Academic Patenting in Europe:

New Evidence from the KEINS Database

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Abstract. The paper provides summary statistics from the KEINS database on academic patenting in France, Italy, and Sweden. It shows that academic scientists in those countries have signed many more patents than previously estimated. This re-evaluation of academic patenting comes by considering all patents signed by academic scientists active in 2004, both those assigned to universities and the many more held by business companies, governmental organizations, and public laboratories. Specific institutional features of the university and research systems in the three countries contribute to explain these ownership patterns, which are remarkably different from those observed in the US. In the light of these new data, European universities' contribution to domestic patenting appears not to be much less intense than that of their US counterparts.

1. Introduction[1]

This paper reports key statistics from the KEINS database, which shed new light on the patenting activity of universities and their staff in France, Italy, and Sweden. Created by the authors, along with Ingrid Schild of Umea University, the KEINS database allows the first cross-country comparison of university patenting patterns in Europe.

The KEINS database covers inventions produced by academic scientists in active service around 2004-2005 in the three countries considered, for which a patent application has been filed at EPO. In particular, it contains both the applications submitted by universities (university-owned patents) and the applications submitted by companies, individuals or governmental and no-profit organizations, as a result of various contractual arrangements between such organizations and the scientists, their universities, and other public or private sponsors (university-invented patents). For sake of clarity, we will speak of "university patenting" when referring to university-owned patent applications, and to "academic patenting" when referring to both university-owned and university-invented patent applications.

The key intuition behind the KEINS data collection effort is that, due to institutional differences, academic patents in Europe are much less likely to be owned by universities than in the USA. These institutional differences concern both the autonomy of universities, the control they exercise over their academic staff, and the legal norms on the assignment of intellectual property rights (IPR) over academic research results; they make European universities much less likely than US ones to own the patents over their scientists' inventions, either because of lower incentives to patent or because of less control over their scientists' activities. This does not mean that European academic scientists do not contribute effectively to the inventive activity taking place in their countries, as one could gather by looking only at the statistics on university-owned patents.

[1] The KEINS database and the present papers are part of the KEINS project on "KNOWLEDGE-BASED ENTREPRENEURSHIP: INNOVATION, NETWORKS AND SYSTEMS", sponsored by the European Commission (contract nr. CT2-CT-2004-506022). Besides the auhtors, many other other people contributed to the database: Julien Penin and Muge Ozman (BETA-Université "L.Pasteur") for the French section; Ingrid Schild and Cecilia Yttergren (Umea Univ.) for the Swedish section; Antonio Della Malva and Christian "Troubleshooter" Catalini (CESPRI-Bocconi); GianPaolo Ziletti, Samuela Bellini, Riccardo Cropelli, Roberto Giusto, and Massimiliano Perini, (University of Brescia). The original data on patents and inventors at the basis of the KEINS database come from the EP-CESPRI database, which is also the result of a collective effort: Lorenzo Cassi, Stefano Breschi, Fabio Montobbio, and Gianluca Tarasconi are among those who have most contributed to it. Participants to the KEINS workshops held in Lisbon (CISEP, Instituto Superior de Economia e Gestão, Universidade Técnica de Lisboa, October 2005) and Jena (Max Planck Institut, March 2007) provided useful comments to successive drafts of the paper, which also benefitted from discussions at the UNI-KNOW / RIDE workshop "Universities as Knowledge Environments of the Future" (Chalmers University, GÖTEBORG -11-12 December 2006), and at seminars in Eindhoven (ECIS- Eindhoven Centre for Innovation Studies, Technische Universiteit Eindhoven, October 2006) and Bergamo (PhD in Economics and Management of Technology, Faculty of Engineering, May 2007). Responsibility for errors and omissions remains with the authors.

The data provided and discussed in this paper will show that the extent of academic scientists' contribution to national patenting in the France, Italy, and Sweden is very similar to what found for the US by other authors. Similarities also exist in the technological contents of academic patenting. What differ are the ownership regimes: as opposed to the US, where universities own the majority of academic patents, Europe witnesses the dominance of business companies, which own no less than 60% of academic patents. In France, and to a lesser extent in Italy, a sizeable share of academic patents is also owned by large governmental research organizations, a result which by the fact that these organizations, contrary to what happens in the US after the Bayh-Dole Act, retain the IPRs over the academic research they fund.

These results provide an interesting contrast with the common perception of European academic research as lagging behind the US one in terms of contribution to technological advancement, a perception that has shaped many recent changes in legislation and governmental policies not only in the three countries considered here, but all over Europe.

In the remainder of the paper, we first discuss existing attitudes towards academic patenting in Europe, and argue that they are based on poor data, and poor data collection methodology (section 2). Then we move on to describe the KEINS database, first the methodology upon which it is based (section 3) and then the evidence it provides (section 4). Finally, we discuss the policy implications of our evidence, as well as our plans for future research based upon the KEINS database.

2. Academic patenting in Europe and the US

Academic patenting is an important part of the larger phenomenon of university-industry technology transfer. In particular, patents are a key tool for protecting innovation in a number of science-based technologies, such as chemicals, pharmaceuticals, biotech, and many fields of electronics. Academic scientists contribute to these technologies both indirectly, by widening the science base, and directly, by producing inventions susceptible of industrial application, and therefore protected by patents.

In recent years, many European countries and the EU have introduced many legislative changes and policy initiatives aimed at pushing universities to take more patents out of their research, due to perceived problems in Europe and perceived advantages in USA with respect of technology transfer *via* patenting.

These initiatives have been based on little or no data, beyond cursory looks at the large number of patent applications filed by US universities, as opposed to the very low numbers coming from European universities.

Recent research, however, suggests that contrasting university-owned patents in Europe and the US is a very misleading methodology, due to differences between inventorship and ownership of patents.

2.1 A perceived patenting gap, and the remedies to it

In the past half a century, the number of USPTO patents applied for by US universities has increased dramatically, even more than the total number of USPTO patent applications. As a result, the weight of US universities' patents over total US domestic patents has increased from less than 1,5% in 1975 to almost 2,5% in 1988 (Henderson et al., 1998); or, even considering only the leading institutions (the so-called Research Universities), from 0.3% in 1963 to nearly 4% in 1999 (Mowery and Sampat, 2005).

This growth has appeared to gain strength after the introduction of the Bayh-Dole Act in 1980, which granted to universities all IPRs over federally funded research, and to have benefited from the general strengthening of patent protection, as well as from generous funding of academic bio-medical research (Mowery et al., 2004). Over the same years, many US companies in science-based industries (often born as university spin-offs) have multiplied and grown rapidly, while many European large hi-tech companies have opened research facilities near US campuses, or acquired US universities' technologies and start-ups. Although never proved, a connection seemed to many to exist between the explosion of university patenting and the hi-tech boom of the 1990s.

By contrast, university patenting in Europe seems a limited phenomenon. Although no systematic attempt of measurement has ever been made, it is a well-known fact that no European academic institution holds as large a patent portfolio as MIT or Stanford, and that many European universities do not have patents at all (OECD, 2003).

This contrast between US and Europe has often been interpreted in the light of the general view of the existence of a "European Paradox", according to which European countries have a strong science base, but also many problems in translating scientific advances into commercially viable new technologies (EC, 1995 and 1993; Dosi et al., 2005). In this view, universities contribute to the European Paradox by disregarding or mis-managing technology transfer activities. Hence, the problem to be fixed is the university patenting and the university support structure to stimulate patenting and related entrepreneurship activities.

In this view, the scarcity of university patents is both a signal of a technology transfer deficit and a problem to be addressed through legislation. Examples of recent legislative initiatives by European countries in the direction of encouraging patenting abound. Many of them revolve around the so-called "professor's privilege" or "Hochschullehrerprivileg", a long-standing norm of the German patent law that allowed academic scientists to retain IPRs over the results of research paid for by their universities (as opposed to R&D employees of business companies and public labs, whose research results belong by default to their employers). Based upon the intuition that universities would be better positioned to exploit their IPRs than individual professors (and therefore would have higher incentives to patent), German legislators abolished the professor's privilege in 2001, and were quickly followed by their Austrian colleagues in 2002. In 2000, Denmark had already abolished the privilege as part of a comprehensive "Act on Inventions at Public Research Institutions", aimed precisely at increasing university patenting. In the same years, Sweden considered its abolition, too (PVA-MV, 2003).

In 2001, Italian legislators *introduced* the professor's privilege, on the basis of the opposite intuition that individual scientists may have a greater incentive to patent than the university that employ them[2].

In addition, initiatives to increase academic scientists' awareness of IPR issues have been regularly launched throughout Europe in the past 10 years or so. Sweden opened the way in 1994, along with the creation of a number of "Technology Bridging Foundations" (Goldfarb and Henrekson, 2003). This was followed by multiple public policy initiatives to encourage academic patenting and university supporting institutions, with a recent example being the Swedish Agency for Innovation Systems (VINNOVA) programme on developing competencies of universities as key actors[3].

As for Italy, Baldini et al. (2006) describe how universities were encouraged by government to adopt explicit IPR policies throughout the 1990s. For France, Gallochat (in OECD, 2003) mentions IPR awareness campaigns as part of new legislation aimed at improving the commercialization of university-invented technologies. Other contributors to the OECD (2003) report on university patenting mention similar initiatives in other European countries.

[2] See also footnote 2

[3] See: http://www.vinnova.se/In-English/Activities/Commercialisation-/The-Key-Actors-Programme/

2.2 Is the patenting gap really there?

All these initiatives to stimulate patenting by universities and university staff, however, were based on scattered or no data at all. Most information on university patenting came either from surveys submitted to university technology liaison offices or from cursory looks at the identity of patent assignees. These methodologies for data collection ignore the specific institutional features of European universities.

In countries where the professor's privilege had a long standing tradition, individual academic scientists disposed freely of their IPRs, so that we can expect most patents to be applied for in scientists' names, or in the name of the business companies with which the scientists entertained consultancy or research cooperation links.

More generally, and also in countries where the privilege never existed, most European universities have for long lacked the autonomy and administrative skills typical of their US counterparts[4]. They traditionally resisted being involved in their professors' patenting activities, and took the shortcut of allowing scientists engaged in cooperative or contract research with various business companies or PROs to sign blanket agreements that left all IPRs in the professors' and their research partners' hands.

The wave of IPR-related reform initiatives we mentioned above is too recent for having changed radically these attitudes. In addition, these initiatives have been directed only at the surface of the phenomenon (the universities' technology transfer strategies), and not at the core issue of universities' autonomy. In many European countries (such as France and Italy) professors are civil servants, whose careers, teaching loads, research opportunities, and wages depend as much (if not more) on ministerial rules applied at the national level, as on local university strategies and management decisions. Similarly, universities rely much more on funding from the national government than on self-financing of any kind; in addition, such funding comes mainly in the form of block grants, rather than through competitive bids for mission-oriented financing (Geuna, 1999). As a result, academic scientists have little incentives to disclose their inventions to their universities' administrations, and the universities administrations lack the incentives to chase for disclosures. Although, in principle, professors-civil servants could be forced by governments to disclose their inventions and even dedicate their time to develop, this can be hardly done in

[4] See footnote 1 for references

practice, due to the physical and cognitive distance that separate the individual scientist from any ministerial bureaucracy in charge of controlling/promoting technology transfer.

Finally, in countries with a public research system dominated by large public laboratories and governmental agencies (such as France and, until a few years ago, Italy), the latter used to retain control over the IPRs on the academic research they funded. Scanning any list of French patent assignees, one can spot many occurrences of CNRS (the National Centre of Scientific Research) or INSERM (the National Institute of Health and Medical Research), whose many laboratories are often placed inside universities and rely on the contribution of academic scientists. As for Italy, one can find many patents owned by CNR (the Italian equivalent of CNRS) and ENEA (the National Agency for Energy and Environment).

These considerations suggests that a large part of academic patents in Europe may simply escape the most commonly available statistics, which classify the origin of the patent according to the identity of the grantees or applicants, rather than of the inventors. If this is true, traditional comparisons with the US may be proved to be misleading, insofar they exaggerate the scarcity of academic patents in Europe.

Following this clue, Meyer (2003) for Finland, and Balconi et al. (2004) for Italy have re-classified patents by inventor, and matched the inventor's names with available datasets on university faculties. They found out that in both countries a significant percentage of the business companies' patents originate from academic inventors (3% of EPO patents in Italy, 8% in Finland). CNR and VTT (the two most prominent PROs of Italy and Finland, respectively) also hold many patents signed by academic inventors.

Attempts to measure the number of academic patents in Germany have relied on a thinner tactic, namely that of looking for the academic title "Professor" in the inventor's field of patent applications, a title which, in Germany, is awarded only to academics with tenured positions. Schmiemann and Durvy (2003) suggest that, according to this kind of calculation, 5 percent of German patents at EPO can be attributed to universities. Gering's and Schmoch's (2003) calculations suggest that academic inventors' patents at the German patent office have grown from about 200 to almost 1800 between 1970 and 2000.

Most recently, US researchers have also attempted to measure university-invented patents as opposed to university-owned ones. In a paper aimed at evaluating the impact of patenting on academic scientists' productivity, Fabrizio and DiMinin (2005) examine a sample of 150 "academic inventors" active in 1975–1995, and find that, of 250 patents applied for in 1995, around 20% were assigned to business companies, while the remaining were almost all assigned to universities (a negligible number was assigned to the individual inventors). For a much larger sample of 2900 US academic inventors, Thursby et al. (2006) find a similar distribution: 62.6% of patents assigned to universities and no-profit organizations, 26.0% to business companies, 5.6% to individual inventors, 4.0% co-assigned to a university and a business companies, and 1.7% held by a governmental sponsor. In this case, data span from 1993 to 2004, and no trend in the proportion between university-invented and university-owned patents is visible.

These figures suggest that academic patents, invented but not owned by universities, are not a peculiar feature of European countries, as they exist also in the US. However, these same figures suggest that the proportion of university-invented patents over total academic patents may be higher in Europe than in the US. For example, Balconi et al.(2004) found that over 60% of Italian academic patents in the hands of industry, almost three times the share calculated for the US.

In what follows we extend the methodology pioneered by Balconi et al. (2004) to France and Sweden, and update the Italian data; this same methodology can and will be extended soon to other European countries, such as the Netherlands and England. At the same time, we show that differences in university ownership of academic patents exist not only between the US and Europe, but also among the three European countries considered here, and that they are largely explained by institutional differences across the university and science systems.

3. The KEINS database

The KEINS database originates from the EP-INV database produced by CESPRI-Università Bocconi, which contains all EPO applications, reclassified by applicant and inventor; and from three lists of university professors of all ranks (from assistant to full professors), one for each of the above mentioned countries (PROFLISTs). Academic inventors have been identified by matching names and surnames of inventors in the EP-INV database with those in the PROFLISTs, and by checking by e-mail and by phone the identity of the matches, in order to exclude homonyms.

3.1 The EP-INV database

The EP-INV dataset is part of the broader EP-CESPRI database, which provides information on patents applied for at the European Patent Office (EPO), from 1978 to January 2005. The EP-

CESPRI database is based upon applications published on a regular basis by the *Espacenet Bulletin* and is updated yearly; presently, it contains about 1,500,000 patent applications. Data relevant for this paper fall into three broad categories:

1. *Patent data*, such as the patent's publication, its priority date, and technological class (IPC 12-digit).
2. *Applicant data*, such as a unique code assigned by Cespri to each applicant after cleaning the applicant's name, plus the applicant name and address.
3. *Inventor data*: such as name, surname, address and a unique code (CODINV) assigned by Cespri to all inventors found to be same person (see below).

The creation of information in category 3. followed three steps, which Lissoni et al. (2006) describe in detail, and we summarize as follows:

FIRST, the standardization of names and addresses (in order to assign a unique code to all inventors with the same name, surname, and address);

SECOND, the calculation of "similarity scores" for pairs of inventors with the same name and surname, but different addresses;

THIRD, the identification (by country) of a threshold value for the similarity score, over which two inventors in a pair are considered the same individual, and assigned the same unique code CODINV.

3.2 National PROFLISTs

Parallel to the creation of the EP-INV database we proceeded to the collection of biographical information on academic scientists in the three countries of interest. The collection effort was directed at medicine, the natural sciences and engineering.

Each PROFLIST comes with a highly idiosyncratic disciplinary classification systems (in the case of Sweden we have indeed two classification systems, which overlap only partially, and are not exhaustive of the professors' list). For the purposes of the KEINS project we produced an 18-class disciplinary classification, loosely based on the French classification system, to which each national classification can be converted (see Lissoni et al., 2006). Similarly, each PROFLIST comes with a different classification system for academic ranks, and it may or may not include non-tenured staff.

Three partner teams were involved at this stage of the KEINS project: CESPRI, BETA and CHALMERS. CESPRI produced the Italian PROFLIST, starting from data already published in Balconi et al. (2004). Those data were based on the complete list of all Italian university professors (assistant, associate, full) active in 2000, provided by the Italian Ministry of Education. A new list, updated to 2004, was obtained from the Ministry [5]. Professors in the two lists did not come with a common code, so CESPRI matched them in the 2000 and 2004 lists by surname, first name, and the date of birth[6].

BETA compiled a French PROFLIST also based upon Ministerial records and similar to the Italian one. The French PROFLIST, however, is the result of separate records for the medical and nonmedical disciplines (only scientific and technical ones). It also refers to tenured academic staff, ranked either as "maitre a conference" or "professeur", active in 2005.

Swedish academic personnel are not civil servants, so no list of university professors could be obtained from the Swedish Ministry of Education. Ingrid Schild (Dept. of Sociology, Umea Univ.) took upon her the task of collecting lists of personnel from as many Swedish academic institutions as possible, and to work with CESPRI in order to standardize and integrate them. Lissoni et al. (2006) provide an inventory of all Swedish universities, pointing out those that contribute or not to the Swedish PROFLIST. Most of the non-contributing ones do not host scientific or technical faculties, and hence the list is quite comparable to the French and Italian one, for the purposes of our research.

A major drawbacks of the Swedish PROFLIST is that many universities provided lists of personnel that included both tenured and non-tenured staff, and in a few cases even technical and administrative staff. We decided to remove from the original lists the administrative and technical staff, but decided to keep the academic, non-tenured staff, for the main reason that it was not always easy to tell them apart from their tenured colleagues. As for the latter, they come classified according to four positions: professor (full or chair professor), senior lecturer ("lektorate"), associate professor ("docent"), and junior lecturer or assistant professor ("forsk lektorate"). However, individual universities' lists may include some idiosyncratic variations, reflecting either linguistic or organizational specificities.

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[5] Thanks to Margherita Balconi's kind help.

[6] Whatever their rank, Italian professors both in public and private universities are tenured civil servants, recorded for all administrative purposes in the Ministry's list. However, the Ministry does not keep central records of PhD students nor of the numerous contract-based researchers and instructors who populate Italian universities.

As a result, we will often refer to all academic personnel in the three countries as "professors", by which we mean both professors and lecturers, as well as both tenured and not-tenured positions. This will be done for sake of simplicity and in order to stress that our statistics do not refer to PhD students or post-doc researchers.

3.3 From the EP-INV to the KEINS database: inventor-professor matching

The identification of academic inventors was pursued in two steps. We first matched inventors from the EP-INV database with professors in the national PROFLISTs, by name and surname, and then sent e-mails and/or made phone calls to the resulting matched professors to ask for confirmation of their inventor status.

Whenever the matched inventor was found to be designated on at least one patent application by either a university, a public research organization, or a non-profit institution - known for sponsoring academic research - we concluded that the professor-inventor match was a sound one (i.e. not a case of homonymy) and could be retained as a "true" academic inventor, with no need of e-mail or phone confirmation.

For example, in the case of French non-medical professors, prior inspection of the patent applicant's identity allowed to confirm 1116 academic inventors and 164 academic co-inventors, for a total of 1'148. The remaining 3025 professor-inventor matches had to be checked by contacting the relevant individuals through e-mail or phone. This in turn required first to retrieve the e-mail address or phone number of the professors[7].

While for Italy and Sweden we managed to check up to 90% of professor-inventor matches, the large number observations for France forced us to limit our check only to the professor-inventor pairs whose latest patent was filed after 1993; this was done in order to maximize our chances that the inventors would still be active and reachable. As a consequence, cross-country comparisons based on the KEINS database are most meaningful when based only on patent applications filed after 1993, and inventors still active after that year.

Table 1 report the populations of patent applications, inventors, and professors in the three countries considered, both for the entire period considered (1978-2004) and for the interval over which French data, and related comparisons, are more reliable (1994-2004).

[7] For more methodological details, see Lissoni et al. (2006)

Table 1. EPO patent applications, inventors, and professors in France, Italy, and Sweden

	Patents[1] (1978-2004)	Patents[1] (1994-2004)	Inventors[1] (1978-2004)	Inventors[1] (1994-2004)	Professors[2] (active in 2004)
France	114052	53285	98035	51804	32006
Italy	51487	27446	37692	23029	32886
Sweden	29148	15361	25660	14807	12175

Sources: [1]EPO-Cespri database; [2] Ministerial records (France and Italy); own elaborations on universities' records (Sweden)

4. Results

4.1 Academic scientists' patenting activity

Table 2 reports estimate of academic patenting intensity in the three countries, as measured by the ratio between academic inventors and university professors active around 2004, in the natural sciences and engineering. The third and fourth column report respectively the number and the percentage of professors who have confirmed to be inventors; the fifth and sixth columns report analogous figure for the professors that did not deny to be inventors, that is those that confirmed and those that were either unreachable or refused to answer our questions. In other words, the third and fourth columns provide a lower bound estimate of academic inventorship, while the fifth and sixth an upper one.

"Confirmed" academic inventors professors amount to over 4% of tenured academic personnel in Sweden, where e-mail and phone contacts allowed us to check almost all the professor-inventor matches based upon names and surnames. The same figure for Italy (where e-mail and phone investigations were also very successful) and France is slightly less than 4%.

However, French data certainly approximate the true figure from far below, because the inventor-professor positive matches were so many (and the information provided by universities' website so poor) that we find it impossible to check all matches. So, we decided to concentrate on checking matches that involved more recent patents, and contacted only the professors which our data suggested to have signed at least one patent application filed after 1993. As a result, the gap between the lower and upper estimate of academic inventorship for France is much higher than that for the other two countries (the upper-bound estimate is over 5%); this is especially true for patenting activity before 1994 and suggests that international comparisons involving France are reliable only after that year.

Table 2. Academic inventors in France, Italy, and Sweden

	Professors (nr) [1]	Academic inventors (nr) [2]	Academic inv. (% of prof.) [2]	Academic inv., incl. unchecked (nr) [3]	Academic inv., incl. uncheck.(% of prof.)[3]

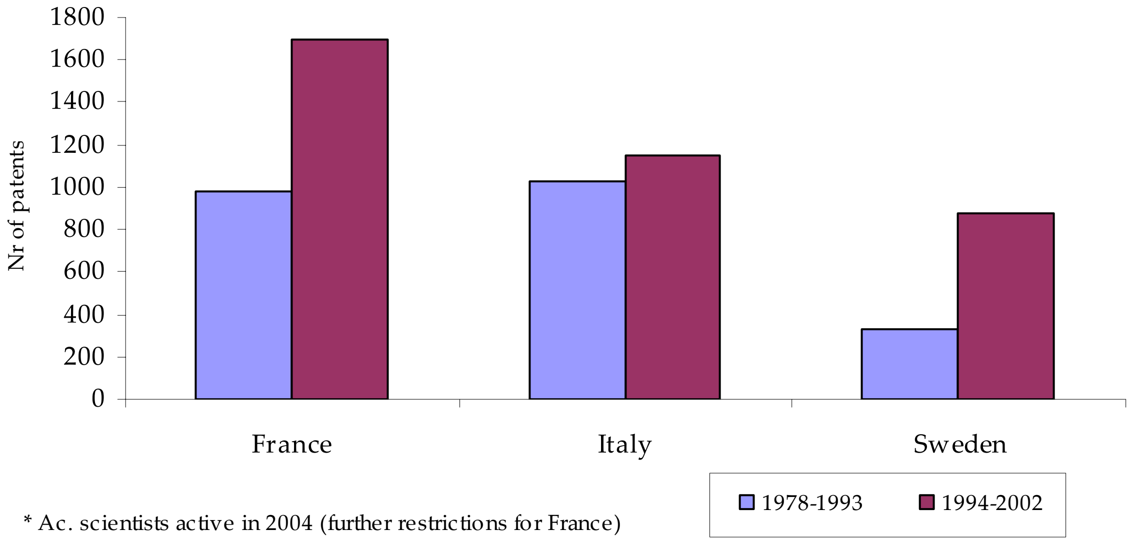
France	32006	1228	3,84	1859	5,81
Italy	32886	1268	3,86	1313	3,99
Sweden	12175	503	4,13	530	4,35

[1] Professors active in 2004 (Italy, Sweden) or 2005 (France). Professors are defined here as: Assistant, Associate, and Full Professors (Italy); "Maitre a conference" and Professor (France); "forsk lektorate", "docent", "lektorate" and full professor (Sweden).
[2] Data from checked professor-inventor matches (professors confirmed to be the inventors)
[3] All records, checked and unchecked (excl. records for which professors denied being the inventors)

From now on we will consider figures based only upon "confirmed" academic inventors.

As shown in figure 1, these academic inventors are responsible for over 2600 patent applications in France, 2100 in Italy, and 1200 in Sweden. Figure 1 also shows how figures for France are much higher for the 1994-2002 time interval, over which the KEINS database for France, as said above, is much more reliable.

Figure 1. Academic patent applications*, by country; 1978-2002



* Ac. scientists active in 2004 (further restrictions for France)

Table 3a shows that in disciplines traditionally close to technological applications, the share of academic inventors may be quite high. In Italy and France, 11% and 9% of university professors of Chemical Sciences hold at least one patent application, while figures for Engineering and Biological science are over 5% and 4% respectively. Figures for Sweden are similar, but less reliable, due to the absence of a proper disciplinary classification for a large number of academic scientists in our PROFLIST.

Table 3a. Academic inventors as % of total professors[1], by discipline

Disciplines	Sweden	Italy	France	All
n.a.	3,6	-	-	3,5
Agricultural & Veterinary	3,9	1,8	n.a.	2,1
Biological sciences	8,1	4,2	4,2	4,5

Chemical sciences	10,2	10,8	8,6	9,7
Earth sciences	0,0	0,3	0,1	0,2
Engineering	4,5	5,5	5,1	5,2
Math and info science	0,9	1,6	0,6	0,7
Medical sciences	4,3	1,9	4,0	2,8
Physical sciences	5,6	2,7	2,4	2,8
ALL DISCIPLINES	*4,2*	*3,9*	*3,9*	*4,0*

[1] Professors active in 2004 (Italy, Sweden) or 2005 (France)

The distribution of academic inventors across disciplines also confirm the importance of Chemical and Biological Sciences (especially for Organic Chemistry, Life sciences, and, to a lesser extent, Chemical and Biological Pharmacology), along with Engineering and Medical Sciences (especially for Electronic Engineering and Medical Life Sciences; table 3b).

Table 3b. Academic inventors[1], % distribution by discipline

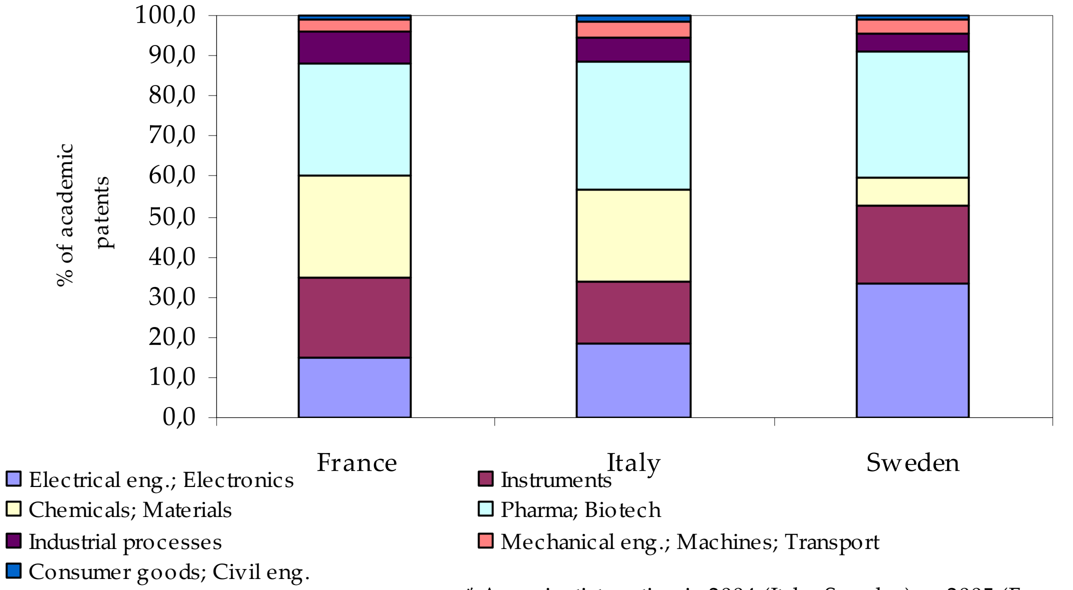
Disciplines	Sweden	Italy	France	All
n.a.	38,1	0,0	0,0	6,5
Agricultural & Veterinary	2,3	2,9	0,0	1,6
Biological sciences	11,3	17,2	18,6	16,8
Pharmacology & pharmacol. biology	*4,9*	*4,1*	*5,3*	*4,7*
Life sciences (biological disciplines)	*2,9*	*12,0*	*10,7*	*9,9*
Biological disciplines (others)	*3,5*	*1,2*	*2,7*	*2,2*
Chemical sciences	9,8	27,7	26,7	24,3
Chemistry (theoretical)	*6,3*	*8,0*	*4,0*	*6,1*
Organic & Industrial Chem.	*3,5*	*12,5*	*19,0*	*13,7*
Pharmaceutical chemistry	*n.a.*	*7,2*	*3,6*	*4,5*
Earth sciences	0,0	0,3	0,1	0,2
Engineering	18,6	28,8	26,2	26,0
Mechanical & Civil eng.	*3,9*	*4,7*	*2,8*	*3,8*
Information & Electronic eng	*10,4*	*15,1*	*17,7*	*15,4*
Chemical eng.; Energy	*4,3*	*9,0*	*5,6*	*6,8*
Math and info science	1,2	0,9	2,8	1,8
Medical sciences	13,9	16,8	20,1	17,7
Life sciences (medical)	*5,3*	*7,4*	*10,5*	*8,3*
Medical disciplines (others)	*8,6*	*9,4*	*9,6*	*9,3*
Physical sciences	4,7	5,4	5,5	5,3
ALL DISCIPLINES	100	100	100	100

[1] Professors active in 2004 (Italy, Sweden) or 2005 (France)

The technological distribution of academic patents in our three countries reflects the distribution of academic inventors across discipline, and resembles closely previous findings on US university patents. Based upon the DT-7 re-classification of IPC codes proposed by the *Observatoire des Sciences et des Techniques*, figure 2 shows that over 30% of applications are for Pharmaceutical and Biotechnological patents, while around 15% are in the field of Scientific and Control Instruments.

In France and Italy, the second most important technological filed is that of Chemicals and Materials, while in Sweden this position is taken by Electrical Engineering and Electronics.

Figure 2. Technological distribution of academic patent applications*, by country; 1994-2002



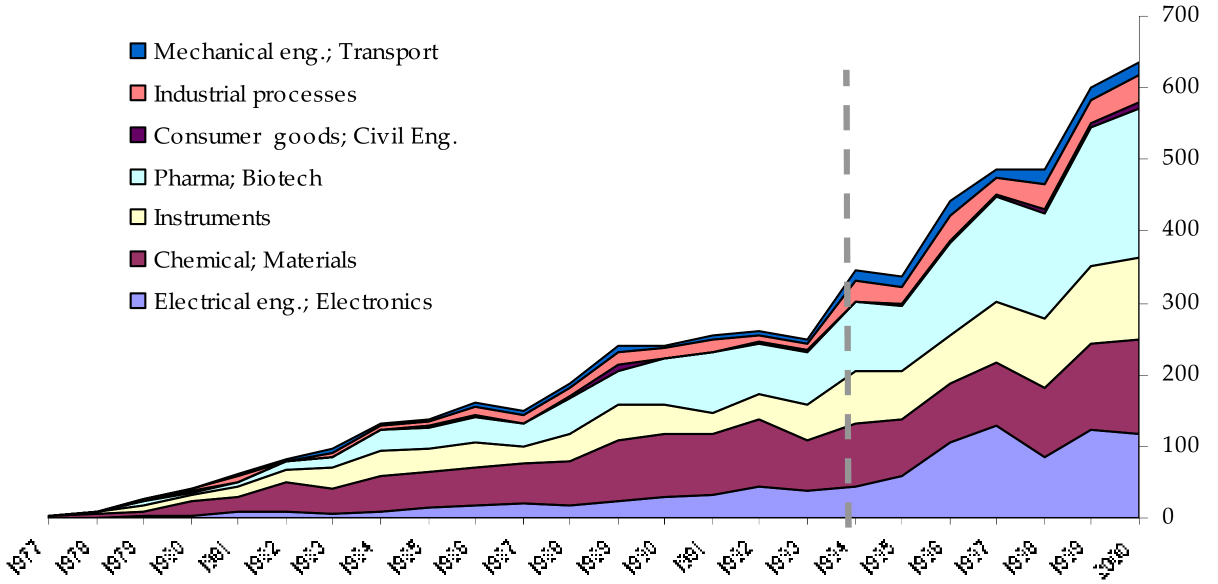
* Ac. scientists active in 2004 (Italy, Sweden) or 2005 (France)

DT-7/OST patent reclassification (OST, 2004; p.513)

Being based on the inventing activity of professors who were still active around 2004/2005, the KEINS database is very likely to underestimate academic patenting in less recent years, particularly before 1994 (when many French patents by still-active professors are also likely to be missing). Figure 3a, however, illustrate a very robust growth of academic patenting and, more interestingly, a change in the technological distribution of academic patents over time: older patents are dominated by Scientific and Control Instruments and, to a lesser extent, by Chemicals and Materials. More recent ones, on the contrary, are increasingly concentrated in the Pharmaceutical and Biotechnological classes.

This pattern is similar to the one observed for US university patents by Mowery and Sampat (2005) and reported in figure 3b, although the latter indicates a more pronounced growth and dominance of Pharmaceutical and Biotech patents, and a more limited role for Electronic ones.

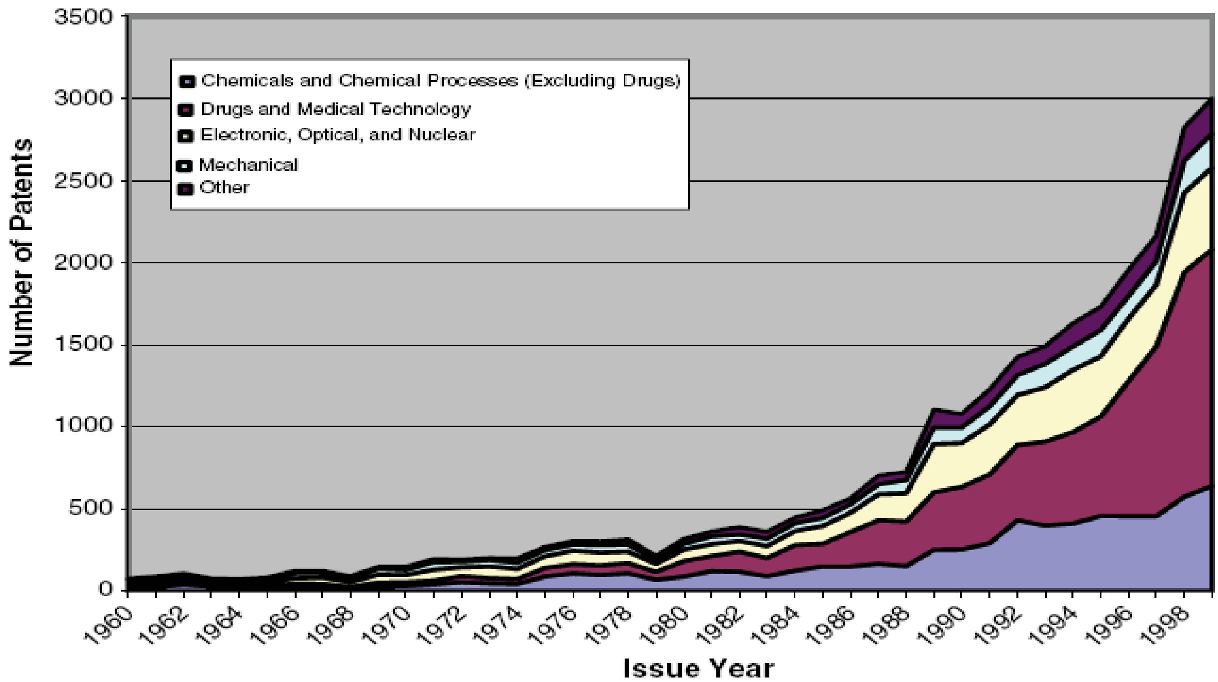
Figure 3a. Academic patent applications from France, Italy, and Sweden; by technology and year



*Ac. scientists active in 2004 (further restrictions for France)

NB.: Technologies defined as in DT-7/OST patent reclassification (OST, 2004; p.513)

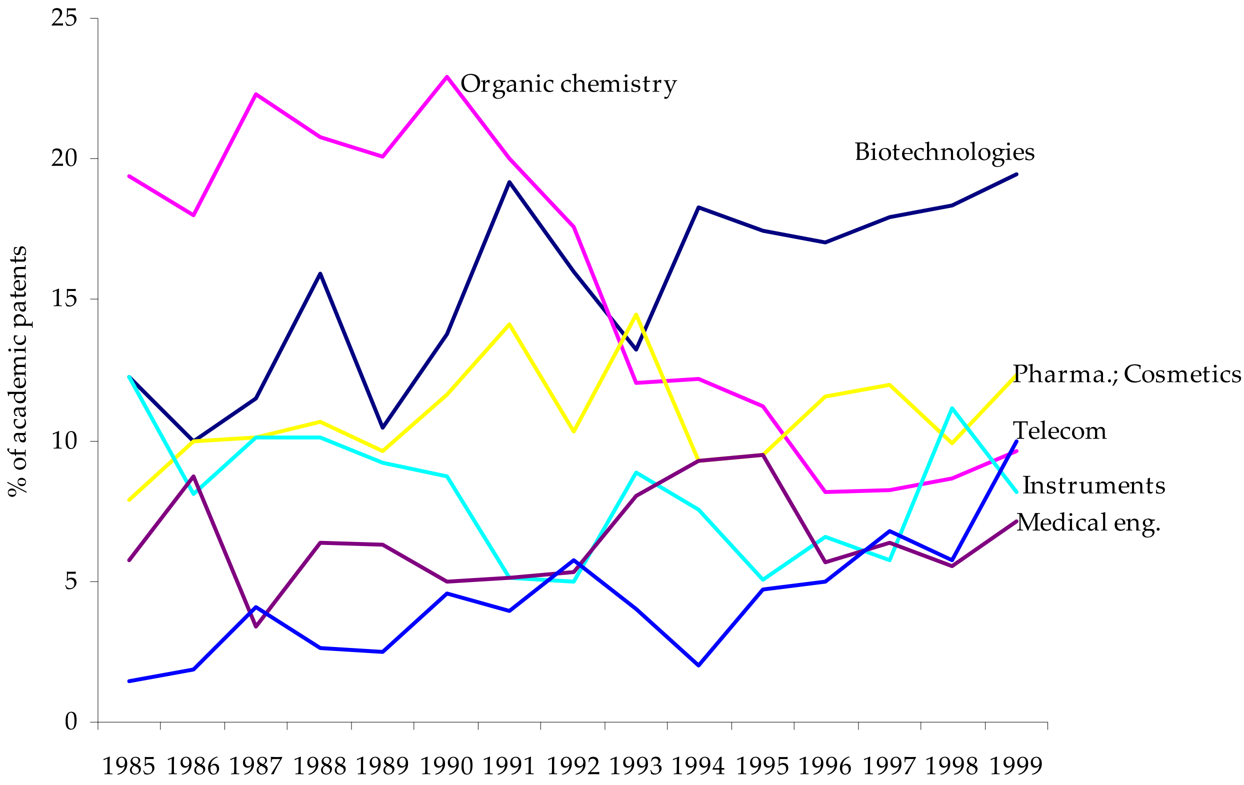
Figure 3b – Technology field of US Research Universities' patents



Source: Mowery and Sampat (2005)

At a greater level of detail, Figure 4 shows the distribution of academic patents across a few selected DT-30 technological classes also proposed by the *Observatoire des Sciences et des Techniques*, between 1985 and 2000. We notice the increasing weight of Biotech patents, the steady share of around 12% for Pharmaceutical/Cosmetic patents, and the decline of Organic Chemistry (which is the most important of all Chemical-related classes). We also notice the growth of the Telecommunication patent share; and the importance of Scientific Instruments.

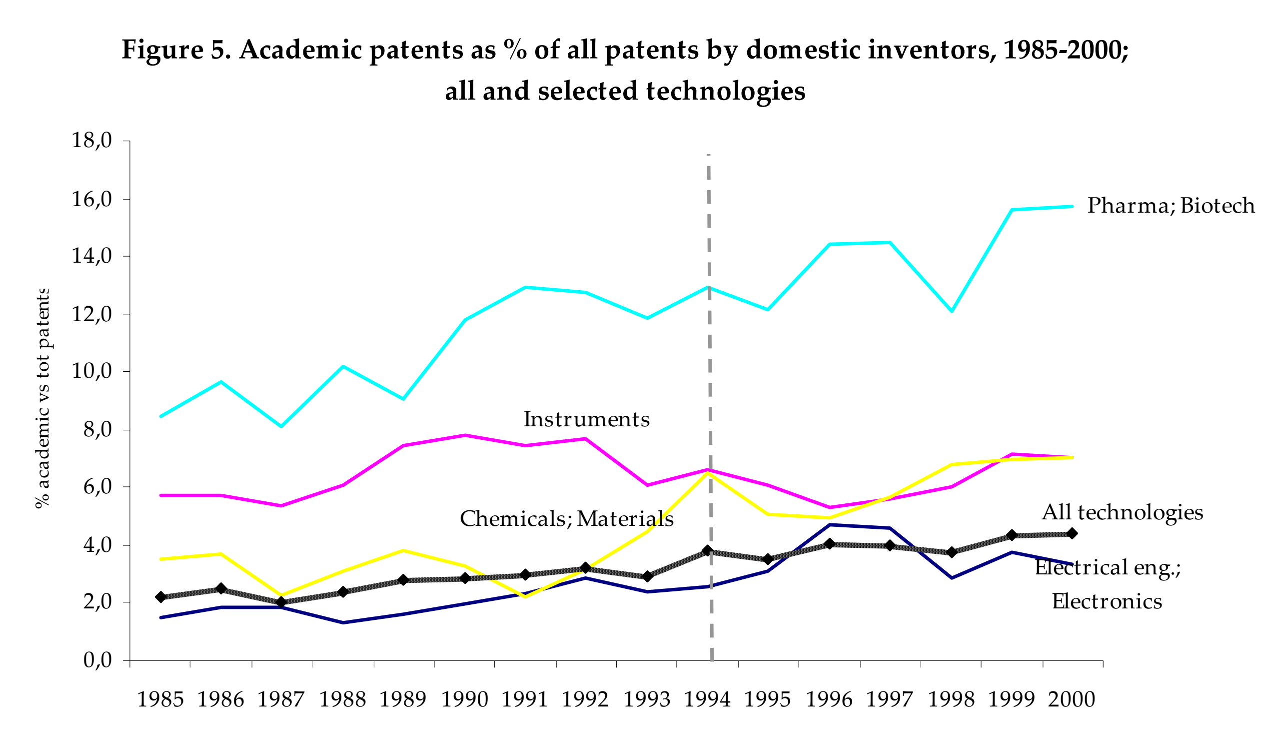
Figure 4. Academic patent applications from France, Italy, and Sweden, 1985-99; detail of most relevant classes



DT-30/OST patent reclassification (OST, 2004; p.513)

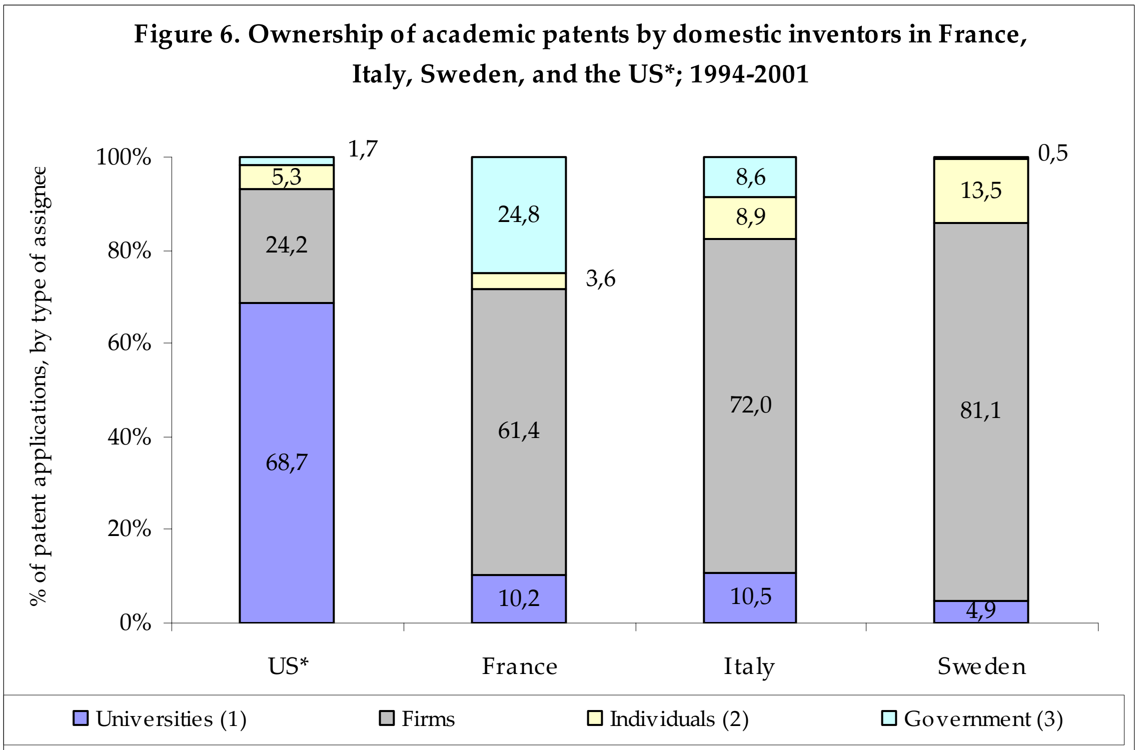
4.2 Who owns the academic patents?

Figure 5 shows that KEINS academic patents represented 2% of total domestic EPO patent applications of France, Italy, and Sweden in 1985, and around 4% of applications in 2000. Figures for Pharma&Biotech patents are, respectively, at 8% and 16%. The weight of academic patents is quite high also in Chemicals & Materials and Instruments.



DT-7/OST patent reclassification (OST, 2004; p.513)

Figure 6 compares the ownership distribution of academic patents in France, Italy and Sweden with that in the US (as from sample calculations by Thursby et al., 2006).



* US patent/inventor pair data from Thursby et al. (2006)
(1) US data include no-profit organizations (4,2% of tot obs); all data include co-assigned patents
(2) US data include "unassigned"
(3) European data include public laboratories
(Missing obs: 10-France, 87-Italy, 2-Sweden)

Over 60% of academic patent applications in France are owned by business companies, which also own 72% of Italian academic patents and 81% of Swedish ones; in contrast, business companies own only 24% of US academic patents. Conversely, universities in our three European countries own a very small share of academic patents: around 10% in France and Italy and less than 5% of Swedish ones, well below the 68% share in the hands of US universities.

This is clearly the result of the specific institutional features of the various national research and innovation systems. One of these features has to do with the heavy weight, in France and (to less extent) in Italy, of large public research organizations such as the French CNRS and INSERM, and the Italian CNR. In both countries, these PROs administer a large share of R&D funds, which they spend directly within their own laboratories rather than in universities; and even when they engage in collaborative research with academics or fund the latter's project, there is no law such as the Bayh Dole Act to impose them to leave the IPRs over the research results to the partner universities. As a result, around 25% of French patents are in the PROs' hands (almost 9% in Italy).

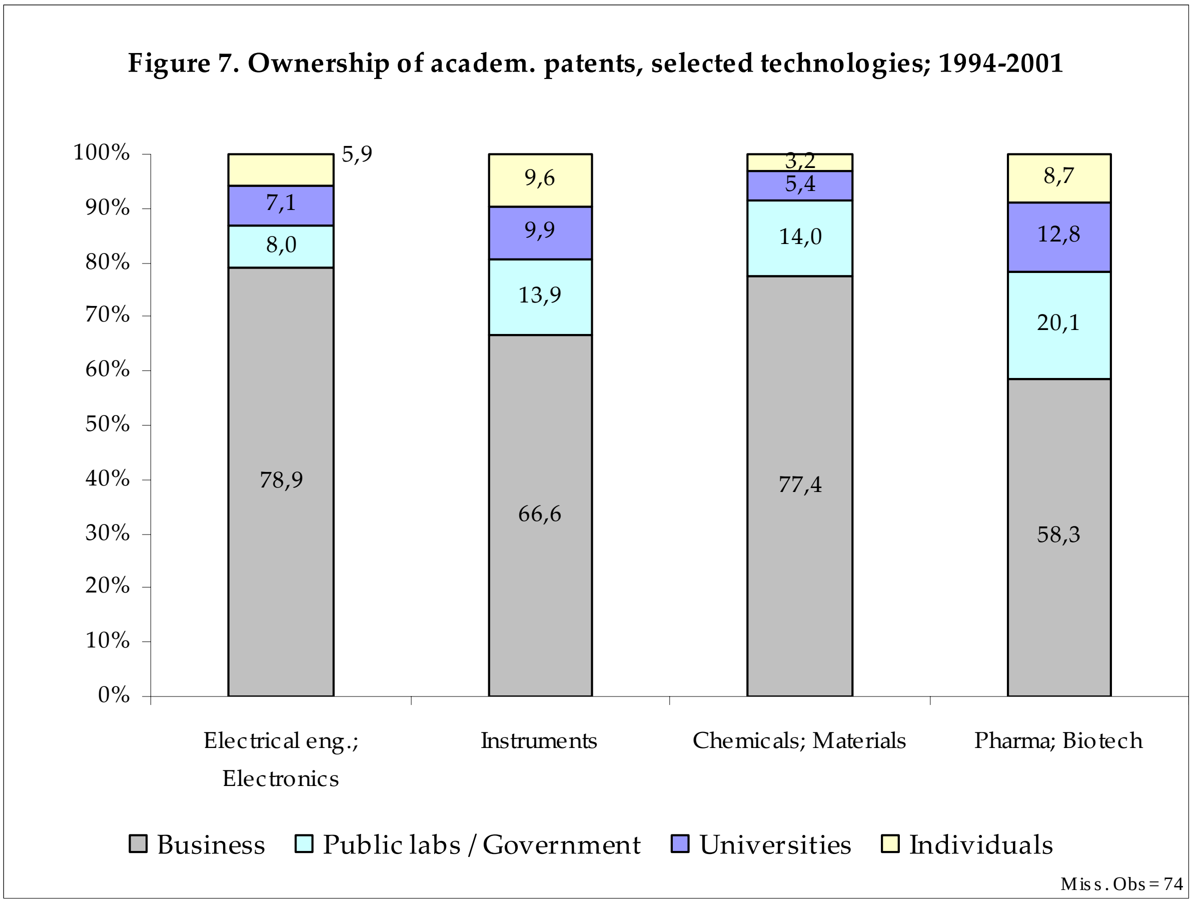
More importantly, in all of the three European countries considered, university administrations have much less control over professors' IPR than in the US. In Sweden, where the professor's privilege is still standing, academic scientists often patent in their own name, as witnessed by the 14% share of patents assigned to individuals; and a large number of the business companies holding academic patents have been set up by the academic inventors themselves with the explicit purpose of handling their IPRs. In Italy and France, professors are first and foremost civil servants, employed and overseen by the central government; invention disclosure obligations towards their universities were introduced very recently and remain unclear, and in any case not paying any respect to them bears little consequences for the professors' careers. As a result, French and especially Italian professors have been so far relatively free to dispose of the IPRs over their research results (things may have changed recently, due to the emphasis on university patenting coming from central governments themselves; we will come back to it below). At the same time, French and Italian universities have so little autonomy from the central government that they developed no tradition of autonomous fund-raising; as one of the consequences, their administrations developed no skills in handling IPR matters, and were happy with leaving them either in the professors' hands or in the hands of any business company willing to sign a research contract, or to sponsor a collaborative project.

Table 4 lists the top assignees of university patents. We notice the prominent position, in France, of both CNRS and INSERM, mirrors in Italy by the role of CNRS.

Table 4. Applicants of more than 10 academic patents, 1978-2001; by country

Applicant	Patents (nr)	Main technological classes
France		
CNRS	220	Biotech., Medical Eng.
INSERM	99	Biotech., Organic Chem.
Total	72	Macromolecular Chem., Thermal Processes, Basic Chem.
France Telecom	55	Telecom.
Cea	52	Surfaces, Coating, Materials, Metallurgy
Thales	45	Instruments, Telecom., Electrical Eng.
Rhodia	40	Macromolecular Chem., Materials, Metallurgy, Organic Chem.
Universite Paris 6	42	Biotech.
Adir & Co.	38	Organic Chem.
Institut Pasteur	38	Biotech., Organic Chem.
Institut Francais Du Petrol	32	General Processes
Aventis	29	Pharmaceuticals, Cosmetics, Biotech.
Alcatel	26	Telecom., Electrical Eng., Audiovisuals., Analysis/Control & Measures
Inra	18	Biotech.
Assistance Publique	17	Biotech.
Institut Curie	11	Biotech.
Italy		
ST-Microelectronics	143	Electronic - Electricity
CNR	111	Chem. - Materials
ENI	97	Chem. - Materials
Sigma-Tau	67	Chem. - Materials
Ausimont	51	Chem. - Materials
Telecom Italia Gruppo	33	Instruments
MIUR	26	Chem. - Materials
Fidia Gruppo	21	Pharmaceuticals - Biotech.
ARS Holding	19	Pharmaceuticals - Biotech.
Optical Technologies	19	Electronic - Electricity
Procter & Gamble	18	Chem. - Materials
Montedison Gruppo	18	Chem. - Materials
Università la Sapienza, Rome	18	Pharmaceuticals - Biotech.
Pharmacia & UpJohn	17	Chem. - Materials
Sweden		
ABB	151	Electrical Machinery And Apparatus
Ericsson	114	Telecom.
Pharmacia UpJohn	75	Pharmaceuticals, Cosmetics
AstraZeneca	40	Pharmaceuticals, Cosmetics
Telia	27	IT
Siemens	25	Medical tech.
Karolinska Institute	19	Biotech.
A & Science Invest	17	Pharmaceuticals, Cosmetics
Sandvik	16	Materials, Metallurgy
Kvaerner Pulping	13	Materials Processing
Landegren, Ulf	11	Biotech.

Both in Italy and in France, large State-controlled companies (such as ST-Microelectronics, ENI, France Telecom, and Tales) hold a very large number of academic patents. Large multinational companies located in the country are important in Sweden, too, witness the role of Ericsson and ABB. Notice that among the top patent holders of Sweden we also find an individual professor, with 10 patents. In all of the three countries, we find only one university among the top patent holders (the country-largest Universities of Rome and Paris, and Karolinska Institute in Stockholm)[8].



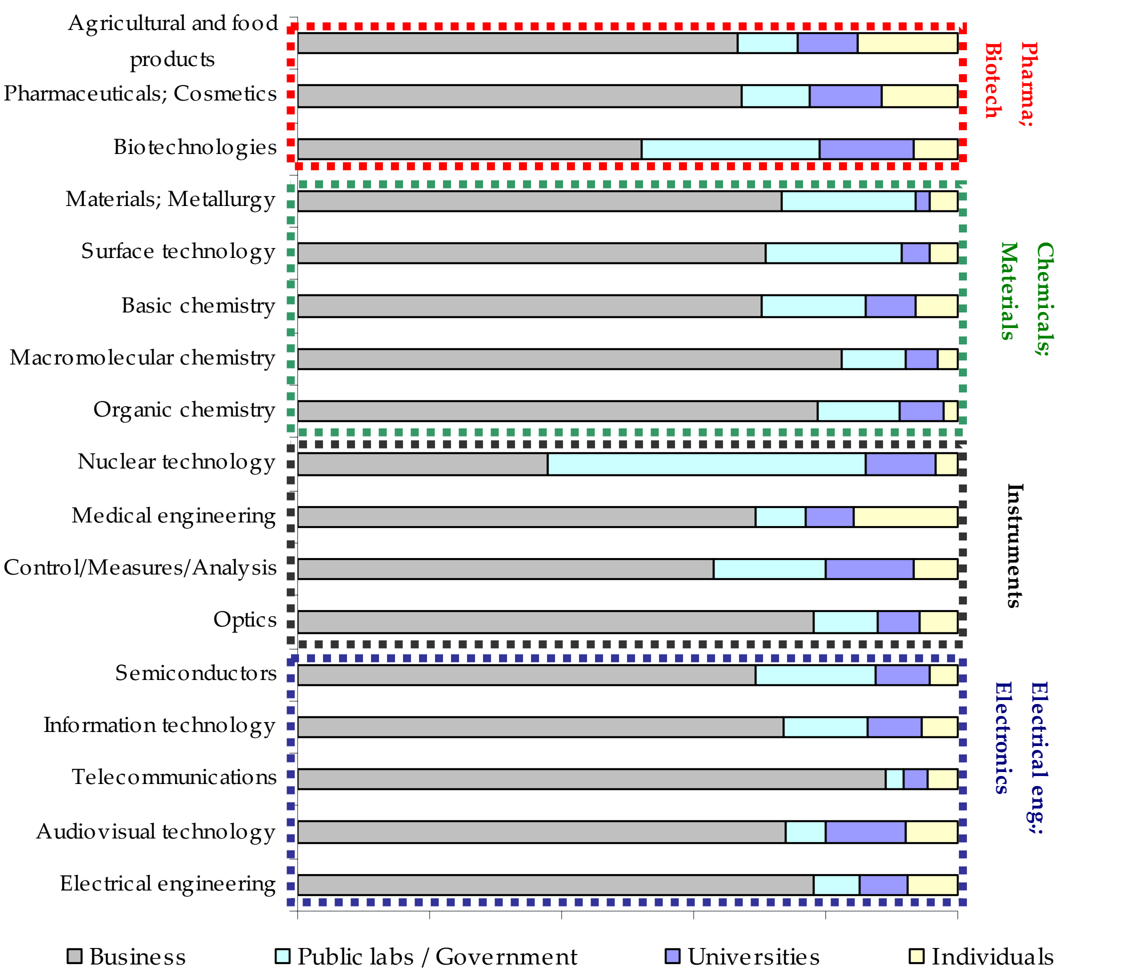
Ownership patterns of academic patents seem to depend also on the disciplinary affiliation of the inventors (and therefore also on the technological contents of the patents). Thursby et al. (2006) find that Biotech patents are more likely to be held by universities than Electronic ones, which in turn have a higher probability to be held by business companies. We find that this is also the case for our three countries: figure 7 reports combined data for France, Italy and Sweden, in the four most "academic-intensive" technologies. It shows that business companies own almost 80% of academic patents in Electronics & Electrical Engineering, but just a little more than 58% of those in

[8] Notice that, unique case in Sweden, Karolinska has had explicit university strategy to own patents since the early 1990s. As for Rome and Paris, the number of applications in their patent portfolio is much more a reflection of their sheer size rather than of any explicitly IPR policy (which, however, they also undertook with the introduction of regulations on invention disclosure).

Pharmaceuticals and Biotechnology (where both Universities and Government hold record shares of 14% and 20%, respectively). It is worth noting that academic patents in Instruments also see a lower-than-average share of business ownership, and the record share of individual ownership (over 9%).

Figure 8 provides a few more details, at it breaks down the four technologies examined so far into 17 smaller classes. The role played by non-business entities (aka Universities, Government and Individuals) in Biotechnology emerges here even more clearly, alongside with the special role of Government in Nuclear Technologies (as one may expect, due to the political sensitivity of the issue).

Figure 8. Ownership of academ. patents, selected technologies; 1994-2001



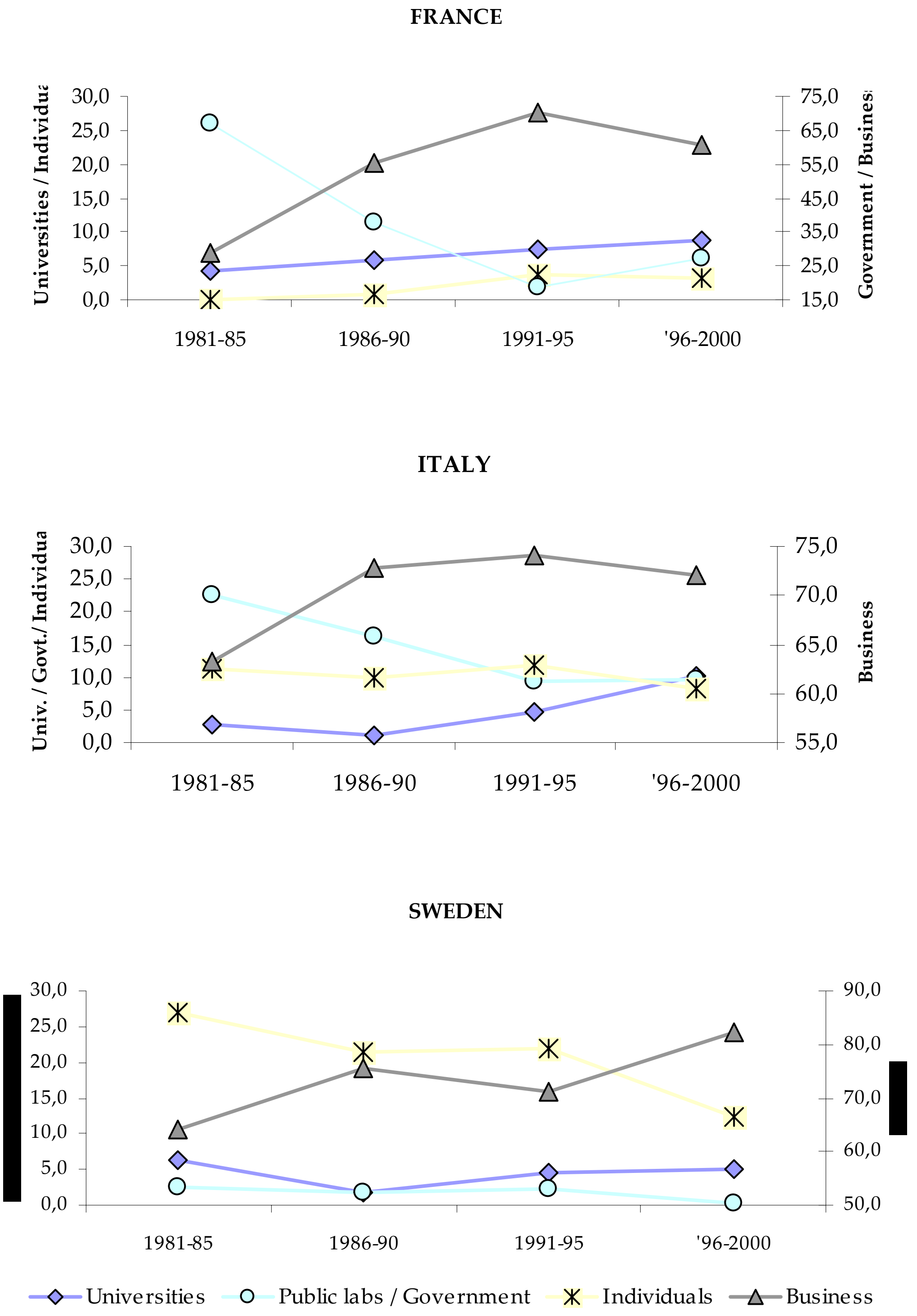
This evidence may have one or a combination of the following explanations. The first explanation refers to how academic research is funded. We observe that the closer a technology is to basic science, the more likely it is that the research programmes are supported by university funds, or from public ones; as a consequence, universities can more easily claim the intellectual property rights over the resulting inventions. Nuclear Technology clearly provides the best example, but so it does the field of Control/Measure/Analysis Instruments, where one can expect many inventions to be the serendipitous results of research programmes addressing fundamental research questions. See also the contrast between Biotechnology patents (which largely result from public funded, fundamental research) and Pharmaceutical patent, which include Cosmetic ones (which are the result of applied research contracts with business companies).

The second explanation is based on the observation that the economic value of a patent depends on its grantee's exploitation strategies. It may be that universities have little interest in holding patents in complex technologies such as all those in the Electronics & Electrical fields, whose products result from the combination of a myriad of hardware and software components. While one single patent may be enough to cover a blockbuster drug or an instrument, a new telecommunication device or electronic apparel is can be obtained only by assembling many bits and pieces, some of which may be covered by the assembler's patent portfolio, but many more may be not. In this case, patents are most valuable as bargaining chips in cross-licensing agreements signed by producers who want to mutually avoid the risk of infringement when it comes to production. But since no university will enter production by itself, it may wiser to leave the patents in some private sponsor's hands, or to find quickly some business partners willing to buy a national patent the university may have registered, and pay for its European extension.

Finally, the share of university-owned academic patent may depend on national IPR legislation for universities: as explained in section 2, in all of the three countries considered in this paper, governments have actively encouraged universities to engage in technology transfer, and in patenting in particular. Figure 9 seems to suggest that these policies may have had some success to the extent that they may have encouraged universities to retain the ownership over a large share of academic patents (notice how such share is increasing in all of the three countries). However, it does not seem that the main "property shift" has occurred from business companies to universities: in France and Italy, the growth of the share of university patents has gone hand in hand with both an increase in the business companies' share, and a substantial decrease of the share of the governmental labs and agencies; the evidence for Sweden is more confused, as the limited increase of the universities' share goes along once with a drop of business companies' share, and once with a similar drop in the share of individuals.

Measuring the relative importance of these three explanation goes beyond the scope of this paper, as it requires combining the KEINS data with information on universities' source of funding, by nature of the funds (public vs. business) and field of destination.

Figure 9. Ownership of academic patents, by year; 1981-2001



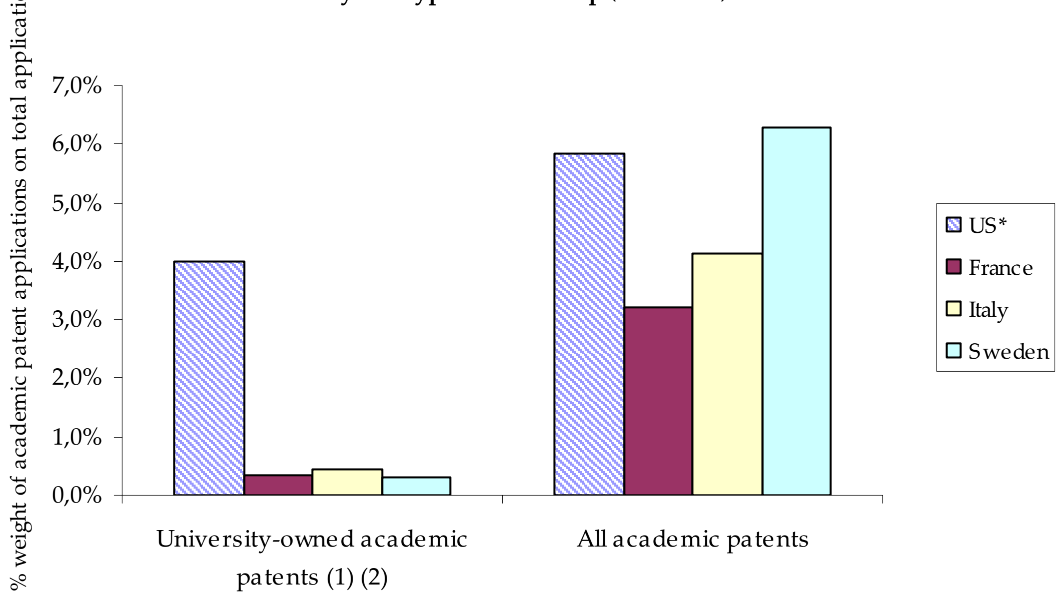
4.3 Academic patents in US and Europe: A Reassessment

The different ownership distribution of academic patents in Europe and the US may explain why, for long, it has been common to under-estimate the contribution of European academic scientists to technology transfer through patenting.

In figure 10 we compare the share of domestic patents held by universities (university-owned patents) with the total share of domestic patents of academic origin (university-owned plus university-invented patents), for France, Italy and Sweden. We also make the same comparison for the US, based upon data from Thursby et al. (2006) and Mowery and Sampat (2005). We limit our calculations to years between 1994 and 2001, in order to make the US-Europe comparison possible (Thursby's data are for 1993-2000, while our data for France before 1993 are not entirely reliable).

We notice that French, Italian, and Swedish university-owned patents are less than 1% of total domestic patents, while, in the same countries, academic patents are respectively around 3%, 4% and over 6%. In contrast, when moving from university-owned to academic patents, US estimates move from 4% to less than 6%. What appears a huge US-Europe gap in terms of university patents, turns out to be a limited gap between US and France and Italy on one side, and no gap at all between US and Sweden.

Figure 10. Weight of academic patents on total patents by domestic inventors, by country and type of ownership (1994-2001)



(1) US univ-owened patent include no-profit organizations (4,2% of tot obs); all data include co-assigned patents (source: Thursby et al., 2006)

(2) Estimate of weight of univ-owned patents in 1999, from Mowery and Sampat (2006)

5. Conclusions

The key piece of evidence produced in this paper can be summarized as follows: universities in France , Italy and Sweden are not so much at a disadvantage with respect to their US counterparts in the terms of patents production (in the case of Sweden, there is no disadvantage at all); rather, they are less likely to reclaim the property of the patents they produce.

One reason for this lower propensity has certainly to do with the different IPR arrangement that regulate the relationship between funding agencies (such as the CNR in Italy and the CNRS in France). Whereas the Bayh-Dole Act allows US universities that received funds from the National Institute of Health or the National Science Foundation to retain the IPRs over the related research results, the same does not apply to Italy and France, where the CNR and the CNRS (or the INSERM) still control those IPRs. Similarly, the existence of the professor privilege explains the role of individual academic patent holders in Sweden.

However, most differences between the US and the European countries considered here depend on patents owned not by public agencies, but by business companies. These do not depend upon IPR legislation, but on the institutional profile of the national academic systems, and possibly on the national specificities of the relationship between university and industry.

With respect to the institutional profile, it is interesting to notice that both Lach and Shankerman(2003) and Thursby et al. (2006) find that US public universities have more difficulties than private ones to retain IPRs over their scientists' inventions.

US private universities are free to exercise a much greater control over their scientists, both when they recruit them and later on, at the time of negotiating or re-negotiating their contractual arrangements. Therefore, they can impose somewhat tight duties or provide generous incentives to disclose inventions. They also have a long history of active fund-raising, both through commercial activities (Bok, 2003), and intellectual assets management (Mowery and Sampat, 2001).

Conversely, US public universities are less free to set proper economic incentives for their professors in order to encourage invention disclosure, and less able to profit from their patent portfolio and to provide their academic inventors with royalty shares.

By extension, it may that European universities, all of them public, experience similar difficulties, because they are even more constrained by governmental regulations concerning the remunerations and duties of their academic staff.

Moreover, European public universities have no tradition of self-financing, let alone any possibility to enter into the details of the labour contract they sign with their scientists. They also lack the autonomy enjoyed by large US State universities, such as the University of California and many Midwestern institutions, which have are not controlled directly by the central (federal) government, but are under the supervision of Boards where representatives of the State sit along with other local stakeholders. These universities recruit their scientists on the labour market, indeed the very same labour market where private ones operate. In France and Italy, by contrast, academic scientists' careers and wages are entirely regulated by the central government, which leaves no room for independent mobility across universities and wage bargaining. In addition, the administrative staff of universities is entirely composed of civil servants, whose task consists much more in exercising control on behalf of the Ministry of Education, than in helping the universities to raise and manage their own funds. In Sweden, universities are primarily public, with the exception of the foundation-run Stockholm School of Economics, Chalmers University of Technology, and Jönköping University. However, both public and foundation universities can recruit their scientists and make independent decisions, but at the same time, both types of universities are subject to extensive regulation and legislation. After the mid-1990s reforms, universities are responsible for their budgets and strategies. Hence, Sweden represents a classic European case, which has made some reforms, inspired from the U.S.

As for the role of university-industry relationship, we may speculate that some of our results depend on the nature of research contracts and collaboration agreements signed by universities and business firms. It may be possible that contracts and agreements in the US refer to more fundamental research than their equivalents in Europe, and thus generate broader patents. Broad patents may be more easily exploitable by universities, to the extent that they may be exploited through licensing-for-royalties, rather than through cross-licensing for production purposes. Our future research plans include investigating these explanations, as well as measuring the value of academic patents (compared to non-academic ones), and evaluating the relationship between individual scientists' patenting and publishing activities.

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