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

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

14 January 2011

* Maastricht University (The Netherlands) (a.dellamalva@maastrichtuniversity.nl)

† DIMI-Università di Brescia and KITES-Universitá Bocconi, Milan (Italy) (lissoni@ing.unibs.it)

‡ BETA, Universitè de Strasbourg (France) (pllerena@cournot.u-strasbg.fr)

Abstract

The Innovation Act was introduced by the French government in 1999, with the aim of encouraging academic institutions to protect and commercialize their scientists' inventions. We explore the effects of the Act on the distribution of Intellectual Property Rights (IPRs) over academic scientists' inventions. We find that before the Act, academic institutions had a strong tendency to leave such IPRs in the hands of their main funders, namely public research organizations (such as CNRS or INSERM), and business companies. After the introduction of the Act, French academic institutions have increased their propensity to claim IPRs over their employees' inventions, mainly under the form of co-ownership with business companies. This result varies with the technological class of the patent, the presence and age of a technology transfer office within the university, and the university size and type.

JEL Classification: L31, O31, O34.

Keywords: academic inventions, academic research, intellectual property, patents

1. Introduction

Starting in the 1980s, various policy initiatives have been undertaken in most European countries with the aim of strengthening the links between Academia and Industry and to increase technology transfer efforts by academic institutions and faculty members. Many of such initiatives have touched upon intellectual property right (IPR) legislation and its relationship to university policy, with the introduction of incentive schemes to induce academic scientists to commercialize more actively their research results, most often through patenting and licensing. All of these reforms share the assumption that European universities and scientists do not undertake enough IPR-mediated technology transfer, especially if compared to their US counterparts (Mowery and Sampat, 2005).

Recent studies, however, have shown that European policy-makers' assumptions may derive from lack of attention to the legal and institutional differences between the university systems of the two continents. In particular, too much faith has been placed in available statistics on the number of patents owned by universities (university-owned patents) as opposed to patents covering inventions by academic scientists, but assigned to the individual scientists, public research organizations and, above all, business companies (university-invented patents; surveys by Geuna and Nesta, 2006; and Verspagen, 2006). Lissoni et al. (2008) suggest that university-owned patents in France, Italy and Sweden are no more than 11% of all academic patents (whether university-owned or merely university-invented), as opposed to 60-80% academic patents owned by business companies. This implies that European universities may contribute to technology transfer activity by producing inventions, the IPRs of which they choose (for institutional, strategic or managerial reasons) to leave entirely in their public or private partners' hands.

When it comes to measuring the effect of patent-inducing policies, therefore, we may be interested not only to measure whether they have indeed produced an increase in patenting by universities, but also whether such increase may derive from a patent property shift (from public partners and business companies to universities) and not only (if any) from an increase in the number of patented inventions. More generally, the number of European academic patents in the hands of business companies is so high that they have necessarily to be taken into account in any evaluation effort.

In this paper we build upon Lissoni et al. (2008) in order to assess the impact on patent ownership patterns of IPR-related reforms. In particular, we explore the consequences of the French government's introduction, in 1999, of the Innovation Act, which promoted, among other things, a more aggressive patenting activity by universities. In particular, we test whether the Act (also known as "Loi Allegre") has significantly increased the likelihood of a French academic patent being 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 the creation of a technology transfer office within the academic inventor's university.

The study is organized as follows. In section 2 we provide a brief review of the IPR-related aspects of science policy reforms introduced in France over the past 10 years, with special emphasis on the Innovation Act. We also provide some comparative information on similar policies introduced in the USA and elsewhere in Europe. In sections 3 and 4 respectively, we present the data and the econometric model used to examine the effect of the new law. Section 5 illustrates and discusses our results and section 6 concludes and outlines the directions of our future research.

2. IPR-related reforms of university policy

2.1 The international experience

Policy-makers' attention to IP aspects of academic research is mainly due to the visibility of the US experience, where universities' contribution to inventing and patenting has increased substantially over the last quarter of a century, also following legislative changes introduced in 1980.[1]

Among such changes, the introduction of Public Law 96-517, better known as the Bayh-Dole Act, stands out. This Act, among other things, allowed US universities to retain IPRs over the inventions resulting from federally-funded research and established the government's march-in right, that is the right to arrange for licensing of patents left unexploited by academic administrations. The Act was meant to provide a unique set of rules for universities that, until then, had had to cope with several funding agencies (such as the National Institutes of Health, the Department of Defence, or the National Science Foundation), each of them with a different IPR policy (Mowery et al., 2001). It was also meant to provide universities with both stick and carrot incentives to commercialize their inventions.[2] More generally, the Bayh-Dole Act complemented another set of policies, all of them aimed at reinforcing the US IP regime, based upon a more severe enforcement of rules against patent infringements and the extension of patentable matters to living organisms and software, two fields where the academic contribution to invention is more than noticeable (Kortum and Lerner, 1999; Jaffe, 2000).

[1] See Henderson et al. (1998), Jensen and Thursby (2001), and Mowery et al. (2004). See also section 2.1 in this paper
[2] As a matter of fact, the stick, that is the march-in right, has hardly, if ever, been used (Rai and Eisenberg, 2003)

After the introduction of the Act, the number of patents issued to universities increased from 264 in 1979 to 2436 in 1997 (NSF, 2006), so that university-owned patents now represent 5% of the total number 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).

In Europe, the British government was the first one to emulate the US initiatives, with the introduction, in 1985, of the right for universities to patent in their own name and commercialize the results of their own faculty's research. Previously, the British Technology Group, a public agency, had the nominal exclusivity on inventions by academics (Clarke, 1995).

Shortly afterwards, at a time of constant or decreasing levels of public financing of universities in Continental Europe, academic institutions were encouraged to look at markets for technologies as a source of complementary funding (Geuna, 2001).[3] Such strategic reorientation has often gone along with the introduction of IP law reforms aimed at increasing universities' and academics' incentives to patenting. Between 2000 and 2002, for example, Germany, Austria, and Denmark all abolished the professor's privilege, a typical institution of German and Scandinavian law, with the explicit aim of increasing the number of university patents (on the other hand, Italy introduced it in 2001, and with the same objective).[4] In the same spirit, many countries have introduced incentive schemes and training programmes for IPR awareness and management, as described by Lissoni and Franzoni (2009).

2.2 The French experience

In France, reforms of the IP regime over academic inventions have coincided in time with broader reforms of the national science system. These have touched upon the relationship between academic institutions and large public research organizations (PROs). Therefore, before examining the specific IP-related reforms of our interest, it is necessary to discuss the role of universities in the French national system of innovation, and how it has changed over recent times

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[3] 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 programmes rather than on public budgetary channels. This switch in sources of funds could be considered a result of the shrinking of public research budgets and change in the rationale for science support occurring in Europe.

[4] The professor's privilege exempts university professors from standard provisions concerning business employees' inventions. National legislations worldwide usually state that IPRs over employees' inventions belong to the employer, as long as the employees' job description includes innovation activities, as with R&D workers and scientists in general. Countries that admit the professor's privilege allow an exception for university professors, who can retain all IPRs over their inventions, and have no or limited disclosure duties towards their employers, (that is their universities). For a discussion, see Lissoni et al. (2009).

2.2.1 The French universities' position in the national system of innovation

Differently from their US counterparts (but also from many European ones, such as the British or the Dutch), French universities have always struggled to establish themselves as central actors in the public research system, let alone to gain the necessary autonomy for the purpose. This difficulty has deep historical roots (Neave, 1993). After all existing universities had been abolished under the Revolutionary regime at the end of the eighteenth century, a new university (one for the entire country) was established by Napoleon in 1808. Under the name of Imperial University (or University of France), the latter had exclusively teaching tasks, for the education of medical doctors, teachers and lawyers, while the *Grandes Ecoles,* a peculiar French institution, were charged with the formation of the technical and administrative elites.[5] It was only in 1896 that the Imperial University was disbanded and regional faculties gained the status of universities, but still no autonomy from the central government. Their research activities were conducted in small personal laboratories by a professor with a few assistants and most often needed funding from external partners (as had happened with Pasteur's laboratory in Lille in 1854). French universities had to wait until the 1970s to gain some rights to self-organize their teaching and research activities, but not yet any freedom in terms of finance and real estate management, let alone the handling of IPR matters. The latter, therefore, were quite neglected or left in the hands of PROs.

PROs, in fact, have long been the dominant force of the French public research system after the WWII, but also one which more recent policies have tried to integrate with academic institutions, in particular universities. The *Centre National de la Recherche Scientifique* (CNRS) was originally established in 1939 with the express goal of supporting academic research and/or performing research through its own labs. Over the years, a similar role came to be played by INSERM (the National Institute of Health and Medical Research) in the medical sciences, and by other, smaller PROs. During the 1960s both demographic factors and a call for democratization of education led to massive university enrolment, which called for the isolation of larger and better endowed laboratories from teaching. As a result, successive governments pushed the CNRS to establish a system of partnerships with universities and their staff, on the basis of a periodic evaluation by

[5] The *Grandes Ecoles* still play the same highly selective role nowadays. They are commonly divided into *Ecoles d'ingénieurs* (Schools of Engineering,), *Ecoles de Commerce* (Business Schools, or ESC) and *Ecoles Normales Supérieurs* (ENS, which offer degrees both in hard sciences, social sciences, and humanities).

CNRS committees. This kind of mechanism, which has been extended over time, led, on the one hand to splitting the academic environment between teaching *versus* research departments, and, on the other hand, to integrating a substantial part of PRO personnel into university research groups. Larger and better connected departments now receive financial and material assistance from CNRS, which results in a vertical hierarchy of university labs: those staffed only by CNRS personnel and funded directly by CNRS; those staffed by both CNRS and university personnel; and finally those exclusively staffed by university personnel, with little or no access to CNRS funds (Larédo and Mustar, 2001). A similar arrangement has been enacted for INSERM.

In the last decade the whole system has witnessed several changes: the members of academic staff in universities have increased to more than 50000 units, whereas the totality of PROs now employs less than 35000 scientists. For a comparison, consider the 1970s, when the CNRS alone had as many researchers as the entire university system. Moreover, a second trait of the academic system, the *Grandes Ecoles*' separation from research, seems to have decreased. Finally, successive reforms have created a complex system of universities with different educational and research aims. According to the DEP/MENR[6] classification we can distinguish between *Grands Etablissements*, *Schools of Engineering*, *Instituts Nationaux Politechniques*, *Universities with a Medical School*, *Universities without a Medical School*, and *Scientific Universities*. This distinction is loosely based on two criteria: the statutory norms according to which they operate; and their disciplinary orientation. Statutory norms set both the *Grands Etablissements* and the *Schools of Engineering* apart, due to the reduced number of students they admit; while the latter are devoted to Engineering disciplines, the former are, from the disciplinary viewpoint, as heterogeneous set. The *Instituts Nationaux Polytechniques* (3 in total) are also specialized in engineering education and correspond to a localised grouping of Engineering Schools (Grenoble, Toulouse, Nancy).

As for disciplinary orientation, Universities are fully interdisciplinary (with the possible exception of medicine), while Scientific Universities are specialized in the hard sciences. In this classification scheme, the *Grandes Ecoles* mentioned above fall into either the School of Engineering category or the *Grands Etablissements* category, according to their specialization.

2.2.2 Technology transfer and the Innovation Act of 1999

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[6] DEP/MENR (Departement d'Etudes et des Previsions/Ministere d'Education Nationale, de l'Enseignement Superieur et de la Recherche) is the official statistical Bureau of the Ministry of Education and Research. The classification we use here was last updated in 2003 and, although it serves mainly statistical purposes, it reflects the legal classification produced by the higher education reforms introduced in 1968, when the old faculties and institutes were reorganized into modern departments (Le Feuvre and Metso, 2005).

The French public research system has often been criticized for being unable to transfer the results of its world-renowned research to industry. University-industry technology transfer was for long characterized by strong intervention of the central government, whose large programmes aimed chiefly at promoting the national independence of strategic sectors such as electronics, defence and nuclear technologies. These programmes were put into practice by CNRS and INSERM and other large PROs, as well as by *ad hoc* agencies (such as CEA for atomic energy, INRA for agricultural research or CNES for telecommunications), under direct control of the government.

The French government's attention towards the innovation role of the public research system increased significantly in the 1970s and bore its early fruits at the beginning of the 1980s, when the Mitterand presidency pushed through the Research Act (*Loi d'Orientation et de Programmation*), which listed among the explicit science policy objectives the commercial valorization and diffusion of public laboratories' research results (art. 14, Public Law 82-610). The same indications were extended to universities two years later (Public Law 84-52). These actions led to the creation of a dedicated agency for the transfer of research results from PROs – ANVAR – and the proliferation of regional centres of innovation – CRITTs – responsible for easing access to the pool of local competences developed in universities. None of these interventions, however, achieved satisfactory results, at least according to the policy-makers' viewpoint (Larédo and Mustar, 2001). As for intellectual property, this did not figure prominently in the government's agenda for university-industry technology transfer. Neither IPR legislation nor any law on universities and PROs specifically addressed the issue of patents over public-funded research results. The new *Code de la propriété intellectuelle* of 1992 never mentioned explicitly the case of academic scientists, whose economic rights over inventions were implicitly disciplined by the same rules applicable to R&D employees; that is, universities and PROs (as employers) formally retained full control over inventions resulting from their scientists' research, to the extent that the latter was conducted as part of the scientists' contractual duties as university/PRO employees. As a matter of fact, large PROs dealt actively with their scientists' inventive activity, either through internal Technology Transfer Offices (TTOs) or subsidiary companies in charge of patent management; but universities did not have this type of organizations, and left IPR matters in their professors' hands (Gallochat, 2003; see also Carayol, 2006).

In the mid-1990s the government was still deeply concerned with cooperation and knowledge transfer between the public research system and industry (Vavakova, 2006). Several consultations and proposals (Fillon in 1994 and d'Aubert in 1997) led to the approval of Public Law 99-597, also known as the Innovation Act or "Loi Allegre", from the name of the Minister of Research at the time. This piece of legislation was profoundly influenced by an earlier ministerial report (the Guillaume report in 1998), which stressed that a number of barriers hampered the flow of knowledge between public research and industry, among them a far too limited use of IPR instruments by universities.

The Innovation Act was not a piece of IPR legislation, comparable to the Bayh-Dole Act, as it left the *Code de la propriété intellectuelle* unchanged, and at the same time introduced a number of provisions that went well beyond intellectual property. However, it aimed, among other things, to increase both the IPR awareness within the public research system and the rate of commercialization of academic inventions. A number of provisions were included in order to encourage universities and PROs to retain the IPRs over their scientists' inventions, or at least to share them with industrial partners (Gallochat, 2003).

First, the Innovation Act added explicitly the commercial exploitation of patents and licences to the universities' mission, on the same footing as teaching and research (art. 1, IV, comma for PROs and art. 2, IV, comma for universities).

Second, it introduced the possibility for both universities and PROs to create internal TTOs (called SAICs: *Services d'Activités Industrielles et Commerciales*), and both to staff them with external personnel and to run them according to business-like budgetary and accounting rules. (art. 2, I, comma for universities).[7]

In order to encourage PROs and universities which had set up TTO-like subsidiaries to switch to SAICs, and to retain control of intellectual property, a favourable taxation rule was introduced. According to this, subsidiaries' industrial and commercial activities were subject to taxation, whereas those of SAICs were not, as long as intellectual property was owned or co-owned by the PRO or university.[8]

Immediately after approval of the Innovation Act, the Ministry of Research diffused a set of guidelines for university-industry cooperation, which included the recommendation to adopt an intellectual property charter (so that, especially in universities, IPR matters could be explicitly regulated) as well as negotiation with companies of "joint ownership agreements" over the results of

[7] Before the Innovation Act, internal TTOs had to be run according to the same public law rules that disciplined the entire activity of universities and PROs. Such rules limited flexibility in recruitment (staff of TTOs had to come from within the organization, and be paid according to wage grids fixed by the government, and mainly related to seniority) and budgeting/accounting (which were intended to allow for governmental control of expenses, rather than business-like management of research and licensing contracts).

[8] This implies that R&D contracts that left all IPRs in the industrial partners' hands were subject to taxation, while those that provided for universities' co-ownership or full ownership were not. These changes were scheduled to take place starting 1 January 2003.

collaborative R&D. According to the *Code de la propriété intellectuelle*, such agreements are necessary in order to allow for flexibility in managing co-owned patents.[9]

2.2.3 How to evaluate the impact of the Innovation Act on academic patenting in France?

In order to assess the impact of the Innovation Act on academic patenting in France, we need to consider that history, both remote and recent, still weighs on French universities. It is clear that the Innovation Act is just one of many steps taken in France over the years in order to promote more autonomy for universities, and less dependence on CNRS and INSERM.

Therefore we expect to observe that its introduction helped universities to retain the property of a higher share of academic patents by withdrawing them from the exclusive control of the largest PROs. We also expect that French universities started engaging in tighter negotiation over IPRs with their business partners. Although the Innovation Act did not introduce financial autonomy for universities, but rather room and tools for limited self-financing *via* the market for technologies, it *legitimized* the use and exploitation of IPRs. More generally, handling complex IPR contracts, managing the related costs and income, or setting personal incentives for academic inventors, are still tasks well beyond the possibilities of many French academic institutions.

Our two hypotheses to be tested, therefore, are the following:

1. The Innovation Act, by strengthening academic institutions with regards to IPRs, has increased the share of academic patents owned or co-owned by such institutions;
2. For the same reasons, the Innovation Act has reduced both the share of academic patents owned exclusively by PROs and the share controlled exclusively by business companies.

In addition, we stress that the Innovation Act followed a decade of earlier reforms, many of which had already encouraged the most research-intensive universities to set up their own TTOs, although possibly in the form of subsidiaries rather than SAICs. Thus, the impact of the Innovation Act can be appreciated only by controlling for the creation date of such offices, the impact of which may have been quite significant on individual universities' IPR policy.

Finally, it is important to stress that data constraints do not allow us to test whether the Innovation Act increased the number of academic patents overall, whether retained by universities or assigned to

[9] In principle, co-owned patents can be managed only through co-owners' unanimous decisions. This would make it difficult to license or sell them. Joint ownership agreements allow one partner to waive some decision rights to the others, so that managerial decisions can be taken more swiftly.

PROs or business companies. The nature of such constraints, and the reason why they are so binding, will be made clear in the next section.

3. Data

Data for this study come from the KEINS database, which provides information on academic patenting in several European countries, and is part of the larger EP-INV database.[10]

The French section of the KEINS database contains detailed information on faculty members who appear as inventors of one or more patents applied for at the EPO (European Patent Office) between 1994 and 2002. It is the result of a matching exercise of names and surnames of scientists and engineers active within academic institutions, with names and surnames of inventors, as reported on EPO patents.

Data on French academic scientists and engineers originate from the Ministry of Education and were provided by BETA (Bureau d'Economie Théorique et Appliquée), a join research unit of University of Strasbourg and CNRS. They refer exclusively to tenured staff on active duty in 2005, to whom we will often refer, for the sake of simplicity, as "professors". In particular, the database contains information on 32006 professors in natural, medical, and engineering sciences, and includes variables such as their date of birth, university affiliation, and discipline, as well as their date of nomination to the current academic rank (either "maître de conférence" or "professeur").

After matching inventors from the EP-INV database with professors in the ministerial records, we filtered out incongruous matches by employing age and discipline filters. The age filter excluded all matches in which the professor turned out to be younger than 21 at the time of the patent filing. The discipline filter was based on a list of "incompatible" academic disciplines and IPC 3-digit codes of the patent.[11] We then moved on to check for homonymic cases, in which two matched individuals share the same name and surname, but are not the same person. Given the large numbers of matches to check, we chose to focus only on those pairs wherein the inventor's latest patent had been filed after 1993, based on the assumption that additional information on the related individuals would be easier to retrieve. This choice left us with 3951 inventor-professor matches. For 2400 of them we collected information either through direct contact (after retrieving the professor's e-mail address

[10] Lissoni et al. (2006) describe in detail the methodology for the classification of patents by inventor in the EP-INV database as well as the methodology applied to build the KEINS database on academic inventors.

[11] IPC stands for International Patent Classification. It is a 12-digit contents-based classification system produced by WIPO (the World Intellectual Property Organization) and adopted by the EPO as the key tool for classifying patents according to the technological field they address.

from the web) or by examining all online-available information (the professor's CV, publications or mentioning in the patent applicant's website).[12] For another 484 matches, the required information was provided by academic co-inventors (as when professor A, co-inventor with professor B of a given patent, provided information on the latter, who had turned out to be unreachable). For the remaining 1067 matches, corresponding to 587 professors and 1215 patents, either no information was available, or the professors never answered our e-mails or telephone calls, so we excluded all of them from the analysis.[13]

As shown in Table 3.1, we ascertained that more than 1700 patent applications filed at the EPO between 1994 and 2002 relate to inventions and co-inventions by 1208 French faculty active in 2005. They represent 3.27% of all French patents. As discussed in Lissoni et al. (2008), these values place France very much in line with other European countries (such as Italy and Sweden), and possibly not very far behind the USA.

TABLE 3.1 HERE

Most of the academic patents are in the fields of Instruments, Chemistry and Pharmaceuticals, respectively 20.07%, 25% and 28.5% (see Table 3.2). Their inventors come mainly from academic disciplines related to the life sciences and electronics (Table 3.3), and represent 2.33% of all French inventors. These findings are in line with those by Lissoni et al. (2008) for Italy and Sweden and Lissoni et al. (2009) for Denmark, and comparable to what was found by Thursby et al. (2009) for the USA.[14]

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[12] Additional information on the universities employing our academic inventors was collected from the database of CURIE, the French network of technology transfer offices.

[13] Dropping patents by non-respondents minimizes Type I errors (where the hypothesis is that an inventor-professor match signals an academic patent), but introduces Type II errors which lead to underestimation of the number of academic patents in any given year. This is one more reason not to rely on our data for a precise estimation of university scientists' contribution to patenting in France, as explained at the end of section 2. As for possible biases with respect to the main research question of the paper (whether the Innovation Act increased universities' propensity to retain the intellectual property of their scientists' invention), we observe that:

- the distribution of non-respondents' patents per year is very similar to that of respondents' patents (Pearson correlation index is over 92%);
- the distributions per technological classes and type of ownership are also very similar.

Thus, we do not expect that including non-respondents' patents in the analysis would have improved our results, indeed quite the opposite. Finally, we suspect that many non-respondents who were not academic inventors simply did not bother to let us know, so that many non-responses are equivalent to negative responses.

[14] Patents by non-respondent professors, which we excluded from the analysis, exhibit a distribution by technology class which is more similar to that of non-academic patents than to academic ones. This suggests that non-respondents' patents are more likely not to be academic ones

TABLE 3.2 HERE

TABLE 3.3 HERE

When it comes to examining time trends, we can only start our observation from 1994. In fact, our counting of academic patents relies on archival information on academic scientists active in 2004-05, which means that we do not have information on the identity of retired scientists. As a consequence, the older the patents we examine, the less likely we are to identify correctly those invented by such scientists. Therefore, we are bound to underestimate the number of academic patents produced back in time.

Our data also suffer from right censoring, as the available patent data at the time of our collection stopped in 2001/02 (indeed, not even all patent applications with priority date in these two years – which we consider jointly - had been published). Although caution in drawing conclusions is to be recommended, Figure 3.1 shows that some positive trends may be detected in the number of academic patents after 1994 (the first year for which our data can be trusted for measuring the extent of the phenomenon), especially in Pharmaceuticals, Chemistry, and Electronics (the 2001/02 dip may be entirely due to a statistical artefact, for the reasons explained above).

FIGURE 3.1 HERE

FIGURE 3.2 HERE

However, this trend does not translate into an increasing weight of academic patenting over total patenting by domestic inventors, as shown in Figure 3.2. This suggests a lack of impact of the Innovation Act on academic patenting, but our data cannot substantiate this evidence, nor can they be explained by it, due to the short time window they cover. So, as already stated in section 2, we prefer to leave it for future research.[15]

We classify assignees of academic patents into three categories:

[15] While right censoring may be less of a problem when investigating patent ownership trends (which depend mainly on shorter-term decisions by university administrators and negotiation with industrial partners or PROs), it is certainly a problem when examining patent numbers. In this case, in fact, the latter turn out to be an indicator of research output, which is affected by research inputs and change over a longer time frame.

- Companies (C), which include both business companies (French and foreign) and individual inventors;[16]
- Public research organizations (PRO), which include all institutions known in France as Etablissements Public à Caractère Scientifique et Technique (EPST; such as CNRS or INSERM) or Etablissements Public à Caractère Industriel et Commercial (EPIC), and are listed as such 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 information. They can be divided according to the DEP/MENSER classification we introduced in section 2.2.1.

Since patents can be co-assigned to multiple assignees, a patent may fall into more than one of the above-mentioned categories at the same time, whenever it has more than one assignee, and two or more of such assignees belong to different categories. We will come back to this problem in section 4.

Table 3.4 shows that companies command the highest share of academic patents, with around 69% of them. The PROs' share comes second, with over 21% of the patents, leaving universities with no more than 10% of academic patents (patents co-owned by n>1 types of applicant are counted n times). Note that this result does not differ much from the findings by Gering and Schmoch (2003) for Germany, another country where public research system PROs (especially the Max Planck Institute) play a key role.[17]

TABLE 3.4 HERE

It is worth pointing out that the ownership distribution of academic patents is not uniform across technologies. Universities appear as applicants of about 14% of academic patents in the Pharmaceutical domain and of 10.5% in Instrumentation, but only of 5% in Chemistry. Companies

[16] Patents assigned to individuals, most often the academic inventors themselves, are only 3.6% of French academic patents (see: Lissoni et al., 2008). This is expected, due to the absence of any legal provision similar to that of the professor's privilege, as discussed in section 2. At the same time though, it may be that several patents formally assigned to business companies are *de facto* owned by their inventors, who control the companies and possibly set them up with the precise intention of using them as vehicles for retaining control of their patents. For these reasons, we have considered the two types of ownership as one. Note also that introducing a separate category for so few patents would not have helped the econometric exercise we run in section 4, the observations in the category being too few to return significant results.

[17] Patents by non-respondent professors, which we excluded from the analysis, exhibit a distribution by type of owner which is more similar to that of non-academic patents than academic ones.

have a disproportionately high share of academic patents in Chemistry (78%), Machinery and Transportation (83%) and Electronics (78%). Patent applications by PROs are mainly in the field of Pharmaceuticals (30.7%).

Figure 3.3 provides details on the ownership distribution of academic patents over time. We note that academic patent applications by Companies decline from 75.57% in 1994 to 64.50% in 2001, although in absolute values they increase from 167 in 1994 to 240 in 2000. In contrast, the universities' share increases from 10.4% in 1994 to 16.42% in 2001, sharply increasing from 8.41% in 1998 to 12.22% in 1999.

FIGURE 3.3 HERE

Research in the literature of technology transfer has shown that university characteristics matter when dealing with university patenting (Owen-Smith and Powell, 2001; Feldman and Desrochers, 2003). We take this into account in Table 3.5, which is based upon the DEP/MENSER classification we introduced in section 2.2.1. We note that faculty members of *Universities with Medical School* patent chiefly in Pharmaceuticals (40% of their patents), whereas only around 10% of patents by scientists from other academic institutions are in the same field. The patenting activity in *Scientific Universities* and *Universities without Medical School* is mainly concentrated in Chemistry (about 40%). *Grandes Etablissements* appear to be most involved in patenting in Electronics (45% of their patents). At the same time, we note that *Universities with Medical School* are responsible for around 60% of French academic patents (1183 out of 1967).

TABLE 3.5 HERE

4. Analysis

In order to assess whether the introduction of the Innovation Act in 1999 has changed the IPR practices of French universities, we perform several econometric exercises. In particular we run both logistic and multinomial logistic regressions, with the type of applicant for the academic patent (Company, PRO, or University) as the dependent variable. The key explanatory variables are two time-related dummies, one which distinguishes between patents applied for before/after the introduction of the Innovation Act, the other that marks the absence/presence, in the application year, of a TTO within the academic inventor's university. Controls include technological classification of the patent and a set of characteristics (such as type and size) of the inventor's university, as well as regional dummies to control for local characteristics of the regions wherein the universities are located.

4.1. The dependent variable

We run two series of regressions, each one with a different specification of the dependent variable, namely a different classification of patent ownership. Note that most patents have a single applicant, but many have more than one (which is often the case when universities are involved in ownership).

In the first series of regressions (logistic), we adopt a binary dependent variable and distinguish only between university-ownership (UNI=1) and non-university ownership (UNI=0). All patents having at least one university among applicants belong to the former category. This means we focus on universities' claim of their share of IPRs, without distinguishing between exclusive ownership and co-ownership, as a result of the introduction of the Innovation Act and controls.

In a second set of regressions (multinomial logistic), we classify patents into three ownership categories, which result from a combination of the types of owners described in section 3. Each category is assigned a discrete value (from 1 to 3), as follows:

- Ownership by a PRO, either exclusive or jointly with a Company (OWNERSHIP=1)
- Exclusive ownership by a company (OWNERSHIP =2)
- University ownership, either exclusive or joint with a PRO or a company (OWNERSHIP= 3)

The main reason for not treating exclusive university ownership as a separate category, but only together with the case of joint ownership with PROs and companies, is that very few patents are assigned exclusively to universities. As explained in section 2, the most research-intensive among French universities usually host a CNRS or INSERM laboratory, which results in a relatively high number of patents jointly owned by the relevant PRO *and* the university. A more limited number of patents is jointly owned by a university and a company, too few for setting them apart, hence the decision to group all of them under the value OWNERSHIP=3. Similarly, the patents jointly owned by a PRO and a company are very few, so we decided to group them under the value

OWNERSHIP=1, which leaves all patents with value OWNERSHIP=2 as those where no public property (via a university or a PRO) is involved.[18]

4.2. The independent variables

Table 4.1 reports the relevant descriptive statistics for all regressors.

TABLE 4.1 HERE

Time-related regressors: the key explanatory variables of interest in the regression are:

- ACT: it takes zero value if the patent was applied for between 1994 and 1998 and value one in the following years (that is after the introduction of the Innovation Act).
- YEAR DUMMIES: In a different specification of the model we substitute the variable ACT with year dummies, taking 1999 as reference year.
- TTO: it takes a value equal to one if the patent was applied after the university had introduced an internal regulation regarding IPR and technology transfer matters, either internally or as external entities, and zero otherwise[19].

We expect ACT and TTO to bear a positive influence on the probability for UNI to take value 1 in the logistic regressions and for OWNERSHIP to take value 3 in the second series of (multinomial logistic) regressions. Similarly, when substituting year dummies to ACT, we expect dummies for years before 1999 to bear a negative and significant sign in both series of regressions.

[18] In an early version of this work, we employed five categories, the three of this study and two more including co-ownership between Companies and PROs and co-ownership between Companies and Universities. However, tests for independence of irrelevant alternatives rejected the latter.

[19] The TTO dummy is a university-specific one, which is based upon information on the opening year of TTOs in French universities taken from the BETA-EcoSc database. If a patent lists only one academic inventor, or several academic co-inventors from the same university, assigning a value to TTO is a straightforward exercise (this happens for 89% of the cases, that is 1552 out of 1744 patents). However, patents invented by more than one academic inventor from different universities may present us with the problem of choosing between different possible values for the TTO dummy, as long as the relevant universities opened their technology transfer office in different years. In these cases we first set aside university-owned patents, with just one university as assignee, and set the value of TTO according to information on the latter (2.3% of the cases). When this criterion cannot be applied, we select the most senior among the academic co-inventors of the patent, and set the value of TTO according to information on this senior scientist's university (5.3% of cases). This choice is based on the assumption that, at the time of the patent, the more junior co-inventors used to work with the most senior one at his/her university, either as PhD, PostDoc or young Assistant Professors, and moved on to their present institute later on. If this assumption proves untenable (the junior co-inventor's move to their present institute pre-dates the patent application), we assume that decisions on ownership attribution of the patent had been taken by the academic inventor from the university with the most expertise in handling IPR matters (the latter being measured by the total number of all patents produced by the university). This choice, which is highly subjective, applies only to 3.3% of the patents.

Institutional differences: We control for the academic inventors' affiliation to one or other type of academic institutions by turning such classification into a set of dummies, which are based upon the DEP/MENSER classification, according to the affiliation of the patent's inventor: *School of Engineering* (to which we add the *Grands Etablissements*, and the *Instituts Nationaux Polytechniques*), *Universities with Medical School, Universities without Medical School*, and *Scientific Universities.* If more than one academic co-inventor is listed on the same patent, and they come from institutes of different type, then the dummy takes value 1 according to the assigning procedure described in Footnote 11. The reference category is *Universities with Medical School.*

Size: We control for university size by classifying the various institutions as *largest, large, medium* and *small*, according to quartile distribution of the number of medical, science and engineering faculties in 2005.[20] We thus employ dummies for each size category. The reference category is *largest* and we expect such universities to be more likely than others to apply for patents in their own name, being better staffed when it comes to administrative issues. In addition, we expect such universities to have greater bargaining power *vis a vis* large PROs such as CNRS, when it comes to negotiations over IPR attribution.

Patent's technological field: This set of controls consists of dummies for the technology class of the patents, which we derived by elaborating a re-classification of IPC (International Patent Classification, used by the EPO) provided by the Observatoire des Sciences et des Techniques (OST, 2004). In particular, we use the following five dummies: *Pharma-Biotech, Instruments (Scientific and Measurement), Chemicals, Electronics* and *Machinery and Process Technologies*, the latter being the reference category.[21]

Regional dummies: Finally, we control for potential differences in the regional environment of the various universities by means of a set of 21 dummies, one for each mainland region of France.

5. Results and discussion

5.1 The binary model of patent assignment

[20] Note that information on faculty size relates only to 2005, the only year for which we have information on universities. In principle, professors' mobility may have been such that relative size in the past differed from that of 2005. However, the largest universities of the 1990s, such as Paris VI, Lyon I, Toulouse III, Grenoble I or Strasbourg I, were and still are the largest at the time we wrote the paper. Also, we found no mention in the literature of significant structural changes across French universities in the years of our interest.

[21] Table A.1 in the appendix provides a description of the technological classification employed in this study.

Table 5.1 reports the results of our logistic regression exercise on the probability of an academic patent being assigned to the inventor's university, either exclusively or jointly with another type of assignee (either a PRO or a company); for the sake of simplicity, we will often refer to this as a university's "*probability of patenting*". We report estimates of marginal effects of explanatory variables calculated as means for continuous variables and changes from 0 to 1 for dichotomous variables.

We employ four specifications. In column (A) we consider only the effect of the Innovation Act (ACT), while in column (C) we also test for the opening of a Technology Transfer Office in the inventor's university (TTO). In columns (B) and (D) we conduct similar exercises, but we substitute variable ACT with year dummies, with 1999, the year when the Act was passed, as the reference case (we expect dummies for years>1999 to be positive, and/or dummies for years<1999 to be negative).

Estimates in column (A) suggest a positive and significant effect of the Innovation Act on the probability that universities will apply for their inventors' patents; in particular, we estimate an increase of probability of around 5.7%.

The controls for university typology do not capture any variation in patent assignment.[22] However, the size of universities seems to matter, as we observe that small and medium universities' probability of patenting is respectively 5.3% and 6.8% lower than that of the largest universities (the reference case).

TABLE 5.1 HERE

Finally, universities are less likely to apply for patents in Electronics and Chemicals than in Pharma-Biotech, Scientific Instruments, and Machinery-Process Technology.

We interpret differences between Electronics and Chemicals on the one hand, and Pharma-Biotech and Scientific Instruments on the other hand, as resulting from differences in the inventive process and funding, and in the relationship between patented invention and commercial product.[23]

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[22] This result is not overly surprising as controls for technological fields are the strongest explanatory factor among our controls (see results for specification 2). At the same time we noticed earlier (Table 3.5) that university types differ for the technological fields in which their inventors sign patents.

[23] Patents in Electronics and Chemicals are more likely to originate from consultancy and contract research than happens in other fields, with commercial sponsors claiming all IPRs. In addition, patented inventions may cover only a small section of larger, more complex product and process technologies than in Pharmaceuticals or Instruments, where a

When substituting ACT with year dummies (column B), universities are found to be less likely to apply for patents before 1999: the dummies associated with the years between 1995 and 1998 are all negative and significant, while the year dummies after 1999 are not significant. Universities' probability of patenting before 1999 is estimated to be between 4% and 5.2% lower than in 1999 and afterwards. As for the other controls, they do not change much with respect to column (A).

Moving to column (C), we notice that the inclusion of TTO captures all the variation attributed to university size in columns (A) and (B); this is because, as expected, the larger universities were the first to open a technology office. The presence of a TTO increases a university's patenting probability to 5.6%. Note that controlling for TTO diminishes, but does not cancel or cut drastically, the impact of the Innovation Act (the marginal effect of ACT is only 1% lower in column C than in column A). Results on the technology classes of the patents do not change much.

The last specification (column D) confirms the results of the previous specifications: the opening of a TTO mitigates the effects of the Act and captures the variation due to university characteristics, while it does not affect other covariates' marginal effects.

The significance of ACT, along with the positive and significant impact of TTO, confirms the importance of institutional changes, both at the micro and macro levels, in increasing university administrations' IPRs awareness. Note that these results resist, and are corroborated, when we employ year dummies to control for the temporal consistency of the positive result found for ACT. We also find that the opening of a technology transfer office has the strongest impact among university characteristics on the decision to retain ownership over academic inventions.

TABLE 5.2 HERE

5.2 The multinomial model of patent assignment

Table 5.2 presents the results (estimated marginal effects) for multinomial logistic regressions. The three-value OWNERSHIP dependent variable allows us to assess whether the increase of patent ownership by universities (as described by the logistic regressions of section 5.1) has occurred at the expense of ownership by PROs and/or companies. We run two different specifications, which we indicate as (1) and (2). In both specifications we assess the effect of the Innovation Act jointly with

patent document may point more clearly to a marketable drug or scientific or measurement tool; the longer the distance between patent and product, the less interest the university may have in retaining the patent and trying to license it, as opposed to selling it straight away for a lump sum payment.

that of a university's opening of a TTO. In specification (1) we do so by means of the ACT dummy, whereas in specification (2) we make use of the year dummies, as described above. The results for each specification are reported in three separate columns, as we calculate and report the marginal effects of the independent variables for all three types of ownership considered, respectively PROs, Companies, and Universities.

The main results we obtain can be summarized as follows:

- The Innovation Act did not significantly diminish the probability for an academic patent to be owned by a PRO, and possibly increased it for a short while, other things being equal. While the marginal effect for ACT [specification (1), first column] is positive but not significant, the year dummies for year<1999 are all negative [specification (2), second column]. This suggests that in the 1990s, before the Act was introduced, PROs had a lower probability for reclaiming ownership or co-ownership of academic patents away from universities (remember that OWNERSHIP=1 in the case the academic patent is owned by a public organization, possibly jointly with a company, but not jointly with a university, in which case OWNERSHIP=3). The year dummy for 2001, however, also bears a negative and significant sign, which may suggest that the effect of the Act, besides being weak, may not have lasted long. It is also possible that the Act did not affect negotiations over IPR assignment between PROs and universities, whereas the more general reform of the relationships between the two (as described in section 2.2) did, albeit not consistently over time. This interpretation is coherent with the descriptive findings by Lissoni et al. (2008), who find that PROs' share of academic patents declined sharply through the 1980s and early 1990s (that is, before the Innovation Act) and bounced back, albeit limitedly, later on.
- Exclusive property of academic patents by companies (OWNERSHIP=2) appears to have been negatively affected by the Innovation Act, which diminished its probability by 7.3% [marginal effect of ACT, specification (1), third column]. This seems confirmed by specification (2) (fourth column), where marginal effects of year dummies show that the probability of having an academic patent in the exclusive hands of private parties was between 12% and 14.5% higher in 1994-1996 than in 1998 and the following years; in the latter, we observe some weak increases in 1998 and 2001.
- As for universities, the interpretation of the results is even more straightforward. As in the binary model (section 5.1), the probability of exclusive or joint ownership by universities increases after the Innovation Act, whether we consider specification (1) (fifth column) or specification (2) (sixth column). In the latter, we observe that universities' probability of patenting

is significantly lower between 1995 and 1998 than it is in 1999, and does not increase or decrease significantly later on.

Overall, these results suggest that the Act, and/or more generally, the political climate around universities and their mission, including IPR management, have made universities more aggressive in reclaiming their share of IPRs over academic patents from companies, but have not changed their attitude much towards PROs. Possibly, the latter have also increased their pressure on companies to share the IPRs over the inventions produced by academics (most likely, with the participation of PROs' personnel and/or in university-based, PRO-staffed laboratories). It is important to stress, however, that the number of patents exclusively assigned to universities is still limited. In order to increase their control over academic patents, universities have mainly obtained to share the property of such patents, especially with companies, which as a result are now less likely to be the exclusive assignees.[24]

When examining the effect of TTO, we find that the estimated effect for the TTO dummy is significant (and positive) for the probability of university ownership (last two columns of Table 5.2), but it is not significant (albeit negative, as expected) for the probability of PRO and company ownership (first four columns of Table 5.2). We explain the result as follows: the impact of TTOs on university ownership is significant *per se*, but it comes at the expense both of ownership by PROs and of ownership by companies; taken separately, these two negative effects are too small to be statistically significant (that is, when splitting the TTO effect on university ownership into two parts, neither parts are significant, although exclusive ownership by companies seems to decline the most).

The regression results in Table 5.2 also provide interesting information on the relationship between PROs, companies, and universities of different type and size. From the first and second columns, we note that the probability for an academic patent to be assigned to a PRO, and not to the inventor's university or a company, is around 8% lower for *Universities without Medical Schools* (compared to those with one); and around 11% lower for *Scientific Universities* (while *Schools of Engineering* do not differ much from *Universities with Medical Schools*). This is possibly because *Universities with Medical Schools* and *Schools of Engineering* depend more on PROs' funding and laboratories. At the same time, we note that academic patents from *large* universities are more likely to be retained by PROs than those from the *largest* ones (reference case) and small and medium ones. Companies appear to be more likely to obtain exclusive ownership of academic patents, when the latter come

[24] Given the limited number of academic patents co-applied for by universities and companies (34 out of 1744 patent applications in the whole sample), we were unable to test such a statement empirically. However, in the university-company academic patent subsample, only 13 (38.2%) were applied for between 1994 and 1998, whereas 56% of all academic patents were applied for during the same years.

from *Scientific Universities* (the marginal effect is around 14.8% in the third column, very much the same in the fourth). As with the logistic regression, university type does not affect the probability of university ownership.

The estimated marginal effects for technology dummies associated confirm the results and interpretation we described in section 5.1. Academic patents in Electronics and Chemicals are less likely to be reclaimed by universities (negative and significant marginal effects in fifth and sixth columns), and at the same time more likely to be assigned exclusively to companies (positive and significant marginal effects in third and fourth columns). PROs are also (weakly) less likely to reclaim property away from universities in these fields (first and second columns).

When it comes to Pharma-Biotech patents, however, PROs are more likely to reclaim property (exclusive or joint with companies), and companies less likely to obtain exclusive property. Note that the multinomial logistic exercise does not reproduce exactly the result we got from the logistic one, since we now find the probability of universities to retain or share the property of patents in this field is positive, but not significant. We also do not find significant differences in ownership patterns for patents over Instruments.[25]

6. Conclusions

In this paper we have dealt with French academic researchers' contribution to inventive activity between 1994 and 2002, as measured by patent applications at the EPO. In particular, we have assessed the impact of a major institutional change (the Innovation Act of 1999) over the ownership distribution of academic inventions. In addition, we have explored the concurrent effects of an important organizational change such as the diffusion of technology transfer offices, over the same years.

As for the distribution of academic patent ownership, we have confirmed what was found by other studies, such as Azagra-Caro et al. (2006) for the specific case of the University of Strasbourg, and Lissoni et al. (2008) for several European countries; namely, that universities own (or, more often, co-own) only a minor share of their scientists' patented inventions (around 11% over the whole period we considered). When we consider ownership or co-ownership by PROs, the share of

[25] We performed the Hausmann-McFadden (1984) and the Small-Hsiao (1985) tests to test for the Irrelevance of independent alternatives (IIA) assumption. Both tests support the IIA assumption.

academic patents in public hands over the period examined rises to around 33%, still much less than those controlled exclusively by business companies. This ownership distribution is due to institutional factors, and not to any peculiarity in the technological distribution of French academic patents; the latter, in fact, does not differ much from what was found by Mowery et al. (2001) for the USA, in an altogether different institutional setting.

The econometric exercise has shown that changes in the institutional and organizational settings, however, may have some noticeable impact, even in a complex academic system such as the French one. However, understanding these effects requires taking into account such complexity, which in France has mainly to do with the relationship between universities and PROs, and with the stratification of universities themselves, by type and size.

We have shown that the Innovation Act, which indicated technology transfer *via* commercialization as a mission for French universities and provided both incentives and recommendation to this end, has increased the probability that universities will reclaim (their share of) property rights over their scientists' inventions. The Act and its effects, however, fit into a more general trend of universities' involvement in IPR management of their scientists' inventions. In particular, we found that many universities' decision to open a technology transfer office pre-dates the Act and has exerted an even bigger effect than the latter. These results are in line with what Baldini et al. (2006) found for Italy, where universities increased the total number of patents applied for in their names after the adoption of internal IPR regulations, as required by a change in national legislation (such an adoption was contextual to the creation of a TTO).

Whether this more aggressive stance of French universities has been (or will be) beneficial in terms of technology transfer and societal welfare remains to be seen, our data being too limited in time and scope to provide information on this issue. Our findings suggest that any increase in universities' patenting rate may be due, at least in part, to a redistribution of ownership rights, rather than an increase in inventive activity. This interpretation is in line with the descriptive evidence provided in section 3. Although the number of academic patents has increased over time, the rate of growth has not exceeded the overall national growth rate, so the academic's share of total patents has not increased in a steady way. In order to check the robustness of this interpretation, we plan to repeat our assessment of academic patenting activity in the near future, based upon archival information on scientists active in more recent years, so to have a more reliable time series.

It may also be that by reclaiming their share of IPRs from companies, French universities will achieve little in terms of financial returns, or strategic control of the knowledge their inventors produce, at the cost of creating tensions with their industrial partners (and possibly their own faculty). Again, this is an important direction for future research.

One limitation of our exercise concerns the possibility of endogeneity in our estimates. In particular, it may be that the Innovation Act was anticipated by French universities, so that the effects of ownership redistribution we observe took place as a result of a strategic change, rather than as the mere results of the implementation of a legislative change. Similarly, it may be that the Act was meant more as a way of extending to some “conservative” universities the technology transfer practices already in place in more “entrepreneurial” ones. At most, however, these limitations may challenge the exact value of the marginal effects we estimated in our logistic and multinomial logistic regressions. They cannot detract from the general findings, which point to a change in the French policy climate during the 1990s, and to the resulting efforts of universities to control more tightly the IPRs over their faculty’s inventions.

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TABLES

Table 3.1: French academic patenting activity between 1994 and 2002

	Patents	Inventors	Patent Productivity
Total Inventors	53285	51839	1.028
Academic Inventors	1744	1208	1.444
Share of Academia	3.27%	2.33%	

Table 3.2: Distribution of French patents and academic patents, by technology class[§]

TECHNOLOGY CLASS	All patents, no. and % (A)	Academic patents, no. and % (B)	All inventors, no. (C)	Acad. inventors, no. (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 - 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%)	1744 (100%)	62226	1501°	3.27%	2.33%

[§] Patents are classified according to the DT7/OST reclassification of IPC (OST, 2004)

°The sum of all academic inventors exceeds their actual number, as given in Table 3.1, because some inventors patent in more than one technology class

Table 3.3: Distribution of academic patents by aggregated disciplines

AGGREGATED DISCIPLINES	Patents	Inventors	Professors
Mathematics	72	35	6270
Physics	125	67	2660
Chemistry	545	321	3829
Earth science	2	1	1090
Biology	356	228	5445
Life science	397	246	6181
Engineering	32	31	2052
Electronics	383	279	4324
All disciplines	1912	1208	31851

NOTE: The sum of all patents by discipline patents is higher than the actual number of patents, due to the fact that inventors from different disciplines appear as co-inventors of the same patents.

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

	TYPE OF APPLICANT					
TECHNOLOGY CLASSES	C	PRO	UNI	%C	%PRO	%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%
Pharmaceuticals	378	209	93	55,58%	30.74%	13.68%
Process engineering	110	40	25	62.86%	22.86%	14.28%
Machinery - transports	55	4	7	83.33%	6.06%	10.61%
Others	13	1	0	92.86%	7.14%	0.00%
Total	1515	469	222	68.68%	21.26%	10.06%

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

Table 3.5: Distribution of academic patents, by technology and type of inventor's university

	TECHNOLOGY CLASSES							
UNIVERSITY TYPE	*Elec.*	*Instr.*	*Chem.*	*Pharma.*	*Eng.*	*M&T*	*Others*	*All*
School of Engineering	30	27	54	23	30	8	0	172
	17.40%	15.70%	31.40%	13.40%	17.40%	4.70%	0.00%	100.00%
Grande Etablissement	21	8	5	5	1	6	1	47
	44.70%	17.00%	10.60%	10.60%	2.10%	12.80%	2.10%	100.00%
Inst. National Polytechnique	20	20	39	8	17	5	0	109
	18.30%	18.30%	35.80%	7.30%	15.60%	4.60%	0.00%	100.00%
University, with medical school	139	251	215	470	70	26	12	1183
	11.70%	21.20%	18.20%	39.70%	5.90%	2.20%	1.00%	100.00%
University, no medical school	24	35	71	25	13	10	0	178
	13.50%	19.70%	39.90%	14.00%	7.30%	5.60%	0.00%	100.00%
Scientific university	38	59	116	31	28	5	1	278
	13.70%	21.20%	41.70%	11.20%	10.10%	1.80%	0.40%	100.00%

El=Electronics; Instr=Instruments; Chem=Chemistry; Pharma= Pharmaceuticals; Eng=Process Engineering; M&T=Machinery & Transport

NOTE: The sum of all patents exceeds the actual number of academic patents due to the fact that patents can be invented by professors affiliated to different typologies of universities.

Table 4.1: Independent variables, descriptive statistics (all observations and by type of patent assignee)

		TOTAL		PROS		COMPANIES		UNIVERSITIES	
		Mean	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std Dev**
TIME-RELATED REGRESSORS	***ACT***	0.44	(0.50)	0.47	(0.50)	0.40	(0.49)	0.58	(0.50)
	1994	0.11	(0.31)	0.08	(0.27)	0.12	(0.32)	0.10	(0.30)
	1995	0.09	(0.28)	0.06	(0.24)	0.10	(0.30)	0.06	(0.25)
	1996	0.12	(0.32)	0.10	(0.30)	0.13	(0.34)	0.07	(0.26)
	1997	0.12	(0.32)	0.15	(0.36)	0.11	(0.32)	0.07	(0.26)
	1998	0.14	(0.35)	0.14	(0.35)	0.14	(0.35)	0.11	(0.32)
	1999	0.16	(0.37)	0.20	(0.40)	0.14	(0.34)	0.21	(0.41)
	2000	0.17	(0.37)	0.19	(0.39)	0.15	(0.36)	0.19	(0.39)
	2001 onwards	0.11	(0.32)	0.08	(0.27)	0.11	(0.31)	0.19	(0.39)
	TTO	0.64	(0.48)	0.61	(0.49)	0.63	(0.48)	0.77	(0.42)
UNIVERSITY CHARACTERISTICS	***Schools of Eng.***	0.15	(0.36)	0.12	(0.33)	0.17	(0.37)	0.14	(0.35)
	Univ. w/ Medical Schools	0.60	(0.49)	0.70	(0.46)	0.55	(0.50)	0.67	(0.47)
	Univ. w/out Medical Schools	0.09	(0.28)	0.06	(0.23)	0.10	(0.30)	0.06	(0.25)
	Scientific Univ.	0.16	(0.37)	0.12	(0.33)	0.19	(0.39)	0.12	(0.33)
	Largest	0.25	(0.43)	0.26	(0.44)	0.22	(0.42)	0.35	(0.48)
	Large	0.29	(0.46)	0.32	(0.47)	0.29	(0.45)	0.30	(0.46)
	Medium	0.37	(0.48)	0.36	(0.48)	0.39	(0.49)	0.25	(0.43)
	Small	0.09	(0.29)	0.07	(0.25)	0.10	(0.30)	0.10	(0.30)
PATENT TECH. FIELD	***Instruments***	0.20	(0.40)	0.18	(0.39)	0.21	(0.41)	0.20	(0.40)
	Pharma - Biotech	0.29	(0.45)	0.42	(0.49)	0.21	(0.41)	0.44	(0.50)
	Chemicals	0.14	(0.35)	0.10	(0.30)	0.17	(0.38)	0.10	(0.30)
	Electronic	0.25	(0.43)	0.20	(0.40)	0.29	(0.45)	0.12	(0.32)
	Machinery - Process Tech	0.12	(0.33)	0.10	(0.31)	0.12	(0.33)	0.15	(0.36)
	# Observations	1744		383		1157		204	

Table 5.1: Results of the Logistic regressions (parameter estimates are expressed as marginal effects§)

	(A)		(B)		(C)		(D)	
	Marginal effects	*Std. Err*	*Marginal effects*	*Std. Err*	*Marginal effects*	*Std. Err*	*Marginal effects*	*Std. Err*
Act	0.057***	0.014			0.047***	0.014		
1994			-0.022	0.021			-0.016	0.022
1995			-0.044**	0.019			-0.042**	0.019
1996			-0.051***	0.017			-0.049***	0.017
1997			-0.052***	0.017			-0.048***	0.017
1998			-0.040**	0.018			-0.040**	0.017
2000			-0.013	0.020			-0.018	0.018
2001 onwards			0.033	0.027			0.020	0.025
TTO					0.056***	0.015	0.056***	0.015
School of Engineering	0.073	0.049	0.068	0.047	0.034	0.041	0.029	0.039
University w/out Medical School	0.043	0.044	0.039	0.043	0.041	0.043	0.036	0.042
Scientific University	-0.026	0.023	-0.026	0.022	-0.025	0.023	-0.025	0.023
Large	0.001	0.021	0.000	0.021	0.018	0.023	0.016	0.023
Medium	-0.068***	0.023	-0.067***	0.023	-0.037	0.025	-0.037	0.025
Small	-0.053**	0.025	-0.050*	0.026	-0.012	0.039	-0.008	0.041
Pharma-Biotech	0.007	0.022	0.007	0.022	0.014	0.022	0.013	0.022
Instruments	-0.028	0.020	-0.029	0.019	-0.024	0.020	-0.025	0.019
Electronic	-0.054***	0.017	-0.054***	0.017	-0.049***	0.017	-0.050***	0.017
Chemicals	-0.080***	0.017	-0.078***	0.017	-0.074***	0.017	-0.073***	0.017
Regional Dummies	Included							
# Observations	1744							
Goodness-of-fit	$\chi2(315) = 436.3$***		$\chi2(732) = 906.9$***		$\chi2(362) = 519.0$***		$\chi2(787) = 1015.3$***	

(* = 10% significance, ** = 5% significance, *** = 1% significance).

§ Marginal effects are calculated at mean values for continuous variables and discrete changes from zero to one for dummies.

Table 5.2: Results of the Multinomial Logistic regressions (outcomes are expressed in marginal effects)

	PUBLIC RESEARCH ORGANIZATIONS				COMPANIES				UNIVERSITIES			
	(1)		*(2)*		*(1)*		*(2)*		*(1)*		*(2)*	
	Marginal effects	*Std. Err*	*Marginal effects*	*Std. Err*	*Marginal effects*	*Std. Err*	*Marginal effects*	*Std. Err*	*Marginal effects*	*Std. Err*	*Marginal effects*	*Std. Err*
Act	0.023	0.021			-0.073 ***	0.024			0.05 ***	0.015		
1994			-0.102 ***	0.029			0.125 ***	0.036			-0.023	0.021
1995			-0.098 ***	0.031			0.145 ***	0.036			-0.048 ***	0.018
1996			-0.067 **	0.032			0.12 ***	0.036			-0.054***	0.017
1997			0.013	0.037			0.037	0.041			-0.05***	0.018
1998			-0.028	0.033			0.071 *	0.037			-0.043**	0.017
2000			-0.018	0.032			0.038	0.037			-0.02	0.019
2001 onwards			-0.091 ***	0.03			0.076 *	0.039			0.015	0.025
TTO	-0.015	0.025	-0.013	0.025	-0.042	0.028	-0.044	0.028	0.057 ***	0.015	0.056 ***	0.015
School of Engineering	-0.03	0.045	-0.027	0.046	-0.003	0.056	-0.001	0.055	0.032	0.041	0.028	0.04
University w/out Medical School	-0.080 **	0.037	-0.086 **	0.035	0.042	0.052	0.055	0.051	0.038	0.043	0.031	0.042
Scientific University	-0.115 ***	0.027	-0.113 ***	0.027	0.148 ***	0.034	0.146***	0.034	-0.033	0.022	-0.033	0.022
Large	0.105 ***	0.039	0.108 ***	0.04	-0.131 ***	0.044	-0.13	0.044	0.025	0.024	0.022	0.024
Medium	0.053	0.043	0.055	0.043	-0.019	0.048	-0.02	0.048	-0.034	0.026	-0.035	0.026
Small	0.01	0.071	0.009	0.071	-0.001	0.077	-0.004	0.078	-0.009	0.042	-0.005	0.043
Pharma - Biotech	0.089 ***	0.04	0.077 *	0.04	-0.107 **	0.043	-0.095**	0.043	0.018	0.023	0.017	0.023
Instruments	-0.008	0.038	-0.015	0.037	0.033	0.041	0.041	0.041	-0.025	0.02	-0.026	0.02
Electronic	-0.064 *	0.036	-0.071 **	0.035	0.116 ***	0.039	0.123***	0.038	-0.051 ***	0.018	-0.052 ***	0.018
Chemicals	-0.035	0.035	-0.042	0.035	0.111 ***	0.038	0.118***	0.037	-0.076 ***	0.017	-0.076 ***	0.017
Regional Dummies	Included											
# Observations	1744											
Goodness-of-Fit	Specification (1) : $\chi2(38) = 226.63$***						Specification (2) : $\chi2(50) = 252.3$***					

(* = 10% significance, ** = 5% significance, *** = 1% significance)

[§] Marginal effects are calculated at mean values for continuous variables and discrete changes from zero to one for dummies.

FIGURES

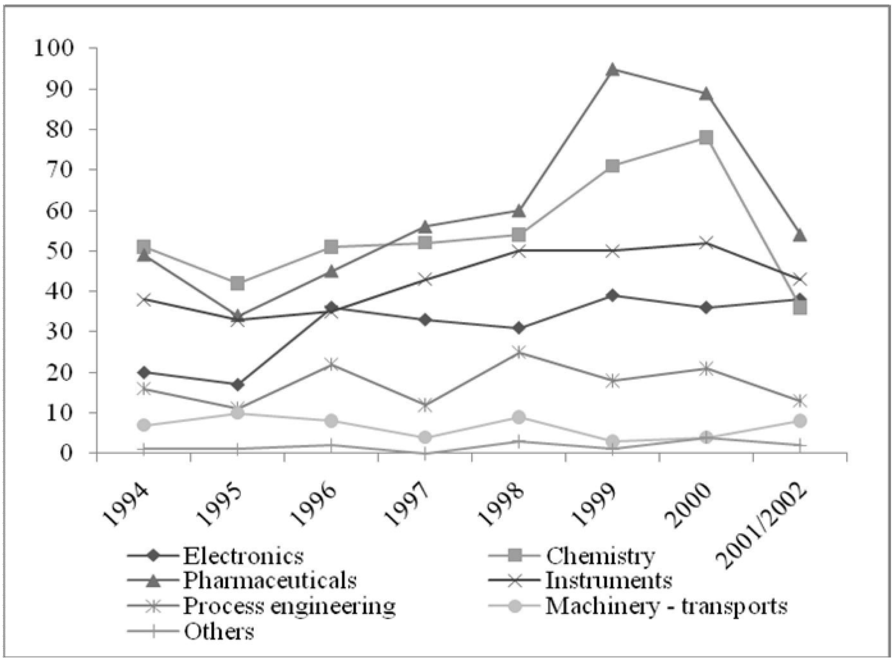

Figure 3.1: Number of academic patents by technological class, 1994-2001/02

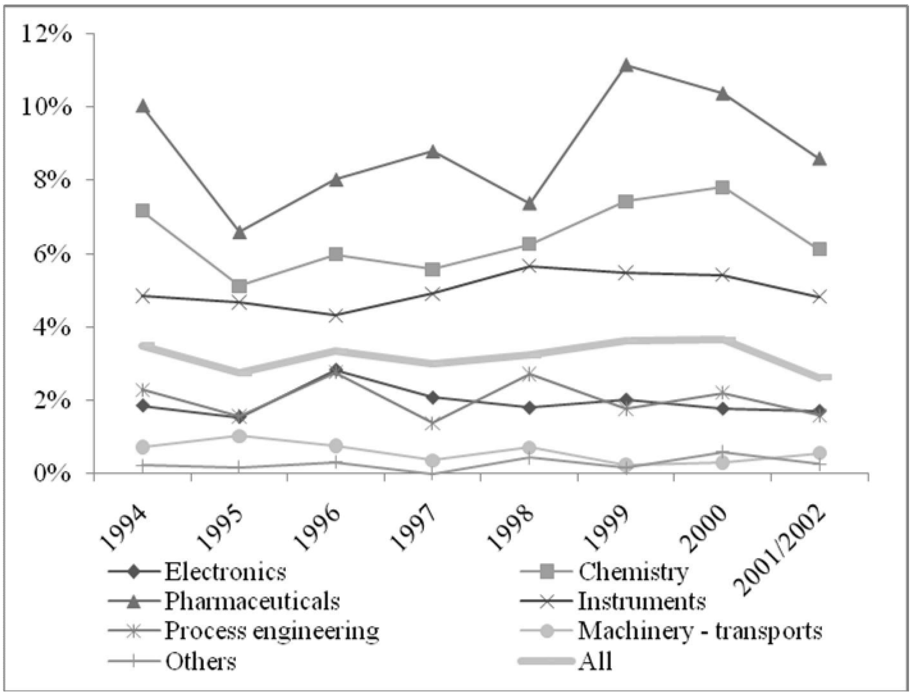

Figure 3.2: Share of academic patents over all patents, by techn. class, 1994-2001/02

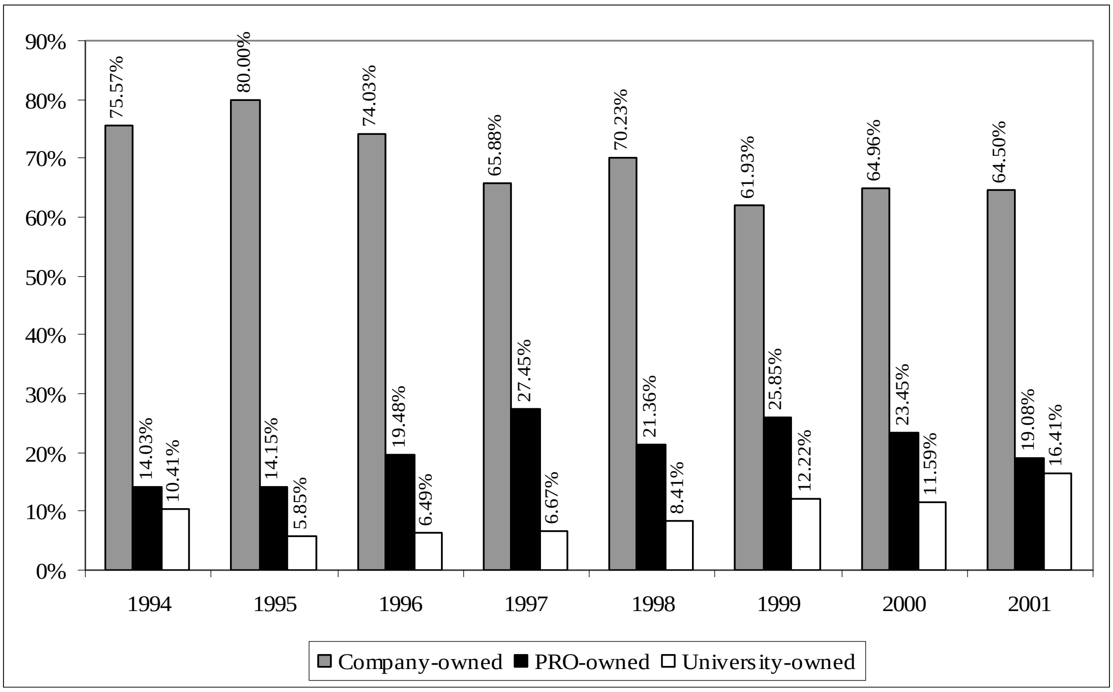

Figure 3.3: Property distribution of academic patents over time