03%
ALL DISCIPLINES	1912	1208	31851	3.79%	1,58	100.00%

The patents are more than the actual number since inventors from different disciplines appeared in the same patents.

Assignees of university-invented patents can be classified in three categories:

- Companies (C), which include not only business companies, but also individual and foreign assignees;
- Institutions (INST), such as domestic PROs, known in France as Etablissements Public à Caractère Scientifique et Technique (EPST) or Etablissements Public à Caractère Industriel et Commercial (EPIC), and listed on the website of the French Ministry of Research;
- Universities (UNI), as listed in the same database from which we extracted the professors' names and info.

Since patents can be co-assigned to multiple assignees, some patents fall in more than one of the above mentioned categories at the same time, whenever the co-assignees belong to different categories. We will come back to this problem in section 4.

Table 3.4 shows the high share of companies' ownership, almost 69%.; institutions, with the exclusion of universities, hold over 21% of the patents, which leaves to universities no more than 10% of university-invented patents (unit of observation here is not the patent, but the applicants). Notice that this result does not differ much from what found by Gering and Schmoch (2003) for Germany, another country whose public research system sees PROs playing a key role, and universities enjoying very limited autonomy.

Table 3.4: Property distribution of academic patents by DT-7/OST technology domains

	APP_TYPE					
TECHNOLOGY CLASSES	C	INST	UNI	%C	% INST	% UNI
ELECTRONICS	237	44	23	77,96%	14,47%	7,57%
INSTRUMENTS	331	86	49	71,03%	18,45%	10,52%
CHEMISTRY	391	85	25	78,04%	16,97%	4,99%
PHARMA	378	209	93	55,59%	30,74%	13,68%
PROCESS ENGINEERING	110	40	25	62,86%	22,86%	14,29%
MACHINERY & TRANSPORT	55	4	7	83,33%	6,06%	10,61%
OTHERS	13	1	0	92,86%	7,14%	0,00%
TOT	1515	469	222			
%	68,86%	21,32%	10,09%			

Patents co-owned by different typologies of applicants are counted as many times as the typologies of applicants.

It is worth pointing out that the ownership distribution of university-invented patents is not uniform across technologies. Universities appear as applicants for 14% of the patents in the Pharmaceutical domain and for 11% of those in Instrumentation, but only for 5% in Chemistry Companies have a disproportionate high share of patents in Chemistry (78%), Machinery and Transportation (83%) and Electronics (78%). Patents applied by PROs are mainly in the field of Pharmaceuticals.

Owen-Smith and Powell (2001) and Feldman and Desrochers (2003) show that university characteristics matter when dealing with university patenting. We take this into account when we turn to academic patenting. In Table 3.5 we employ the French Ministery for Research classification, which distinguishes between Schools of Engineering, Grands Etabilissements, Instituts Nationals Politechniques, Universities with medical school, Universities without medical school and Scientific Universities.

Faculty members in universities with medical school patent overall in the technology class of Pharmaceuticals (40% of the patents); on average only 10% of the patents from other institutions are in the same domain. The patenting activity in scientific universities and universities without medical school is mainly concentrated in Chemistry, about 40%. Grandes Etablissements appear to be more involved than other institutions in Electronics (45% of the patents).

Table 3.5: Technology distribution of academic patents by typology of university

		TECHNOLOGY CLASSES							
UNI_TYPE		ELECTRONICS	INSTRUMENTS	CHEMISTRY	PHARMA	PROCESS ENGINEERING	MACHINERY &TRANSPORT	OTHERS	TOT
Schools of Engineering	Patents	30	27	54	23	30	8	0	172
	%	17,96%	16,17%	32,34%	13,77%	17,96%	4,79%	0,00%	100,00%
Grandes Ecoles	Patents	21	8	5	5	1	6	1	47
	%	91,30%	34,78%	21,74%	21,74%	4,35%	26,09%	4,35%	100,00%
Instituts Nationals Politechniques	Patents	20	20	39	8	17	5	0	109
	%	68,97%	68,97%	134,48%	27,59%	58,62%	17,24%	0,00%	100,00%
Universities (medical school)	Patents	139	251	215	470	70	26	12	1183
	%	81,29%	146,78%	125,73%	274,85%	40,94%	15,20%	7,02%	100,00%
Universities (no medical school)	Patents	24	35	71	25	13	10	0	178
	%	160,00%	233,33%	473,33%	166,67%	86,67%	66,67%	0,00%	100,00%
Scientific Universities	Patents	38	59	116	31	28	5	1	278
	%	54,29%	84,29%	165,71%	44,29%	40,00%	7,14%	1,43%	100,00%

4. The econometric model

In order to assess whether the introduction of the Innovation Act in 1999 has changed the behaviour of domestic PROs and universities in retaining intellectual property right over those discoveries stemming out of in-house research projects, we use econometric probability models, in particular multinomial logit models, wherein patent assignment is related to a set of characteristics of the patent, the university the inventor belongs to, the region in which the university is located and to time-controlling variables in order to catch the effect of the introduction of the legal initiative and the opening of technology transfer offices in those universities whose faculty members appear among the inventors of a patent after 1994.

For the purposes of the econometric analysis we divided patent assignments into five categories, which result from the combination of the types of owners described in section 3 and are assigned as many values when treated as dependent variable (OWNERSHIP) in our regressions:

exclusive INST ownership (value=1)
exclusive C ownership (value=2)
UNI ownership, either exclusive or joint with INST (value = 3)
Joint INST and C ownership (value=4)
Joint UNI and C ownership (value=5)

The reason not to deal with exclusive UNI ownership, and to consider it together with the case of joint UNI and INST property, is that very few patents are assigned exclusively to universities. In fact, universities that are most active in research usually host a CNRS laboratory, wherein academic and CNRS researchers work jointly.

The key explanatory variables of interest in the regression are:

- ACT, which takes zero value when the patent application occurred between 1994 and 1998 and one in and after 1999, that is after the introduction of the Innovation Act;

- TTO, coded as one when an internal IPR regulation, proxied by the opening of a fonction de valorisation, is introduced in an university[9].

We expect both variable to bear a positive influence on the probability of OWNERHSIP to take value 3 or 5.

Among control variables, many represent university-specific characteristics, and pose a few technical problems. Whenever a patent lists only one academic inventor, or more than one academic co-inventors, all of them affiliated to the same university, the creation of university-specific control variables is straightforward.
On the contrary, with patents by more than one academic co-inventors from different universities we had to make a few complex choices. In particular, we exploited the dates of nomination to the current position of the professors: if the date of nomination of one academic inventor is later with respect to the priority date of the patent, then it is likely that the professor used to work for the university of the professors nominated previously to the priority date. If still no conclusion can be reached, the reputation of the universities of affiliation of the co-inventors played a critical role: we have to remark that this criterion of choice, totally subjective, was employed marginally.
In a few cases, when an academic-owned patent was claimed by two or more universities, we assigned the patent to the "pivotal" university, that is the university which had a major role in determining the choice of applying for it: we did it on the basis of the patenting history of the universities appearing as assignees.
A set of controls refer to the technological contents of the patent. In particular, we introduced two dummies for patents in Biotech and Pharmaceutics (BIO) and Scientific and Measurement Instruments (INSTR)
Other variables control for the standing of the institution where the academic inventor come from. As mentioned in section 2, the French higher education system includes both Universities, Schools of engineering and Grands Etabilissements, each category having different domestic and international reputation and visibility, and different involvement in research. At the same time, there are peculiarities within every group of academic institutions. In order to deal with them, we employ the French Ministery for Research classification, from which we derive dummy variables for:

- Schools of Engineering and Instituts Nationals Politechniques (ENG) [10]
- Grands Etabilissements (GRET)
- universities with medical school (UNI_MED)
- universities without medical school (UNI_NON_MED)
- scientific universities (SC_UNI).

We control also for university size. We expect larger universities to apply directly for more patents, because better equipped in dealing with IPRs issues. Furthermore, we would expect domestic PROs to collaborate with the most prominent universities, likely to be the largest, but at the same time, since invested by the mission of sustaining the university-research system (at least for CNRS), to be of crucial relevance for research projects in small and medium-sized universities. The variable SIZE takes value one for the 25% of universities with the largest number of hard-scientists in 2005[11].

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[9] Sourced from the BETA-EcoSc database.

[10] Since the Instituts Nationals Politecniques are only three, we group them with the schools of engineering, given that they are involved in the same fields of research.

[11] Albeit professors mobility, happening overall during the first years of a professor's career, and the variation of the absolute size of universities along the nine years of analysis, we cannot surely affirm that the relative size

The last characteristic of French universities we want to control for is the universities' traditions and attitudes with respect of IPRs. Owen-Smith and Powell (2001) look for reasons explaining the different rates of invention disclosure by academics at two American universities, with different institutional status. Among the reasons behind the gap in terms of disclosure, they find that "the technology transfer process and capacity on each campus is shaped by the unique histories and environments that characterize each institution"(Owen-Smith and Powell, 2001; p. 105). We borrow the rationale of this statement, and, to contextualize it, we construct three control variables: C_INT, INST_INT and UNI_INT. All three variables are calculated as the stock of inventors which signed patents for respectively companies, domestic PROs and universities, at each point in time, divided by the number of hard-science academics affiliated to a given university. The stock is lagged of one year.

Table 4.1: Example of the calculation of the number of inventors per typology of applicant.

Inventors	Patent	Applicant	Applicant typology	Number of inventors counted
A	X	P	INST	3 INST
B		Q	INST	
C		R	INST	
D	Y	S	C	3 C
E		T	C	3 INST
F		V	INST	

Other control variables were produced from data sourced from both the website of the French Ministry of Research and from the National Bureau of Statistics in order to take into account regional characteristics: we used an average of regional GDP over the period 1992-2002. Similarly, variables for private expenses in R&D and public expenses in R&D were introduced. We then gave the value of one to those patents signed by academic affiliated to universities located respectively in the largest regions and those regions with the highest intensity of private and public R&D. We employed the same criterion used to identify the largest universities.

Summing up, our regression will be:

OWNERSHIP = f (BIO, INSTR, ENG, GRET, INP, UNI_MED, UNI_N_MED, SC_UNI, C_INT, INST_INT, UNI_INST, SIZE, GDP, PRRD, PBRD, ACT, TTO)[12]

changed: largest universities, such as Paris VI, Lyon I, Toulouse III, Grenoble I and Strasbourg I were and still are among the most scientifically productive universities of France .

[12] A list of the variables and descriptions is provided in the Appendix (table AX.1).

5. Results

The results in the first column of table 5.1 are referred to patents assigned to PROs. The variable ACT is not significant, and this outcome could be explained by twenty years of patenting by PROs preceding the passage of the act. Indeed, during the 1970s the government set up several agencies specialized in transferring the research capabilities accumulated in the public sector to industry. The most important of these, the ANVAR, manages patent portfolios and finds industrial partners for both the CNRS and university laboratories. Therefore the patenting activity is not new at PROs in 1999, when the Innovation Act passed.

Table 5.1: Results of the Multinomial logit regression (outcomes are expressed in odds ratios)

	Odds	Std. Err.	Odds	Std. Err.	Odds	Std. Err.	Odds
Ptype	1		3		4		5
Eng [1]	0,73	0,73	2.294 *	1,12	0,94	0,57	1,33
Gret [1]	1,21	0,56	3.351 *	2,48	1,89	1,63	1,41
Uni_n_med [1]	0,7	0,23	2.356 *	1,16	0,94	0,62	0,65
Uni_sc [1]	0.651 *	0,15	0,91	0,29	0,78	0,31	1,33
C_int	1414.188 *	5447,16	0 *	0	46,36	290,97	9.06E-07
Inst_int	112,19	695,84	3.94E-07	4.03E-06	205,43	2154,22	1840391
Uni_int	1.54e+12 **	1.83E+13	4.81e+21 ***	6.23E+22	3.90E-06	0	4.25e+15 *
Gdp	1,41	0,33	1,21	0,26	1.818 *	0,63	1,25
Prrd	1,19	0,31	1,28	0,4	0.503 *	0,21	0,69
Pbrd	0.686 **	0,13	1,16	0,29	1,69	0,58	0,9
Instr	1,2	0,23	1.712 **	0,41	1,01	0,38	1,21
Bio	2.037 ***	0,33	3.501 ***	0,77	3.869 ***	1,05	2.345 **
Act	0,8	0,15	1.997 ***	0,44	1,21	0,38	2.345 *
Tto	0,81	0,13	2.654 ***	0,6	0,83	0,23	1,27
Size1	1,28	0,28	1.906 *	0,74	1,89	0,8	0,68
N. observations	1744						
R^2	7.48%						

(* = 10% significance, ** = 5% significance, *** = 1% significance).
Categories: 1=PRO applicant; 2=Company applicant; 3=University applicant; 4=PRO and Company applicant; 5=University and Company applicant. Base category is 2=Company applicant.
1) The reference category is university with medical school.

In addition, patents in the technological domain of Pharmaceuticals are more likely to be retained by PROs with respect to other technology classes. The coefficient of BIO is both positive and significant at 1%.

Patents are more likely to be assigned to PROs in universities with medical schools rather than in scientific universities. Indeed, by looking at the technological distribution of patents over university typology, we can observe that almost half of the patents signed by the faculty of universities with medical schools are in the domain of pharmaceuticals, which is also the domain in which PROs have the highest share of academic patents. On the other hand, scientific universities are more involved in the technology class of Chemistry, in which over 70% of academic patents are claimed by the Industry. This result can be interpreted as being in line with the latest finding: life science is of crucial importance for patenting at Public Research Organizations. The coefficient associated to the dimension of the university is positive but statistically not significant. The statements by Chesnais (1993) regarding a major

collaboration between larger and better connected universities and PROs do not appear to be valid.
To conclude, PROs are likely to retain IPRs at universities located in larger regions, proxied by the regional GDP. The variable GDP has a positive and 10% significant coefficient. The variable PBRD, which is a proxy of the public R&D intensity of a region displays the same significance as above, 10%, but inverse direction: a possible interpretation of this finding could rely on the importance of PROs in patenting for regions with low levels of R&D expenses, being public or private.

When dealing with the likelihood of a patent to have as applicant a university rather than a company, both the variables referring to institutional changes turn to be significant, at 1%, and positive. Results are reported in the second column of table (number to define). The most striking difference with the outcome previously shown is the significance of ACT and TTO. By 1999, French academic institutions start being more aggressive in IPRs retention than they did before. The passage of the Innovation Act have led to an higher involvement of Academia in IPRs administration; the same occurred also when a university introduced an internal IPR regulation. Indeed, patents applied for after the opening of a technology transfer office – TTO –, proxy of an internal IPR regulation, are more likely to be assigned to the university the academic inventor is affiliated to. The result is in line with Baldini et al.'s (2006) findings for Italy, where the total number of patents owned by universities increased after the adoption of an internal IPR regulation (which often was contextual to the creation of a TTO). The absence of effects of the Act on academic patenting by PROs and the rise in terms of weight of universities result in a relatively minor importance of private patents signed by academics, so that possible explanations of this phenomenon could be a stricter control by universities over those professors who have ties with the Industry and over professors which are used to apply for patents individually.
As noted earlier for patents claimed for by PROs, patents belonging to the technology class of Pharmaceuticals are more likely than patents in other technology classes to be applied for by universities. We can also observe the same result for patents in the technology domain of Instrumentation. Dealing with university characteristics, schools of engineering and grands établissements are more likely than universities with medical schools to appear as applicants of patents signed by their faculty, whilst, in line with our expectations, an environment in which patenting for Academia is widely diffused positively influences the probability of assignment to universities (UNI_INT positive and significant at 1%).
The dimension of the academic inventor's university is slightly significant (just over 10%): larger universities seem to be more likely than smaller universities to appear as assignees of academic-invented patents. This low level of significance is partly due to the fact that Schools of Engineering and Grands Etablissements, which have on average fewer researchers affiliated than public universities, pay great attention to IPR issues, as shown above. With regards to regional characteristics, the outcomes are somehow different to those previously obtained for academic patents whose applicant is a PRO. None of the regressors referring to them is significant, albeit showing a positive direction of the sign.
These results confirm the current view of academic institutions being more and more involved in IPRs retention and management, and of being responsive to institutional changes encouraging them.
As stated earlier, the act does not affect the IPR attitude of PROs at French universities. The likelihood a patent to be applied both by a PRO and a company is not influenced by the passage of the act: ACT is positive but not significant, whereas the sign of the coefficient associated with the opening of a technology transfer office is negative, and still not

significant. Such a result witnesses the critical role of PROs as founders of research at universities laboratories and continuous collaboration between the two entities.

Academic patents in the Pharmaceuticals sector are the most likely to have both a PRO and a company as applicant (again, the issue of the centrality of biotechnologies for patenting at PROs); furthermore, faculty affiliated to universities in larger regions tend to be the inventors of patents co-owned by PROs and companies. We can also observe a negative impact of private spending in R&D on the probability a patent be co-owned (PRRD significant at 10%): this is probably due to an indirect effect on the likelihood by public expenses in R&D (it has to be mentioned that the p-value associated to PBRD is only slightly higher than 10%).

The probability of a patent to be applied jointly by universities and companies dramatically increased after the passage of the Innovation Act. The variable ACT is positive and significant at 5%. This outcome is quite straightforward, given that, as previously seen, with the passage of the Innovation Act the Academia displays more interest in IPR issues. This is particularly true for patents in pharmaceuticals (BIO positive and significant at 5%). Contrary to sole university-owned patents, the opening of a TTO does not change the likelihood a patent being co-applied by universities and firms.

A further doubt emerges when we point out these results: who is responsible for this shift in the property pattern of academic patents? Is it the case that universities already engaged in IPR management became more aggressive in IPRs issues after the passage of the bill? Or is this surge in academic-owned patents due to new entrants?

To answer this questions we employed the same model as above, but applied only to those universities that opened a technology transfer office before the Innovation Act was approved, expecting them to be more responsive to such change. The results in table 5.2 are consistent with our expectation: the passage of the act has both a positive and significant, at least at 1%, effect on the likelihood a patent is assigned to universities. By 1999, French academic institutions already involved in IPRs issues appear to be more aggressive in IPRs retention than they did before. As we expected, the higher propensity to seek for intellectual protections resulted in the table 5.1 is to attribute to established universities, and not to new entrants, which are not yet ready to effectively manage such an institutional change.

Table 5.2: Results of the Multinomial logit regression (only universities with a TTO open before 1999)

	Odds	Std. Err.	Odds	Std. Err.	Odds	Std. Err.	Odds	Std. Err.
Ptype	1		3		4		5	
Eng [1]	0,84	0,41	2,09	1,03	0,27	0,31	0,7	0,74
Uni_n_med [1]	0,73	0,47	1,07	0,96	1,12	1,47	2.70E-13 ***	2.14E-13
Uni_sc [1]	1,03	0,31	1,38	0,58	1,42	0,81	2,08	1,36
C_i	2191,2	11324,27	0	0	3.19E+08 **	2.86E+09	2,52	34,9
Inst_int	332,94	3463,83	8.35E-13 *	1.34E-11	1.29E-09	3.01E-08	0,06	1,33
Uni_int	0	0	1.54E+16 **	2.33E+17	4.81E-19	1.58E-17	1.38E+27 **	3.62E+28
Gdp	1,26	0,35	1,11	0,29	1,93	0,88	1,75	1,19
Prrd	2,11	0,99	6.025 ***	3,62	3,2	2,35	1,83	1,96
Pbrd	0.319 ***	0,13	0.320 **	0,17	0.279 **	0,18	0.176 **	0,14
Instr	1,27	0,3	1.796 **	0,53	0,73	0,41	0,96	0,66
Bio	1.586**	0,37	3.177 ***	0,83	2.938 ***	1,22	2.273 *	1,14
Tto	1,74	0,65	3.893 **	2,53	5,33	3,9	2,87	2,73
Act	0,84	0,21	2.607 ***	0,74	0,8	0,4	1,25	0,64
Size1	1,4	0,45	1,12	0,4	1,21	0,76	0,67	0,48
N. observations	1030							
R^2	7.5%							

(* = 10% significance, ** = 5% significance, *** = 1% significance).
Categories: 1=PRO applicant; 2=Company applicant; 3=University applicant; 4=PRO and Company applicant; 5=University and Company applicant. Base category is 2=Company applicant.
1) The reference category is university with medical school.

A striking difference with the outcomes in table 5.1 is the non significance of the variable ACT when dealing with academic patents co-applied by universities and companies. The passage of the Act does not seem to change the attitude toward IPRs when an industrial partner is involved.
When considering geographical characteristics, it emerges that the universities in regions with high level of private R&D spending are more likely to apply directly for patents. The high effort in innovation by the firms in these regions and long lasting collaborations with academic laboratories could be a possible explanation of this outcome. The opposite holds for public R&D spending[13].
Other outcomes are in line with the previous results: an academic environment supportive of patenting fosters the innovative activity of the faculty (UNI_INT significant at 5%); the variables associated to the typology of universities are no longer significant. Only universities without medical school are less likely (even unlikely) to appear as applicants together with companies.
Finally, consistent with previous results, patents signed by academics are overall in the technology domain of Pharmaceuticals and life sciences, no matters the typology of applicant.

[13] The negative and significant impact of public R&D for all categories is due to indirect effects: we suppose that this is mainly due to the importance of the R&D activity of PROs for those regions with low levels of R&D, where the involvement of private entities in collaborative agreements with faculty is low.

6. Conclusions

In this study we explored French academic patenting activity in the last decade and the impact of two major institutional changes which occurred before and during the time frame taken into account: the Innovation Act of 1999 and the opening of a technology transfer office in a university.

As Azagra-Caro et al. (2006) have shown for the Université Louis Pasteur, it is common in France the habit of leaving to a business company the ownership of a patent whose inventor is an academic: in the whole country only 10% of the patents applications signed by faculty members have a university as assignee, being 222 out of 1744 patents. It is likely that this phenomenon was either unknown or largely underestimated by policy makers who pushed for the introduction of the Innovation Act.

Furthermore, it has to be stated that the patenting activity is concentrated in some universities. The same universities had technology transfer offices well before the 1999, and persistently appear among the best scientific performing universities of the continent.

The technology classes related to Chemistry and Pharmaceuticals are those in which faculty members are more active, together accounting for 53.5% of the academic invented patents. This outcome is consistent with whom is critical with the enthusiasm toward the Bay-Dole Act: in 2001 Mowery et al. suggested that the boast in academic patenting during the 1980s was rather due to the emergence of technological opportunities in the field of life sciences. Moreover, universities tend to appear as applicants in the class of pharmaceuticals, where 93 patents have at least a university among the assignees.

The econometric analysis shows that the passage of the Innovation Act resulted in a much more aggressive behaviour of French universities in retaining IPRs: a 4.5% increase is recorded in the likelihood that a patent signed by an academic is applied for by the university they are affiliated to. The opening of a technology transfer office has even a stronger effect on the probability a patent is assigned to the university of affiliation rather than to business companies (its marginal effect is equal to 7.2%), almost doubling the likelihood of academic assignment, after controlling for patent, university and regional characteristics.

The next steps in this analysis will be to test whether the shift of ownership attribution induced by the Innovation Act occurred independently or because of an increased propensity to patent by academic scientists. Measuring such propensity over time is not an easy task, since available methodologies (such as the one adopted here) trace only patents signed by academic scientists still active after 2000 (that is, they ignore patents signed by scientists who retired before then, which results in sever underestimation of early academic patenting activity). In addition, as proved by a number of recent studies, scientific productivity, measured by publication activity, is a key determinant of a scientist's likelihood to sign a new patent; this will require us more data collection efforts.

On the policy side, we will also have to test whether the more aggressive stance of universities towards IPR retention was beneficial or not for technology transfer and/or for the finances of universities. By no means, in fact, our results can be interpreted as proof of "success" by the Innovation Act, until these two other aspects of its effect will be clarified.

7. References

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Appendix

Table A.1: List of variables and description

VARIABLES	DESCRIPTION
BIO	Dummy if patent belongs to biotech
INSTR,	Dummy if patent belongs to instrumentation
ENG,	Dummy if school of engineering
GRET,	Dummy if grand établissement
INP,	Dummy if institut national politechnique
UNI_MED,	Dummy if university with medical school
UNI_N_MED,	Dummy if university without medical school
SC_UNI,	Dummy if scientific university
C_INT,	Company patent intensity
INST_INT,	PRO patent intensity
UNI_INST,	University patent intensity
SIZE1	Dummy if among 25% of larger universities
GDP	Dummy if among 25% of larger regions
PRRD	Dummy if among 25% of regions with highest private R&D spending
PBRD	Dummy if among 25% of regions with highest public R&D spending
ACT	Dummy for 1999 onwards
TTO	Dummy for opening TTO onwards