



Paper to be presented at the Summer Conference 2009

on

CBS - Copenhagen Business School
Solbjerg Plads 3
DK2000 Frederiksberg
DENMARK, June 17 - 19, 2009

ACADEMIC PATENTING AND THE PROFESSOR S PRIVILEGE

Peter Lotz

CBS
pl.ino@cbs.dk

Francesco Lissoni

Brescia / Bocconi
francesco.lissoni@unibocconi.it

Jens Schovsbo

Copenhagen University
jens.schovsbo@jur.ku.dk

Adele Treccani

INO, CBS
treccaniadele@yahoo.it

Abstract:
In 2000, Denmark was, among the countries which had previously introduced it, the first to abolish the professor s privilege on patents from academic research. We show that over the years following the abolition, a considerable amount of patenting activity has moved out of the professors hands into those of their universities. More noticeably, we also show that the bulk of academic patenting consists of inventions owned by business companies, and this is holds true both before and after the privilege. In this respect, Danish academic patents conform to the European pattern as described in the recent literature.

Academic Patenting and the Professor's Privilege: Evidence on Denmark from the KEINS database

Francesco Lissoni^{i,ii.}, Peter Lotz^{iii.}, Jens Schovsbo^{iv.}, Adele Treccani^{i.,iii.}

^{i.} DIMI, Università di Brescia (IT)

^{ii.} KITEs/CESPRI, Università "L.Bocconi", Milano (IT)

^{iii.} INO, Copenhagen Business School (DK)

^{iv.} Faculty of Law, University of Copenhagen (DK)

Abstract

Since 1957, the Professor's Privilege allowed Danish professors to retain IP rights over the results of their research. This changed in 2000, when Denmark – as the first of several other countries - abolished the Privilege and granted IP over research results to universities. We show that in the first years following the abolition, a considerable amount of patenting activity has moved out of the professors' hands into those of their universities. We also show that the bulk of academic patenting consists of inventions owned by business companies, and this is holds true both before and after the privilege. In this respect, the Danish case conforms to the European pattern as described in the recent literature and provides useful suggestions on the likely effects of re-distribution of IP rights between universities and their faculties.

KEYWORDS: university patents; technology transfer; professor's privilege

1. Introduction

This paper analyzes the extent of academic patenting in Denmark, with special reference to the effects of legislative changes introduced in 1999. Such changes, which were part of a broader *Act on innovation at public research institutions* ("Lov om opfindelser ved offentlige forskningsinstitutioner"), abolished the Professor's Privilege regarding inventions, a long-lasting legal institution typical of German-speaking and Scandinavian countries. The Privilege allowed university professors to retain patent and utility model rights over their research results, contrary to scientists employed in public laboratories or private industries, whose inventions belong by default to their employers.

Denmark's decision to abolish the privilege was the first in a series, with Germany, Austria, Norway, and Finland all following in between 2001 and 2007 (Kilger and Bartenbach, 2002; PVA-MV, 2003; Iversen et al., 2007). This 'abolitionist movement' owes to policy-makers' wish to recreate in Europe similar conditions to those of the US, where universities retain all intellectual property rights (IPRs) over the results of public funded research. Since the introduction of the Bayh-Dole Act (or University and Small Business Patent Procedures Act) in 1980, it has become possible for universities to force the faculty to disclose their public-funded inventions to the university administration, and to engage in exclusive licensing. Despite the real effects of the Bayh-Dole Act have been disputed, most European policy-makers seem to be under the impression of the existence of a strong causal link between the Act and the sharp increase of university patenting in the US over the 1990s (OECD, 2003).

Denmark being first to abolish the Privilege, it offers the earliest evidence of the effects of the abolition, if any. To this end, we have extended to Denmark the KEINS database on academic patenting in Europe (Lissoni et al., 2006, 2008a, and 2008b). The database allows for the identification of academic patents, that is all patents signed by academic scientists, both those filed by the scientists' universities and those filed by the scientists themselves (as it was their right under the privilege regime), by their commercial partners, or by any public funding agency.

Although the KEINS database is by and large cross-sectional, we can provide some evidence on the redistributive consequences of the privilege abolition. In particular, we show that a considerable amount of patenting activity moved out of the professors' hands into those of their universities; however, we also show that the bulk of academic patenting consists of inventions owned by business companies, and this holds true before and after the enforcement of the privilege.

In section 2 we summarize the contents and aims of the change in legislation which forms the object of our enquiry. In section 3 we explain briefly the methodology followed to build the dataset in use, so we can discuss its strengths and drawbacks in relation to the objectives. In section 4 we examine the distribution of academic patenting in Denmark, by technology and ownership regime, before and after the privilege abolition. Section 5 concludes.

2. The Danish Act on Innovation at Public Research Institutions

The professor's privilege was introduced in Denmark in 1957, through an amendment to the *Act on Employees' Inventions* of 1955. According to the original version of the *Act*, which still applied to non-academics, inventions have to be disclosed to the employer, who has the right to take title to it within a (short) period following disclosure, and with "proper" compensation to the inventor. The Professor's Privilege was introduced as an exemption for a special category of employees, the full-time university researchers, who felt their research freedom could be threatened by disclosure duties. The exemption did not extend to researchers working in Public Research Organizations (PROs).

Concerns that the Privilege might hinder technology transfer date back at least to the 1970s, at a time when traditional science policies, and their emphasis on basic research, had come under reconsideration in all industrialized countries. Proposals directed at its abolition were resisted by the Danish faculties' trade unions, which equated the proposals to an expropriation of professors' economic rights. Also some universities resisted, opposing the interference from other institutions in their affairs. Finally, some individual scientists viewed the creation of any technology transfer office as a complication to the management of their existing consulting and research contract activities with business companies (OECD 2003, Baldini 2006).

Doubts circulated also among industry representatives. In public, many were eager to have the regulations changed "in order to have one institutional counterpart instead of up to ten individual inventors"; in private, as many seemed more sceptical either because they feared an increase in the prices of academic inventions (OECD 2003; p. 129), or simply because of the expected contractual hazards derived by involving a third party (the university administrations) in their dealings with academics.

It was only in 1998 that the Danish Ministry for Research and Technology sent a preliminary proposal to all universities and PROs. The main feature of the proposal was to give universities and research

institutions the right to take over all IPRs of research employees (including inventions and copyright), establish a secrecy period of up to 12 months, and sanction researchers who did not comply with the new rules on disclosure. The proposal was not well received and was therefore weakened: disclosure duties were restricted only to patentable inventions (and not know-how in general); universities were given only two months to decide whether to take title and file a patent, or let the matter in the inventors' hands; and no specific provisions were made in order to sanction the failure to comply with the disclosure duty. In this form, the law was voted unanimously by the Parliament in May 1999, with the name of *Act on invention at public research institutions*¹.

As stated in article 1, the aim of the Act was to ensure "... that research results produced by means of public funds shall be utilized for the Danish society through commercial exploitation". Some important provisions refer to the economic treatment of inventors, which may vary across universities and instances, but have to be approved by the ministry. In case the university gives up its rights, the patenting initiative falls in the inventor's hands, and the economic returns have to be split only between the inventor and his/her department.

While the spirit of the legislation was that of imitating the Bayh-Dole Act, the Danish universities' expertise in handling IPR matters at the time of the law approval was far inferior to that of their US counterparts in 1980 (as documented by Mowery et al., 2004). In fact, at the end of the 1980s, only the technical-oriented University of Ålborg had an active TTO. At that time, the other universities and their hospitals had only (small) offices for the external relations, whose main purpose was to advise on applications for external funding of research projects. Such a lack of experience in technology transfer made it initially hard for universities to understand the obligations imposed by and the resources needed to establish a TTO. Even though the parliament set aside a total grant of about EUR 8 millions in four years to make implementation of the new law more attractive, only some of the major institutions initially established full-time positions for transfer activities.

As for the effects of the Act, we are not aware of reliable statistics on either the number of academic patents, or their distribution by ownership and technological contents. A partial exception is the annual Public Research Commercialisation Survey by the Danish Agency for Science, Technology, and Innovation, which for 2007 reports a recent increase in the number of disclosures by academic scientists to their universities' TTOs (FI, 2007). As for the data on Denmark reported by OECD (2003), they suggest that disclosures to universities' and university hospitals' TTOs doubled over the first

¹ Both the full text of the bill, and the official remarks attached to its promulgation can be found at: http://www.folketinget.dk/doc.aspx?Samling/19981/lovforslag_som_fremسات/L93.htm

year of enforcement of the Act. These data, however, are all based on a survey of TTO staff, and not on primary data from the Danish or European patent offices. As a consequence, they tell us nothing of patents over academic inventions which are not disclosed to the TTOs, but filed directly to the patent office by individual scientists, or by the companies they may collaborate with. In the absence of such data, it is impossible to verify whether any increase in the number of patents filed by universities is due to a growth in inventive activity by academic scientists, or simply to a property shift. The data presented in following sections were collected in order to fill this gap.

3. The KEINS database and its extension to Denmark: a methodological note

The KEINS dataset contains information on academic scientists' patent applications at EPO, the European Patent Office. It covers France, Italy, the Netherlands and Sweden, and it was extended to Denmark for the purposes of this article. Extension to the UK is under way. Besides information on the priority date and technological classification of patents, the dataset provides details on the identity of both the inventors and the applicants.

The KEINS dataset originates from the EP-INV database produced by CESPRI-Università Bocconi, which contains all EPO applications, reclassified by applicant and inventor, and from several lists (PROFLISTS) of university professors of all ranks (from assistant to full professors), one for each of the included countries. 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 (Lissoni et al., 2006).

3.1 The EP-INV dataset

The EP-INV dataset is part of the broader EP-CESPRI database, which contains information on over 1,500,000 patent applications at the European Patent Office (EPO) from 1978 to 2003².

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.

² By the time the present paper was published, the EP-CESPRI database was merged with the PATSTAT database and updated to 2006

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 methodology for producing information in category 3, which is crucial for this paper, is described extensively by Lissoni et al. (2006). Here we limit ourselves to point out that such methodology is susceptible to introduce both type-I measurement errors (identifying a professor as an inventor, when in fact the two are just bearing the same name) and type-II measurement errors (failing to identify a professor as an inventor, when in fact the two are the same person). Type-I errors would lead to *over-estimate* the extent of academic patenting in Europe, a mistake we want to avoid since one of our goals is to prove that conventional wisdom tends to *under-estimate* it. As a consequence, we placed special care in trying to minimize type-I errors, at the cost of not eliminating all type-II errors.

3.2 The Danish PROFLIST

Parallel to the creation of the EP-INV database we proceeded to the collection of biographical information on academic scientists in medicine, the natural sciences and engineering (PROFLIST).

The basic data were provided by the *Danish Agency for Public Personnel*, (Personalestyrelsen) which provided us with about 113.000 records.³ They cover all personnel (academic and non-academic) of Danish universities in two distinct years: 2001 and 2005. These data are assembled by the Agency on the basis of files produced by the individual universities, which (unfortunately for us) have some latitude in defining their personnel's Position (academic or technical/administrative rank of the employee) and Category (academic vs. non-academic nature of the job, plus information on the faculty/discipline)⁴. Since the Agency was not able to provide us with a comprehensive key for Positions and Categories, we proceeded to clean and harmonize the data across universities.

We first eliminated from the database all the Positions and Categories which, upon reading, clearly pointed at non-academic jobs or to academic jobs which were not included in the KEINS database for

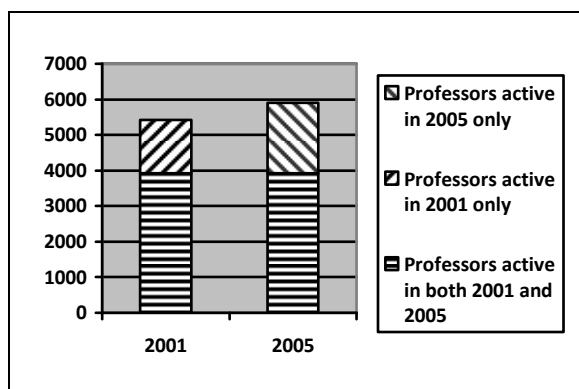
³ Notice that for each country in the KEINS database the PROFLIST comes from a different source, a mix which creates some problems of comparability across countries.(see Lissoni et al., 2008a).

⁴ These pieces of information were derived from the *Stillingsbetegnelse* (Position) and *Personalkategori* (Category) fields in the Agency's records.

other countries (such as the doctoral students). After this cleaning effort only 55 Positions and 25 Personnel Category remained in the database, for a total of 10220 observations over two years.

For these individuals we then collected information on residence address from the Scientific Office of the Ministry of Health, which is the agency in charge of the census-database for Denmark. We were provided not only with their the current address, but also with a series of historical addresses for each person. Combined with information on the professors' date of birth, these new data allowed us to identify all cases of homonymy between the two lists, for 2001 and 2005. This left us with the identification of 7395 professors, 3925 of which active both in 2001 and 2005, and the remaining active only either in 2001 or 2005 (the former having now retired, or moved to a non-academic job; the latter being new faculty recruited after 2001). For all of these observations, we now had: unique identification number, name, surname, date of birth, university affiliation and academic rank (if any) in 2001 and 2005. Information on the scientific discipline is also available, but not yet standardized.

Figure 1: The Danish PROFLIST after cleaning



After the elimination of such a large number of observations from the raw data, we checked for possible distortions in the composition of our PROFLIST (such as in the case an eliminated Position or Category was to be found in one university only). No cleaning-induced distortion is apparent.

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

Table 1 reports the Danish populations of patent applications and inventors (from EP-INV), as well as that of professors (from PROFLIST). For comparative purposes, we report similar data also for the other countries in the KEINS database.

Starting from these data, the identification of academic inventors proceeded in two steps. First, we matched inventors from the EP-INV database with professors in the PROFLIST, by name and

surname. This exercise (see Lissoni et al., 2008a) returned 895 inventor-professor matches.⁵

Table 1. EPO patent applications, inventors, and professors in Denmark, France, Italy, the Netherlands, Sweden, and the UK

	All EPO patents (1978-2002, if not otherwise stated) *	All inventors of EPO patents (1978-2002, if not otherwise stated) **	Professors (active in 2001, 2004 or 2005, as stated)
Denmark	12640 ^a	11306 ^a	7395 ^c
France	114052	98035	32006 ^d
Italy	51487	37692	32886 ^e
Netherlands	42665	43205	21684 ^d
Sweden	29148	25660	12175 ^e
UK	51276 ^b	65381 ^b	27335 ^f

^a 1978-2004; ^b 1994-2002; ^c active in 2001 and/or 2005; ^d active in 2005; ^e active in 2004; ^f active in 2001

* Total nr of patents signed by at least one inventor with address in the country

** All inventors of EPO patents with address in the country

Sources: EPO-Cespri database; Ministerial records (France, Italy); Authors' elaborations on universities' records (Sweden, the Netherlands, Denmark); RAE (2001) for the UK

Second, for 716 of the matched professors we managed to retrieve an e-mail address, to which we sent a request of confirmation (each professor was provided with a list of the patents signed by the matched inventor, and asked to confirm such patents as his/hers). This effort produced 184 validated matches (the professor confirmed to be the same person as the inventor), while in 90 case the match was rejected (the professor denied to be the same person as the inventor, or pointed out that he was the person, but all the patents were filed at a time when he/she was not working as an academic scientist). Based on our own judgement of the records we added 122 cases to the list of confirmed matches. This left us with 306 confirmed academic inventors and 494 academic patents (that is patents in which at least one academic appears as inventor).

After the completion of the main survey and the analysis for this paper we launched a follow-up phone survey in order to examine the 499 cases for which the match was still not checked⁶. After at least two, and in most cases three or more attempts, we had another 32 matches confirmed, 224 matches were rejected, while 243 persons were inaccessible. On this basis the combination of the 306 academic inventors from the original survey and the following 32 inventors, a total of 338 academic inventors constitute the most conservative (*lower bound*) estimate of the number of Danish academic inventors active in 2001 and/or 2005. The *upper bound* estimate is as much as these 328 inventors plus the 243 apparently inaccessible ones (for a total of 571) under the extreme

⁵ Matches were excluded if they could be easily interpreted as cases of homonymy, such as when a Biology professor's name was matched to the name of an inventor with patents in Semiconductors or Civil Engineering.

⁶ These were the cases for which we had not found an e-mail address or the mail had not been responded to, and we could not form our own judgement)

assumption that all of the inaccessible turned out to be academic inventors. The most realistic estimate of the number of Danish academic inventors is around 370, assuming the same hit-rate for the remaining unchecked cases as we obtained in the follow-up survey. In Table 2 we report these figures. In all other tables, however, the analysis is referred to the 306 academic inventors and 494 patents for which we obtained information by e-mail.

Table 2. Academic inventors in Denmark, France, Italy, the Netherlands, Sweden, and the UK; nr. and % over nr. of professors

	Academic inventors (nr) ¹	Academic inventors (% of prof.) ¹	Academic inv., incl. unchecked (nr) ²	Academic inv., incl. unchecked (% of prof.) ²
Denmark	328	4,44	571	7,72
France	1205	3,99	1822	6,04
Italy	1353	4,29	1395	4,42
Netherlands	600	2,75	731	3.35
Sweden	725	4,55	773	4,86
UK	630	2,30	4826	17,66

¹ Data from checked professor-inventor matches (professors confirmed to be the inventors)

² All positively checked and unchecked records (records for which professors denied being the inventors are excluded)

Table 2 also reports data for the other countries covered by the KEINS database. Notice that for Italy, the Netherlands, and Sweden the second step (e-mail confirmation, in these two cases supplemented by phone interviews) covered 90% of professor-inventor matches; for France, the large number observations forced us to limit our check only to the professor-inventor pairs whose latest patent was filed after 1993 (as for the UK, we met the same problems occurred for Denmark).

When it comes to measuring the total number of Danish academic patents over time, our data suffer of two limitations. First, our data fail to capture all patents signed by academic scientists who retired or moved out of the university system before 2001, who are not listed in our PROFLIST, and therefore could not be matched to inventors from the EP-INV lists. Second, as explained above, we have not identified all academic inventors within the ranks of the Danish faculties in years 2001 and 2005. We therefore have an uncertain measure of the ratio of academic patents to all Danish patents.

Still our data constitute a large and reliable sample of all Danish academic patents, which provide useful information on the distribution of the latter by technology, university, and type of ownership. We therefore are in a good position to assess the possible effects of the abolition of the Danish Professors' Privilege according to these three dimensions.

4. Before and after the privilege: Danish academic patenting 1977-2003

4.1 Who owns Danish academic patents?

The recent evidence on academic patenting in Europe points unanimously at three facts:

- a) The vast majority of academic patents are not owned by the universities, but by business companies, with large “national champions” as the most important owners.
- b) The remaining academic patents are distributed between universities, governmental agencies, and individual scientists, with proportions that reflect both the legal discipline of IPRs over academic research (chiefly, the existence of any professor’s privilege provision) and the institutional features of the national science system⁷
- c) Any advantage of the US, in terms of universities’ contribution to domestic patenting, appears much reduced when the contribution is measured by taking into account not only the university-owned patents, but also the university-invented ones.

Denmark is no exception. Figure 2 shows that almost 70% of the patents in our database on Danish academic patents belong to business companies, followed by patents filed by their own inventors (almost 16%), universities (less than 12%), and governmental agencies (less than 3%).

Figure 2. Danish academic patent applications at EPO, by type of applicant (% distribution); 1978-2003

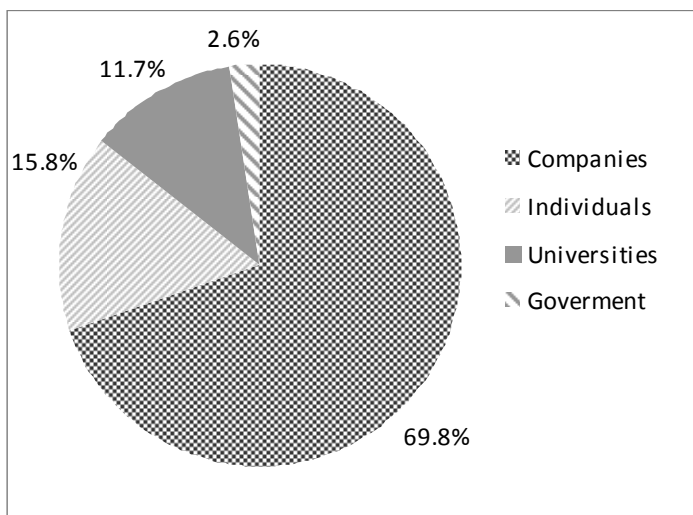


Table 3 reports the top 10 applicants of academic patents in Denmark, from 1977 to 2003, as from the KEINS database; all together, they own 23% of the academic patent applications in the database.

⁷ See: Meyer (2003), Saragossi and van Pottelsberghe (2003), Balconi et al. (2004), Geuna and Nesta (2006), Iversen et al. (2007), Lissoni et al. (2008a)

The largest portfolio of academic patents is in the hands of the most important Danish pharmaceutical company, Novo Nordisk (to which we added Novozymes since the fission between them took place only in 2000), while the third largest patent holder is H.Lundbeck, another pharmaceutical company. In between the two we find the largest Danish academic institution, Copenhagen University. A few individual scientists control (or share with other individuals the control) of patent portfolios whose size, albeit small, is as large or larger than the second-, third-, and four-largest universities in the country (as measured by patent ownership; respectively: Aalborg Univ., Aarhus Univ., and the Danish Technical Univ.).

Table 3. Top 17 applicants of Danish academic patents, 1978-2003

Type ¹	Applicant	nr. patents
C	NOVO NORDISK (incl. Novozymes)	44
U	KOBENHAVNS UNIVERSITET	31
C	H. LUNDBECK	23
I	NIELSEN, PETER EIGIL	16
I	EGHOLM, MICHAEL	11
U	AALBORG UNIVERSITET	9
U	ARHUS UNIVERSITET	8
I	BUCHARDT, DORTE	8
U	DANMARKS TEKNISKE UNIVERSITET	8
C	NOKIA	8

¹ C=company; U=university; I=individual

Figure 2 compares Denmark to other countries in the KEINS database, and with the US.⁸ In all European countries covered by the KEINS database, no less than 60% of academic patents are in the hands of business companies, whose share of US academic patents is, according to the literature, no more than 25%. Reversely, the universities' share of academic patents is as high as 68.7% in the US, and never higher than 27% in the European countries covered by the KEINS database.

The important role of business companies as patent owners in the European countries as opposed to the U.S. may primarily be attributed to differences in the institutional features of the two academic systems, as well as to differences in the respective traditions of IPR management in universities.

First, most European universities are by and large public institutions which operate under tight financial regulations imposed by their central governments. Traditionally, they have lacked the

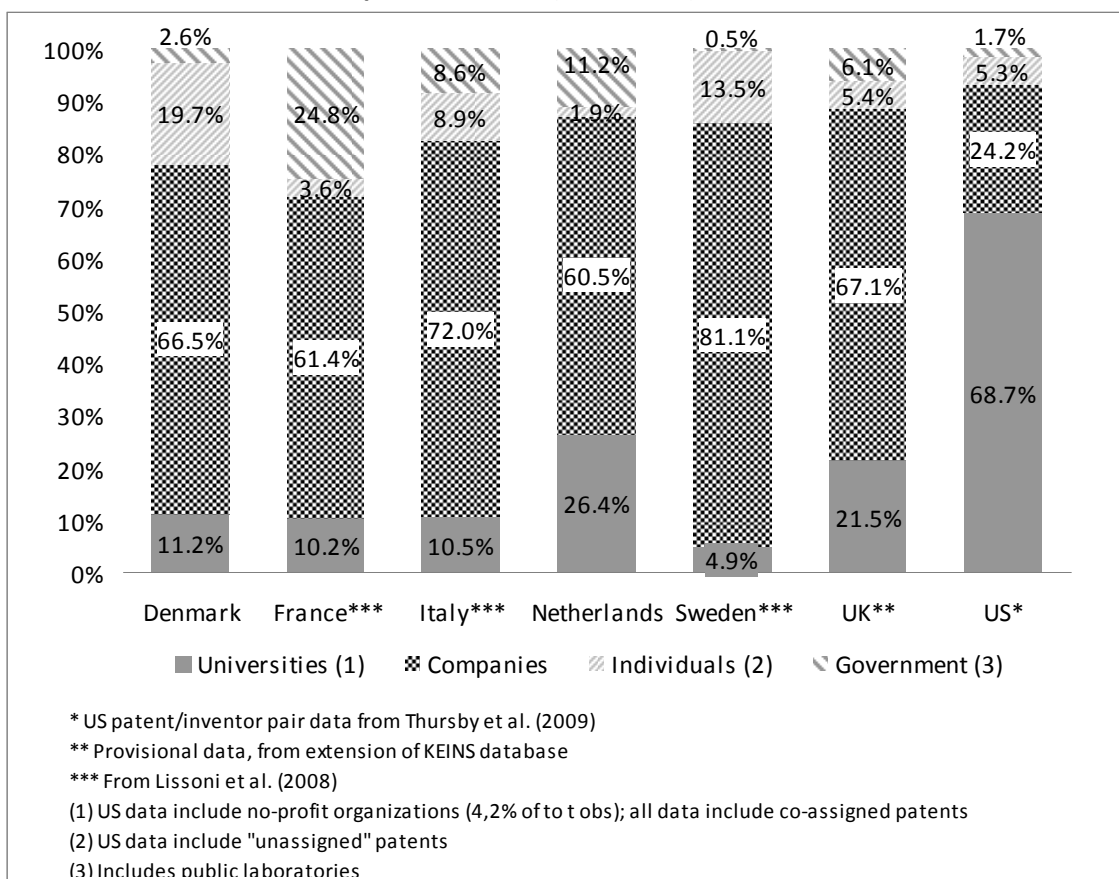
⁸ The comparison is limited to patents filed after 1994, only after which the KEINS data for France and UK are reliable. Patents co-assigned to more than one applicant, and with applicant of different types, have been considered as assigned to universities in case at least one applicant is a university; and as assigned to public agencies, if at least one applicant is a public agency and no applicant is a university. With almost no exception, co-assigned patents do not include both individuals and organizations, the latter being businesses, universities, or public agencies. On the contrary, the cases in which universities or public agencies are listed as joint applicants, and/or alongside a business company, are rather frequent.

budgetary and organizational autonomy necessary to exploit their faculty' inventions. As a consequence, they may have decided in the past, and still decide today, to allow their scientists to leave all the IPRs over their research results to any business companies willing to finance, or co-finance, such research.

Second, university patenting was common in the US academia well before the introduction of the Bayh-Dole Act in 1980, although it was not necessarily associated with a profit motive (Mowery and Sampat, 2001; Apple, 1989).

Third, it may be that European universities exert less control over their faculty's extra-academic activities, especially consulting, from which a large number of business-owned patents may arise. It may also be that consultancy for large "national champions" and local companies was and still is actually encouraged.

Figure 3. Distribution of academic patents, by type of applicant; Denmark (1994-2003) vs. US and other European countries (1994-2001)



We also notice that the share of academic patents owned by business companies, as reported in figure 3, may be overestimated, at the expense of the individual inventors' share. This is because some of the business companies which we find to own one or a few academic patents may be

academic start-ups controlled or participated by the academic inventors, in which case their patents could be seen as owned by the inventors themselves. Unfortunately, at this stage of our research, we cannot quantify the relevance of this possible mis-attribution.

As for the distribution of non-business owned academic patents, we notice that Denmark differs considerably from other European countries with respect to the ratio of individually owned patents. The percentage of Danish academic patents owned by individual scientists is the highest in the KEINS countries (almost 20%), and it is followed closely only by that of Sweden (around 13%), which is the only other country in the KEINS database whose legislation provided (and still provides) for the Professor's Privilege⁹. In France, the Netherlands, and the UK the percentage of individually owned academic patents is lower than 6% (the highest being in the UK, where the University of Cambridge by statute used until recently to grant the privilege to its faculty). In Italy, where the privilege was introduced in 2001, but professors had always enjoyed a free hand in dealing with IPR matters, related to their research, the percentage is almost 9%.

As for the percentages of patents owned by universities or public agencies, these reflect by and large the weight the latter have in the national science policies, and the autonomy they enjoy with respect of financial management and recruitment policies. In France, where for many years science policies favoured PROs, roughly a quarter of academic patents are owned by the latter. The Netherlands, Italy, and the UK follow, with percentages in between 6% and 12%¹⁰. As for Denmark and Sweden, where the national science policies have never relied upon as big public research organizations as CNRS or CNR, the percentage of academic patents in the government's hands is less than 3% and 1%, respectively.

Finally, we notice that the UK and the Netherlands, whose universities enjoy the highest degree of autonomy in Europe, exhibit a percentage of university-owned patents (over the total academic patents) of no less than 20%, as opposed to percentages of 10-11% in France, Denmark, and Italy, and less than 5% in Sweden.

The large number of business-owned academic patents suggests that the common perception of a US-Europe gap in terms of university patenting may be overstated. According to Lissoni et al.'s

⁹ Despite a similar legislation, we observe major differences between Denmark and Sweden. Indeed, we expected Sweden to exhibit a higher share of academic patents owned by individual professors, the professor's privilege there being still in place. However, we observe the opposite. We suspect that this might be because Swedish academic research has more frequently been carried out in collaboration with industry, due to the presence of higher number of large companies and multinationals active in science-based or hi-tech sectors.

¹⁰ On the role of large public agencies in France, with special reference to CNRS and INSERM, see Mustar and Laredo, 2001. On the rise and fall of CNR in Italy, see: De Marchi et al., 1999.

(2008a,b) calculations, French, Italian, Swedish, and Dutch university-owned patent applications at EPO since 1994 amount to no more than 1% of total national applications at EPO. When considering also university-invented patents, the contribution of universities to national patenting at EPO goes up to percentages in between 4% and 6%, the latter being the figure for the US suggested by the literature. In other words, when considering all academic patenting, and not just patents owned by universities, European universities do not seem to contribute less to national patenting than US ones. As for Denmark, for the reasons described above, our data do not cover the entire set of patents signed by academic scientists. However, it is clear that also for Denmark, any estimate of academic patenting based exclusively upon university-owned patents would be little more than meaningless, the latter covering just a minority of all patented inventions produced by Danish academic scientists.

4.2 A closer look at technological classes and individual universities

Table 4 illustrates the distribution by technological field¹¹ of all patents signed by at least one Danish inventor (i.e. an inventor with Danish address), and compares it with the distribution of the subgroup of Danish academic patents.

Table 4. Distribution of Danish patents (all vs. academic), by technological field, 1978-2003

Technological class	Nr. patents (1)	% patents	Nr acad. patents (2)	% acad. patents	(2)/1
Electronics	1766	13.9%	56	11.4%	3.2%
Instruments	1864	14.7%	86	17.4%	4.6%
Chemistry-Materials	1566	12.3%	51	10.3%	3.3%
Pharmaceuticals-Biotechnologies	2463	19.4%	253	51.2%	10.3%
Process Engineering	2282	17.9%	30	6.1%	1.3%
Mechanical Engineering	1499	11.8%	13	2.6%	0.9%
Consumer Goods-Others	1281	10.1%	5	1.0%	0.4%
Total	12721	100%	494	100%	3.9%

Danish academic patents are overwhelmingly concentrated in Pharmaceuticals & Biotechnologies. As for the weight on academic patenting of other science-based technologies, such as Electronics, Instruments (which includes scientific instruments), and Chemicals & Materials, this is not dissimilar to the weight these technologies carry on all patents. Much less represented, instead, are more traditional technologies such as Process and Mechanical Engineering, and Consumer Goods. In the

¹¹ Patents in the KEINS database are classified according to the original IPC classification in use at the EPO, which in turn is the basis for the OST-INPI/FhG-ISI technology nomenclature, upon which table 3 and the following are based (for reference OST, 2004, p.513). See Lissoni et al. (2006) for more details

right hand column, the table indicates the importance of academic patenting for the overall Danish patenting activity in each field. As explained above the absolute number of academic patents is underestimated, but unless there are significant biases in the degree to which we had underestimated the number of academic patents across technological classes (which we have no reasons to believe), the table still is a valid picture to which technologies university research contribute the most. The results suggest that at least one in ten Danish patents in Pharmaceuticals & Biotechnologies come from an academic scientist or a team of scientists including at least an academic. On the contrary, the percentage of academic patents in the other science-based fields ranges between 3% and 4.6%, while it is at most 1.3% in the traditional fields¹².

Figure 4. Distribution of academic patents, by technological field, cross-country; 1978-2002

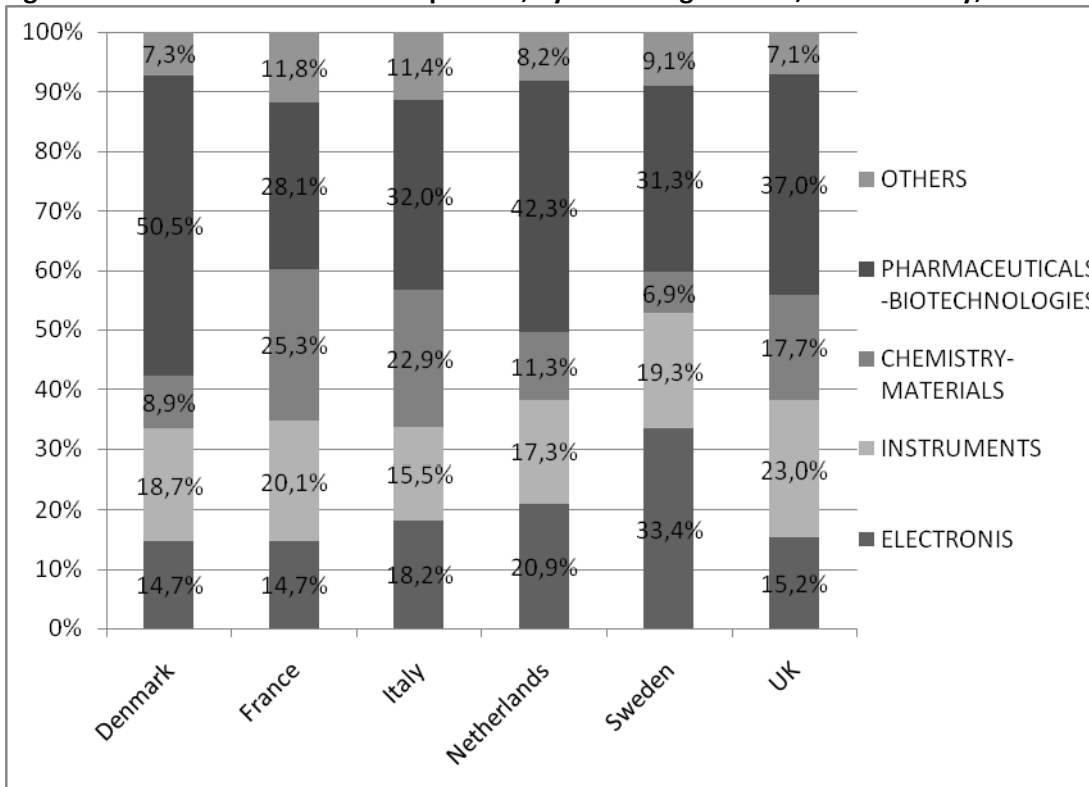


Figure 4 provides a comparison of Denmark with other countries in the KEINS database. We notice that the concentration academic patents in the four science-based fields, as opposed to the traditional ones (here grouped under the single heading “others”), is similar across countries. This

¹² When we consider also the unchecked professor-inventor matches (upper bound estimate of academic inventors) the distribution of academic patents by technology (fourth column of table 4) changes. In particular, the percentage of academic patents in pharmaceuticals and biotechnologies drops to 30%, while the percentages of process engineering, mechanical engineering, and consumer goods go up respectively to 15%, 7.6% and 6.1% (percentages for the other technologies change of no more than 1 percentage point). This is again consistent with the hypothesis that many professors who did not reply to our e-mails are homonyms of inventors from industry. In fact, we expect such homonyms to concentrate more in technologies that previous studies unanimously suggest to be far from academic scientists’ inventive activity.

evidence is consistent with data reported by the literature on the US, where the growth of university patenting has been proved to be closely linked to that of biotechnologies (Mowery et al., 2004). But we also notice that Denmark has the highest concentration of academic patents in the Pharmaceuticals & Biotechnologies. This is due to a long-term specialization of Danish university research in bio/medical-related areas.

The largest academic institution in Denmark, Copenhagen University, is a particular point in case. This university is responsible for around one third of all Danish academic patents; almost 70% of them are in Pharmaceuticals & Biotechnologies (see table 5). Also the third largest inventor of academic patents, Aarhus University, has a similar percentage patents in that field, and even the largest engineering school in Denmark (DTU) has significant patenting activity in the bio/medical area. This is a peculiar Danish phenomenon. France, Italy, the Netherlands and the UK host several universities whose impact on academic patenting is both remarkable and not overwhelmingly linked to biotechnologies.¹³

Table 5. Distribution of Danish academic patents, by technological field and university, 1978-2003

	Electronics	Instruments	Chemistry- Materials	Pharma- Biotech	Others	All fields (universities' % share)
Aalborg University (AAU)	43.1%	25.5%	3.9%	7.8%	19.6%	10%
Århus University (AU)	3.7%	11.0%	8.5%	72.0%	4.9%	17%
Technical University of Denmark (DTU)	13.5%	32.3%	12.5%	25.0%	16.7%	19%
Danish Pharmaceutical University ¹	0.0%	5.0%	45.0%	42.5%	7.5%	8%
IT University of Copenhagen (ITU)	100.0%	0.0%	0.0%	0.0%	0.0%	1%
Veterinary And Agricultural University ¹	0.0%	11.4%	4.5%	70.5%	13.6%	9%
University of Copenhagen (KU)	6.7%	12.8%	5.4%	69.1%	6.0%	30%
Roskilde University (RUC)	33.3%	0.0%	0.0%	66.7%	0.0%	1%
University of Southern Denmark (SDU)	12.0%	28.0%	8.0%	52.0%	0.0%	5%

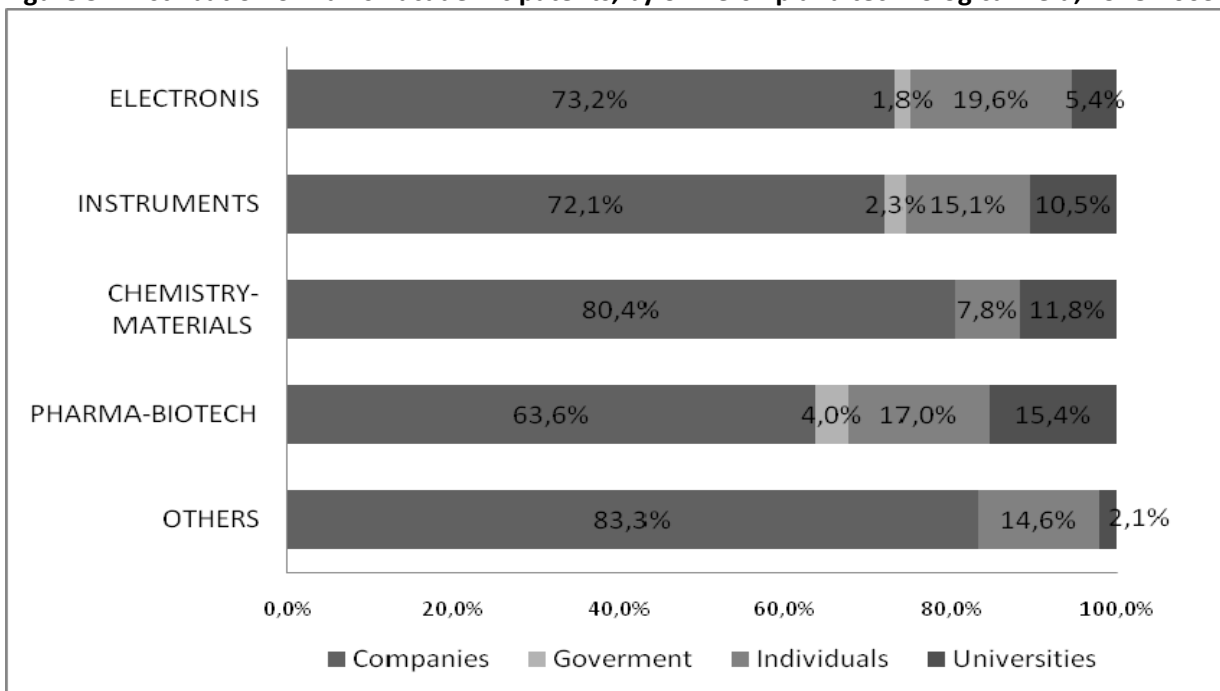
¹ Since 2007 it is part of University of Copenhagen (KU)

The distribution of academic patents by technological class is correlated with the distribution of ownership. Figure 4 illustrates how the share of academic patents in business companies' hand is the lowest in Pharmaceuticals & Biotechnologies, where we also register the highest share of patents in universities' hands.

¹³ For example, the Polytechnic of Milan, the leading engineering institution of Italy, is the third largest producer of academic patents in the country, but has virtually no patents in Pharmaceuticals and Biotechnologies. The same applies to the Eindhoven Technical University in the Netherlands. As for Sweden, it does not exhibit a higher-than-expected concentration of patents in Pharmaceuticals & Biotechnologies, but in Electronics.

This distribution is parallel to what is found by Lissoni et al. (2008a) for France, Italy, and Sweden, and it may have two complementary explanations. First, academic patents in Electronics, Instruments, and Chemicals are more likely, compared to those in Pharmaceuticals & Biotechnologies, to arise from contract research and private sponsorship. In these cases, the sponsor companies most often impose contract clauses that ensures them exclusive IPR control over all possible research results. Second, many patents in complex technological fields, such as Electronics and, to a lesser extent, Instruments, do not have much commercial value by themselves. They produce valuable innovations only if combined with others, in order to protect complex new products; or they are valuable as bargaining chips, when cross-licensing becomes necessary for avoiding mutual infringement actions between large players (Hall, 2004). So, individual scientists and universities may have less incentive to retain the property of such patents, since no licensing-for-royalties can be easily negotiated. On the contrary, patents on drugs may have a large licensing value, since a one-to-one correspondence between patent and product is more easily envisaged, and royalties are calculated over the product sales.

Figure 5. Distribution of Danish academic patents, by ownership and technological field; 1978-2003



4.3 Danish academic patents, before and after the privilege abolition

We cannot infer from our data whether the privilege abolition led to an increase (or, less likely, a decrease) in the number academic patents in Denmark. As mentioned in section 2, the main reason for this limitation is that the academic scientists in our database are only those who were still active

in 2001 and 2005. We cannot retrieve the patents signed by academic scientists who are now retired. This means that the farther we go back in time, the more severely we underestimate the number of academic patents; and that we certainly underestimate the number of academic patents before the abolition of the professor's privilege.

Figure 6. Danish academic patent applications 1977-2003

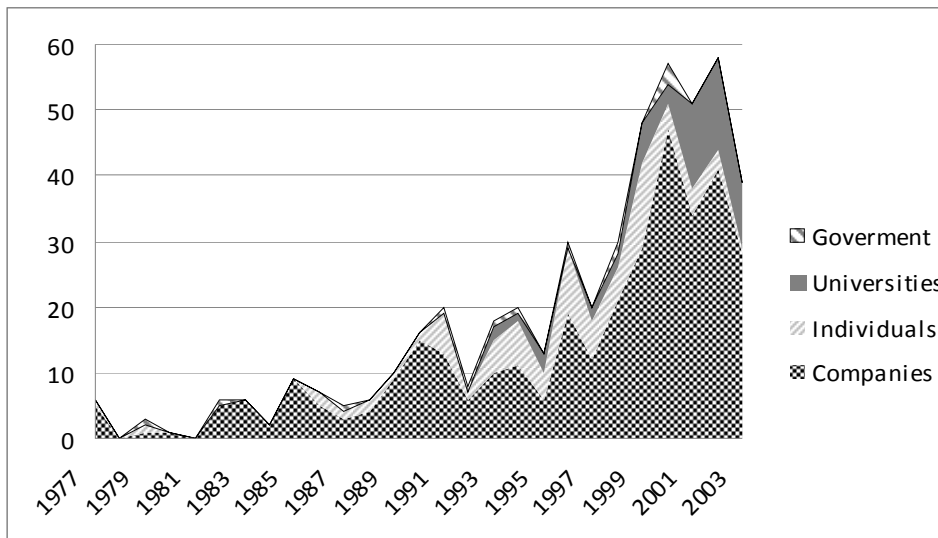


Figure 6 reports the distribution of Danish academic patents, as from KEINS, by priority year. The farther we go back in the time, the smaller is the proportion of all academic patents that are invented by professors in service in 2001 and/or 2005. The diagram should therefore not be taken as picture of the growth in academic patenting, but only of the distribution of ownership. Visual inspection suggests that universities are increasing their share in ownership at the expense of individuals.

By furthermore restricting our attention to the years immediately before and after the abolition of the privilege we get a clearer picture of the abolition's effects. The suggested change in ownership is confirmed by table 6 in which we break down the number of patent applications by type of owner for the years before and after the abolition. The evidence is clear: the university-owned patents' share increase (from 5.6% in 1977-99 to 20% in 2000-03), as opposed to the decline of individually-owned patents (from 23.2% in 1977-99 to 5.7% in 2000-03).¹⁴ This "property shift" is confirmed by table 7, which reports the time distribution of the applications filed by the top ten applicant universities and individuals. It appears clearly that most of the individual scientists' patents date

¹⁴ Approaching the date for the new act to come into force, scientists and companies were on - a modest scale - reported to "hoard" patents. The percentages for company-owned and individually owned patents taken out in the first period may therefore be slightly overestimated, while the university-share might be underestimated in the second period.

back to before the privilege, while most of the universities' patents were filed after then.

Table 6. Distribution of Danish academic patents by type of owner, before and after the professors' privilege abolition (nr. of patents and % over total nr of patents)

	1977-1999	2000-2003	1977-1999	2000-2003
Companies	192	153	67.6%	72.9%
Individuals	66	12	23.2%	5.7%
Universities	16	42	5.6%	20.0%
Government	10	3	3.5%	1.4%
Total	284	210	100%	100%

Table 7. Time distribution of academic patent applications filed by the top ten individual or university applicants

Type ¹	Applicant	nr. patents	% patents, 1977-99	% patents, 2000-03
U	KOBENHAVNS UNIVERSITET	31	25.8%	74.2%
I	NIELSEN, PETER EIGIL	16	100.0%	0.0%
I	EGHOLM, MICHAEL	11	100.0%	0.0%
U	AALBORG UNIVERSITET	9	33.3%	66.7%
U	ARHUS UNIVERSITET	8	0.0%	100.0%
I	BUCHARDT, DORTE	8	100.0%	0.0%
U	DANMARKS TEKNISKE UNIVERSITET	8	0.0%	100.0%
I	JENSENIUS, JENS CHRISTIAN	7	71.4%	28.6%
I	BERG, ROLF HENDRIK	6	100.0%	0.0%
I	FEY, STEPHEN JOHN	6	100.0%	0.0%

So while the abolition of privilege has inverted the relative size of the individuals' and universities' shares of academic patents, it has not changed much the companies' share, which has moved slightly up from 67.6% in 1977-99 to 73.2% in 2000-03 (the difference is significant at 90%). A closer look at the distribution of academic patents and their owners by technological class, in table 8, reveals that the only field where companies' share of academic patents has declined is Chemicals & Materials, where shares are calculated on a very limited number of patents; in Electronics and Pharma-Biotech, where numbers are more substantial, the companies' share has increased, while it has not changed in Instruments and in the Other fields. We also notice that the "property shift" of academic patents, from individual scientists to universities, has led the latter to diversify their patent portfolio: before the abolition of the privilege, such portfolio included only patents for Instruments and Pharmaceutical & Biotechnological inventions. After the privilege, the share of patents for Instruments has remained pretty much the same, while that of Pharmaceutical & Biotechnological has declined substantially; Danish universities now also own patents in Electronics, Chemicals & Pharmaceuticals, and even very few patents in fields such as Process Engineering or Consumer

Goods.

Table 8. Distribution of Danish academic patents by technology and type of owner, before and after the professors' privilege abolition

	1977-1999				2000-2003			
	Companies	Gov't	Individuals	Univ.s	Companies	Gov't	Individuals	Univ.s
ELECTRONIS	64.5%	3.2%	32.3%	0.0%	84.0%	0.0%	4.0%	12.0%
INSTRUMENTS	71.1%	4.4%	20.0%	4.4%	74.4%	0.0%	10.3%	15.4%
CHEM.S-MATERIALS	88.6%	0.0%	11.4%	0.0%	62.5%	0.0%	0.0%	37.5%
PHARMA-BIOTECH	58.9%	5.0%	26.2%	9.9%	70.0%	2.7%	5.5%	21.8%
OTHERS	81.3%	0.0%	18.8%	0.0%	86.7%	0.0%	6.7%	6.7%
All technologies	67.6%	3.5%	23.2%	5.6%	73.2%	1.5%	5.9%	19.5%

Summing up, it is clear that universities take ownership of more patents, but also that this comes at the expenses of individual professors' ownership, which after the act – as expected - is dramatically reduced. Interestingly, also the share of industry-owned patents increases after the act, if only marginally. Taken together, these observations support the conclusion that the act did not produce the wanted outcome, namely for universities to take ownership of more patents in order to create an open market for IP rights to university-based inventions. Companies engaged in collaborative research with university scientists seem to secure ownership to even more inventions than before the introduction of the act. However, even if the universities did 'only' move ownership from individuals, it might be that the university TTOs are better than individuals (with their legal and commercial support) in commercializing their share of the inventions. This study has no evidence to investigate such a hypothesis.

Coming back to the question of why the company-owned share of academic patents seem to increase or to remain stable rather than to fall, we might speculate that both companies and scientists perceive the introduction of a 'third wheel' as a strain to their relationship. The idea that universities ought to own the rights to the inventions is challenged from two sides. On the one hand, even in the bio/medical area most results of basic research are not patentable at all, so legislation on ownership of IP rights is irrelevant. Only legislation on patent subject matters would matter, to the extent that a less clear-cut distinction between inventions and scientific discoveries would make it easier for university (or their scientists) to take patents.

On the other hand, most applied research is carried out in close collaboration with specific companies. In such relationships, anything else than an *ex-ante* agreement saying that the rights to commercialize the results of the joint research belongs to the company may effectively preclude collaboration. If this is a realistic description of the current situation, probably the change of the professor's privilege will have very little effect (see Valentin and Lund, 2007, for a similar conclusion).

5. Conclusions

Extending the KEINS database on academic patenting to the case of Denmark provides useful evidence on the effects of the abolition of the professor's privilege in that country. Such effects seem to consist mainly in a "property shift", with universities replacing many individual scientists as applicants for patents over the latter's inventions. This shift, however, is of limited importance compared to the amount of academic patents that remain in the hands of business companies.

Although still exploratory and incomplete, our analysis lends itself to some policy conclusions. The abolition of the professor's privilege, although decided on a national basis, has been the result of a re-assessment of IPR policies for universities that has taken place throughout Europe. These have been largely inspired by the policy-makers' shared vision of the existence of a European Paradox, according to which European research institutions can compete with US ones when it come to producing scientific advancements, but underperform in innovation, also due to lack of university-industry technology transfer (EU, 1995). However, the literature and the data we present here contribute to proving the premises of such IPR reforms to be wrong: European universities both in the past (before the abolition of any privileges) and in the present (after such abolition) contribute substantially to patenting, although they tend to leave most patents in the business partners' hands (for a more general criticism of the Paradox theory, see Dosi et al., 2006).

The similarities we find between Denmark and other countries suggest that there is room for a co-ordinated European action. Such action must be based on a clear understanding of the quantity, quality, and management practices of European academic patents, whoever their owners are. Such action should arguably also take into account the overall mission of the universities to society and any special characteristics of university patents (e.g. their often close relationship with "basic science"). In the absence of this understanding, meddling with professor's privilege (either to abolish it, as in Denmark, or to introduce it, as in Italy) is just likely to scratch the surface of the phenomenon, and actually provide no help to further a better use of IPRs in relation to science-based inventions. It may even be the case that altering the distribution of IPRs between scientists and their institutions will generate tensions between the two, or with business firms, which are the most relevant third party.

The time may have come for national governments to co-ordinate their actions addressing academic patenting. It is important though that such actions are seen as incidental to university and science

policies. This is suggested by the differences between Denmark and other European countries that we observed, alongside with similarities. Such differences mirror national specificities in the relative importance of different disciplines, and of universities *versus* public research organizations. They also reflect the different composition of national industries, which expresses most of the demand for academic inventions. This suggests that, at least until recently, it was not the IPR legislation that conditioned the actions of universities and scientists, but the general features of the national innovation systems (and the position of universities therein) that conditioned the observed IPR management practices. However, the increasing attention dedicated to academic patenting may change things. For these changes to be positive, policies for academic patenting must support, and not stand in the way of the many fruitful existing relationships between academic scientists and universities.

References

- Apple R.D. (1989), "Patenting university research. Harry Steenbock and the Wisconsin Alumni Research Foundation", *Isis* 80, pp.375-94.
- Balconi M., Breschi S., Lissoni F. (2004) "Networks of inventors and the role of academia: an exploration of Italian patent data", *Research Policy* 33(1), pp. 127-145
- Baldini N. (2006), "The Act on inventions at public research institutions: Danish universities' patenting activity", *Scientometrics* 69 2, pp 387–407
- De Marchi M., Poti B.M., Reale E., Rocchi M., Scarda A.M. (eds.) (1999), *Il sistema scientifico pubblico in Italia*, FrancoAngeli, Milano.
- Dosi G., Llerena P., Sylos-Labini M. (2006) "The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'", *Research Policy* 35(10), pp. 1450-1464
- EC 1995, *The Green Paper on Innovation*, Commission of the European Communities, Luxembourg
- FI (2007), *Public Research Commercialisation Survey*, Forsknings- og Innovationsstyrelsen (Danish Agency for Science, Technology and Innovation), <http://en.fi.dk/publications/publications-2008/public-research-commercialisation-survey-denmark-2007/UK-Kommercialisering07-screen.pdf> (last visited: march 2009)
- Geuna, A. and L.J.J. Nesta 2006. University patenting and its effects on academic research: the emerging European evidence. *Research Policy* 35, 790–807.
- Hall B. (2004), "Exploring the Patent Explosion", *The Journal of Technology Transfer* 30, pp. 35-48
- Henderson R., Jaffe A., Trajtenberg M. (1998), "Universities as a source of commercial technology: a detailed analysis of university patenting 1965-1988", *Review of Economics and Statistics* 80, pp. 199-127
- Iversen, E.J., M. Gulbrandsen and A. Klitkou 2007. A baseline for the impact of academic patenting legislation in Norway. *Scientometrics* 70(2), 393–414
- Kilger C., Bartenbach K. (2002), "New Rules for German Professors", *Science* 298/5596, pp. 1173 - 1175
- Lissoni F. Sanditov B. Tarasconi G. (2006), "The Keins Database on Academic Inventors: Methodology and Contents", *CESPRI working paper* 181, Università "L.Bocconi", Milano
- Lissoni F., Llerena P., McKelvey M., Sanditov B. (2008a), "Academic Patenting in Europe: New Evidence from the KEINS Database", *Research Evaluation* 16, pp. 87-102
- Lissoni F., Pellicciari F., Tartari V. (2008b), "The KEINS data-base of Dutch academic inventors", presentation at the workshop on *University-Industry Linkages in the Netherlands: Research Issues and Policy Challenges*, Eindhoven University of Technology, April 16
- Meyer, M. 2003. Academic patents as an indicator of useful research? A new approach to measure academic inventiveness. *Research Evaluation* 12(1) 17-27.
- Mowery D.C., Sampat B.N. (2001), "Patenting and Licensing University Inventions: Lessons from the History of the Research Corporations", *Industrial and Corporate Change* 10/2:317-355.
- Mowery D.C., Nelson R.R., Sampat B., Ziedonis A. (2004). *Ivory tower and industrial innovation: university-industry technology transfer before and after the Bayh-Dole Act in the United States*. Stanford: Stanford University Press.

- Mustar P., Larédo P. (2001), "French Research and Innovation Policy: Two Decades of Transformation" in Laredo and Mustar (eds.) *Research and Innovation Policies in the new Global Economy*, Edward Elgar, Cheltenham UK
- OECD 2003, *Turning Science into Business. Patenting and Licensing at Public Research Organizations*, Organisation for Economic Co-operation and Development, Paris.
- OST (2004), *Indicateurs de Sciences et de Technologies – Rapport 2004*, Observatoire de Sciences et de Technologies, Paris (http://www.obs-ost.fr/services/rapport_ost/)
- PVA-MV (2003), *Report on the abolition of the German professors privilege: Overview of changes and challenges*, Vinnova - Swedish Agency for Innovation Systems, Stockholm
- Saragossi S., van Pottelsberghe B. (2003), "What patent data reveals about universities – The case of Belgium. *Journal of Technology Transfer* 28(1),pp. 47-51
- Schovsbo J. (2008), "Universitetsansattes immaterialrettigheder: Fra irrationelle professorprivilegier til irrationelle universitetsprivilegier?", *Tidsskrift for Rettsvitenskap*, 121(3), pp. 271- 288
- Schovsbo J.(2001), *Lov om Opfindelser ved Offentlige Forskningsinstitutioner*, DJØF Publishing
- Thursby J., Fuller A.W., Thursby M. (2009), "US faculty patenting: Inside and outside the university", *Research Policy* 38/1, pp. 14-25
- Valentin F., Lund J.R. (2007), "Effects on academia-industry collaboration of extending university property right", *Journal of Technology Transfer* 32, pp. 251-276