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Changes to university IPR regulations in Europe and the impact on academic patenting

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Abstract

This article develops a general framework to describe the changes in university IPR regulations in Europe and their effects on the patenting activities of universities and on knowledge transfer processes. Understanding the effects of changes in IPR regulations on academic patenting is a complex issue, and parallels with the US case can be misleading. First, despite the general trend towards institutional ownership, university IPR regulations in Europe remain extremely differentiated and there is no one-to-one mapping to the US system. Second, it is difficult to disentangle the quantitative and qualitative effects of changes in IPR ownership regulations on academic patenting activities from the effects of concurrent transformations in the institutional, cultural and organizational landscape surrounding academic knowledge transfer. The article proposes a review and typological classification of national university IPR ownership systems on the basis of their development since 2000, and uses it to analyze the aggregate dynamics of academic patent ownership in several European countries. The analysis of patterns of ownership of academic patents shows that there has been a general increase in university patenting since 1990, with a significant slowdown (and even reduction in some countries) after early 2000s accompanied by a switch in academic patents ownership in favor of university ownership though preserving the European specificity of high company ownership of academic invented patents.

Keywords: academic patenting, university-owned patents, university-invented patents, intellectual property rights regulation, university-industry knowledge transfer

JEL: I23; O31; O34

1. Introduction

Over time, in most European countries, universities have become increasingly involved in the management of the inventions produced by their staff. In particular, the patenting of such inventions is increasingly advocated as a strategy to improve the immediacy and effectiveness of knowledge transfer from academia to industry, and in turn to promote the universities' ability to contribute to social and economic innovation and development.

While the characteristics of processes of knowledge transfer through patents are affected by numerous issues, one key aspect common to all jurisdictions is the ownership of the intellectual property rights (IPR) on research results. Since the end of the 1990s, most European countries have been moving away from inventor ownership of patent rights towards different systems of institutional ownership. Inventor ownership (or professor's privilege) describes a situation where the results of publicly-funded research created or developed by researchers are owned by the researcher and not by the institution where the research is carried out; institutional ownership means that the results of publicly-funded research are instead owned by the institution employing the researcher responsible for the work.

In Europe, professor's privilege prevailed in the German-speaking and Scandinavian countries: it allowed university professors to retain patent and utility model rights over their research results, while the inventions of scientists employed in public research laboratories or private industry belonged by default to their employer. Denmark was the first country to decide, in 2000, to abolish professor's privilege in favor of institutional ownership, followed by Germany, Austria, Norway and Finland

in the period 2001-2007. In other countries like France and the UK, where institutional ownership was already in place, universities were encouraged to enforce such rights. These initiatives were driven by the shared objective to imitate conditions in the US, where, since the Bayh–Dole Act of 1980, universities have been allowed to retain IPR on the inventions resulting from federally funded research.

While some recent literature has begun to investigate changes in the systems regulating the ownership of university IPR in Europe and the quantitative and qualitative effects of such changes on the patenting of inventions emerging from academic research, we are still quite far from a complete understanding of these phenomena. The objective of this paper is to develop a general framework to think about how IPR regulations are changing and what are their effects on the patenting activities of universities and on knowledge transfer processes. We show that understanding the effects of changes in IPR regulations on academic patenting is a complex issue and that parallels with the US example can be misleading. First, we show how, despite the general trend towards institutional ownership, university IPR regulations in Europe remain extremely differentiated and there is no one-to-one mapping to the US system. Nonetheless, it is possible to subsume the historical development patterns of the IPR systems of different countries into a small number of categories, which can help us to discuss their differences in a more systematic and orderly way. This issue is discussed in Section 2, which provides a review and typological classification of changes to the regulations on assignment of IPR on academic research results since 2000. Second, we provide, in Section 3, an overview of the aggregate dynamics of academic patent ownership in several European countries, reviewing and integrating data from several sources and highlighting

emerging quantitative patterns. Finally, in Section 4, we discuss how it is very difficult to disentangle the quantitative and qualitative effects of changes in IPR ownership regulations on academic patenting activities from the effects of concurrent transformations in the institutional, cultural and organizational landscape surrounding academic knowledge transfer. This complexity calls for specific country based analyses to fully understand the impact of IPR regulations on academic patenting.

Table 1. Ownership of IPRs at universities in selected European countries

<i>Country</i>	<i>Institution</i>	<i>Inventor</i>
Austria	◆ (2002)	
Belgium	◆ (1997/98)	
Czech Republic	◆ (1990)	
Denmark	◆ (2000)	
Finland	◆ (2007/2010)	◇
France	◆ (1982)	
Germany	◆ (2002)	◇
Greece	◆ (1995)	◇
Hungary	◆ (2006)	
Italy		◆ (2001/2005)
Netherlands	◆ (1995)	◇
Norway	◆ (2002)	
Poland	◆ (2000)	
Slovak Republic	◆ (2000)	
Slovenia	◆ (2006)	
Spain	◆ (1986)	
Sweden		◆ (1949)
Switzerland	◆ (1911)	
UK	◆ (1977/1985)	

◇ : Inventor ownership is assigned on certain types of inventions
 In brackets: years in which last change in regulation took place

2. Regulation changes and university bylaws

Table 1 presents an overview of the current state of regulations on university ownership of IPR¹ for a group of European countries. For each country, we report whether ownership of the intellectual property (IP) produced by academic researchers is vested primarily in the inventor or the institution, and indicate the year when the regulation changed. The information in Table 1 shows that in Europe, with few

¹ The analysis in this paper is limited to patents and does not include other forms of protection such as copyrights, design rights and, trademarks.

exceptions, the system of institutional ownership of academic patents is the most common. The prevalence of this system has increased since 2000, with many countries switching from inventor ownership of IPR (or systems where ownership was assigned to the State) to institutional ownership. Only two countries, Italy and Sweden, maintain systems primarily centered on assigning IPR ownership to the inventor.

2.1 A typology of changes in national IPR regulations

Despite the fact that countries have followed different historical patterns to arrive at their current configurations, it is possible to identify a small set of country groups based on the evolution of IPR regulations pre and post 2000. This typology (presented in Table 2) identifies five distinct groups based upon (i) the direction of the change in IPR ownership after 2000 (from institutional ownership to inventor ownership; from inventor ownership to institutional ownership; continuing institutional ownership; continuing inventor ownership) and (ii) the tradition of involvement of the university in IP management (weak or strong).

Table 2. A typology of changes in national IPR regulations

		<i>Traditional involvement of university in IP management</i>	
		Strong	Weak
<i>IPR ownership regulations after 2000</i>	Continuing institutional ownership	UK Spain Switzerland	France Greece
	From inventor ownership to institutional ownership		Germany Denmark Finland Norway Austria
	From institutional ownership to inventor ownership (and back)		Italy
	Continuing inventor ownership		Sweden

A first group comprises early adopters of the institutional ownership system such as the UK, Spain and Switzerland. The UK was one of the first European countries to implement university ownership of academic property rights. The Patent Act 1977 states that an employee invention is owned by the employer (under normal circumstances) and there is no special provision for academics.² From 1948, in the UK academic property rights were managed by a government organization: the National Research Development Corporation (NRDC). In 1981, NRDC merged with the National Enterprise Board to form the British Technology Group (BTG) which gained the exclusive rights to commercialize the results of publicly funded research till 1985 when UK universities were allowed to decide whether to own and manage their patents independently or rely on the services provided by BTG (Macdonald, 2009). In 1992, BTG was privatized and became a private supplier of IPR brokerage services to universities and other companies. Although universities had been allowed to claim the rights to their employees' inventions, it was only after the UK Department of Trade and Industry published the White Paper *Realizing our Potential* (DTI, 1993), which called for universities to play a key role in national innovation and competitiveness, that university patenting activity began to increase (Macdonald, 2009). This trend increased up to 2000, with several policy reports and guidelines (see Tang, 2008) encouraging universities to adopt a more "commercial" model of interaction with external stakeholders. Also Spain should be included in the early adopters with a strong university IP management, the framework for scientific and patenting activities was established in the 1980s, based on the University Reform Law which allowed university researchers to receive income from contracts with firms,

² However, the application of the rule in respect of university academics has been challenged in court a few times and a 2009 decision of the Full Court of the Federal Court of Australia in *University of Western Australia v Gray* seems not to support its applicability (Pila, 2010).

including arrangements that led to patents and licensing (Azagra-Caro, 2010). It allowed researchers to add to their income through contract work. The 1986 Law for the Promotion and General Coordination of Scientific and Technological Research (the “Science Law”) required universities to become better aligned to societal needs and economic development in particular, and stated that universities and public research organizations retained ownership of their research results. This rendered the regulatory framework in Spain very similar to that in the US, although it had not been directly inspired by the US model (Azagra-Caro, 2010).

The second group includes countries such as France and Greece, which favored institutional ownership, but where its enforcement was weak. In France, historically, the main function of the university was education, and the university sector was heavily controlled by central government. Beginning in the 1970s, universities’ autonomy and involvement in research and interaction with public research institutes increased. Professors and teachers had the status of civil servants, which meant that the patent rights on their inventions belonged to their employers, the universities. However, the universities usually did not retain these rights, since this was considered “counter-productive” in terms of knowledge diffusion or attracting industry funding (Azagra-Caro, Carayol and Llerena, 2006). In 1999, to try to address the low levels of cooperation and knowledge transfer between university and industry, the government introduced Public Law 99-597, also known as the Innovation Act. It was aimed at increasing universities’ awareness of IPR and facilitating IPR commercialization through the creation of a technology transfer infrastructure (Azagra-Caro, Carayol and Llerena, 2006).

The third group is composed of countries which implemented a strong “professorial rights” system – Germany, Denmark, Finland, Norway and Austria – and which in the early 2000 modified their IPR regulations to introduce institutional ownership. In Germany, in 2002, the professor’s privilege was abolished (in socialist East Germany professorial right did not apply) and universities were given the right to file patents on their employees’ inventions, although if they did not do so within a certain period of time, the rights revert to the inventor. This change was motivated by a concern among policymakers that individual researchers might be unwilling or unable to pursue commercial application of their ideas through patenting or licensing activity (Czarnitzki, Hussinger and Schneider, 2008). By requiring universities to assign 30% of the gross revenue from a patent to the inventor, and to pay all the costs associated with patent application, the law was designed to increase the incentives for the scientists to disclose their inventions. Similar shifts towards institutional ownership have taken place in Austria, Denmark, Finland and Norway.

The fourth group includes a country, Italy, which moved from institutional ownership to inventor ownership, bucking the general trend. Legislation on intellectual property in Italy dates back to 1939 and assigns ownership of property rights on any invention developed by an employee during his or her working time, to the employer (Della Malva et al., 2007). Before the 1990s, universities as employers were managed by the Ministry of Education and had little decisional or financial autonomy. They were not interested in exploiting their IP because until 1996, they received no income from it (Baldini et al., 2010). A situation very similar to the French case. New legislation introduced in 2001 granted IPR ownership to the researcher/professor, and allowed the university to receive a share (between 30% and 50%) of the revenue from patents.

If an inventor had not used a patent after five years, the university would be granted a free non exclusive license to use the invention. It was assumed that individual inventors would be better placed to profit from their discoveries, since universities lacked the competence and culture to commercialize inventions (Della Malva et al., 2007; Baldini et al., 2010). Funnily enough, the exact opposite view justified the change of regulation in the German speaking countries in the same period.³ In 2005 the regulation changed again. Professor's privilege applies only in the case of research that has been fully financed by the institution employing the individual; in the case of research that is partly privately funded or funded by government or an international government agency, the IPR belongs to the university. Since external funding is very important for most research laboratories, this reduces the possibilities for researchers to own the IPR to their inventions, and has led to conflict, as it can be difficult to directly link a financial input to a specific research output.⁴

The fifth group includes a country which has chosen to maintain invention ownership systems based on professor's privilege, Sweden. Professor's privilege was implemented in Sweden in 1949 and allows the researcher to receive all the benefits from a patent but also to bear all the costs. Although the rules on IPR assignment have not changed, the rules for funding of universities (Sellenthin, 2006) and cultural and policy attitudes to technology transfer have changed since "third mission" activities were formally recognized as compulsory in 1997 (see discussion in section 4).

³ "Ai posteri l'ardua sentenza", it is for posterity to judge who was right.

⁴ Dissatisfaction with this mixed regulation on the part of the professional community has resulted in various attempts to re-introduce university ownership rights. In 2006/07 and again in 2010 a regulation that would assign full patent rights to the university went through the parliamentary procedure, only to be rejected at the final implementation stage.

Finally, for sake of completeness, European countries belonging to the former “Eastern group” should be considered as belonging to a separate group (not discussed here): these countries began updating their general patent systems in the early 1990s and assigned ownership of academic IPR to universities, in a change from the government ownership system typical of the communist period.

Though the typology presented indicates a general trend towards institutional ownership, this does not equate to greater homogenization of university IPR ownership systems in Europe for two main reasons. First, institutional ownership systems are very different from each other with respect to numerous dimensions, and so are the two inventor ownership systems (Section 2.2). Second, national regulation are modified by the application of university specific bylaws on the allocation of patent rights (Section 2.3).

2.2 Differences within national IPR systems

National IPR systems allowing institutional ownership differ substantially along several dimensions. First, in terms of the regulations on academic patenting, the system may be regulated by national laws (public research acts or similar), or by default (i.e. general laws on IPR ownership). In some cases, non-binding national codes of practice have been formulated to provide guidance to universities. Second, there are differences in how the rights are vested in the university. Under the “pre-emption rights” principle, the researcher is the first owner of the invention but the university has the right to “claim” the invention within a specified period. In the event that the invention is not claimed within the specified period, the rights remain with the

inventor. This specified time period varies between 2 and 6 months from notification (but in Belgium it is 3 years) (DLA PIPER, Mason Hayes+Currant , 2007). Countries with pre-emption rights systems are Austria, Czech Republic, Denmark and Norway. Under “automatic ownership”, the university is the first owner of the IPR, which usually cannot revert to the inventor. Countries with automatic ownership systems include France, the Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain and the UK. Finland, Germany, Greece and Hungary have hybrid systems. Third, the type of invention can affect the ownership, in Finland, the law distinguishes between inventions coming out of “contract research”, which automatically are assigned to the institution, and “open research” (wholly university funded, or where there is an agreement with external sponsors to consider the research “open”) which means rights belong to the inventor and the institution can acquire them only if the inventor does not intend to use or publish them. Thus, Finland’s system can be described as “qualified professor’s privilege” (DLA PIPER, Mason Hayes+Currant, 2007), similar to the current system in Italy. Germany, Greece and Hungary make a distinction between “service inventions” which result from the employee’s activity during the term of employment (and which fall under automatic ownership) and “free inventions” (or “dependent inventions” or “employee inventions”) which include all other inventions (rights are assigned to the inventor and the institution can commercialize them under a non-exclusive license).

The two professor’s privilege systems also differ. The scope of professor’s privilege in Italy is wider than in Sweden, since it applies to all the employees and potentially all consultants and third parties involved in the university research, while in Sweden it applies only to teachers, postgraduate students and doctoral candidates. In 2005 Italy

reintroduced partial institutional ownership. There are also differences in the allocation of the profits deriving from exploitation of an invention, the obligation of the researcher to patent, and derogation to the general inventor ownership rule: the Italian system is more binding than the Swedish one⁵.

2.3 University bylaws

An added complexity in the regulatory framework is that universities can often override national regulations in order to negotiate different IPR arrangements with third parties: such cases are usually regulated by university bylaws. In most countries, if research is sponsored fully or in part by external contractors (e.g. private companies) it is possible for parties to negotiate a different agreement on the allocation of patent rights between sponsor, university and individual inventor. In some cases, the university can override existing national regulations by developing internal patent rights regulations and processes for how to enforce them; the most well know case is the University of Cambridge that till 2001 did not enforce fully the university ownership right (still in 2010 an handful of professors with old contracts maintain some inventor' rights) and had assigned very few patents till 2006.

Since the early 1990s most European universities have been given increased autonomy which has allowed them to devise bylaws that apply to the management of knowledge transfer. Issues such as the share of royalties to be assigned to the employees involved in the invention, the rights of PhD students involved in an invention, the baseline for TTO activities, the timing of patent filing procedures, can

⁵ See DLA PIPER, Mason Hayes+Currant (2007) for a more detailed comparison of the regulations in the two systems.

vary widely among universities in the same country. The role of university bylaws in order to regulate IPR ownership and related conditions is particularly important in countries where there is no strong legislative framework regulating academic patenting, such as the UK, Ireland and Switzerland, and in countries where the national regulatory framework applies only if researchers and other parties have not agreed alternative rules, such as Sweden (Sellenthin, 2006); but also in most other European countries universities have some flexibility to define internal rules. The variety of bylaws is constrained, however, by a process of institutional imitation. For example, Baldini et al. (2010), based on an in-depth study of the evolution of Italian universities' patenting regulations, show that most universities tend to adapt the patent regulations applying in the prestigious universities, which has led to a fairly standardized set of practices. The progressive emergence of a community of technology transfer professionals employed by university TTO has led to the creation of professional associations which has contributed further to the consolidation of these practices.

The analysis of national regulations and university bylaws defining ownership of IPR from academic research shows that the shift towards institutional ownership has not resulted in greater homogeneity of IPR ownership systems, nor a "one size fits all" adaptation of the US framework. Therefore, comparisons with US experience could be misleading. In the USA one of the main justifications for the Bayh-Dole Act was that government ownership of publicly funded inventions hampered their commercialization, and the Act placed the property rights *nearer* to the inventor (Mowery and Sampat, 2005). However, in Germany, Denmark and Norway, for example, academic inventors owned the IPR, and the abolition of professor's

privilege had the effect of placing IPR ownership *further away* from the inventor. Even in countries like France or Italy, where institutional ownership existed before 2000 but where universities were not enforcing it, it could be argued that in practice the management of the IP was directly in the hands of the inventor, so that a shift to institutional ownership would remove it away from the inventor's control. The possibility for the inventor to dispose of his or her IP (due either to law or custom) is likely to have fostered a different system of relationships between the inventor, the university and industry, with respect to countries where institutional ownership has traditionally been present and enforced.

3. Academic Patenting: The evidence

Previous work (Geuna and Nesta, 2006) has pointed out the scarce availability of statistical information on academic patenting in Europe, the situation has much improved since then, but it is still far from optimal. Here we organize a set of disparate sources (public and not) to provide the best possible evidence on European academic patenting and its evolution during the last twenty or so years. We consider both (a) patents owned/applied for by a university or other higher education institution - *university-owned patents* and (b) patents that have one or more university researcher in the list of the inventors but which are owned/applied for by some other individual or organization (e.g. company, government agency, non-profit organization) - *university-invented patents* (Geuna and Nesta, 2006). Following Lissoni et al. (2008), academic patenting refers to both forms of patenting, while university patenting refers exclusively to patents directly owned/applied for by a university.

Official data on university-owned patents are produced by the EU, OECD, national government agencies and TTO associations. None of these sources makes available time series data that are comparable across countries. The only public database available online is the Eurostat Science and Technology database⁶ which provides information on patent counts (based on patent applications to the European Patent Office (EPO) by priority year at national level) across countries starting from the late 1990s. Table 3 presents a preliminary overview of the changes in university patenting in Europe between the late 1990s and the mid-2000s for a selected sample of European countries, and the US (as a benchmark). Most countries show a remarkable increase in university patenting, with output in the EU-27 doubling, although there are a few exceptions. Sweden and the US present negative growth and the Netherlands and the UK present only weak growth. These results are confirmed by OECD data on the share of patents owned by universities in international Patent Cooperation Treaty (PCT) filings with EPO designations, for 1995-1997 and 2003-2005 (OECD, 2008).

Table 3. Patents owned by HEI

	04-06 ^(p)	01-03	98-00
European Union (27 countries)	1059	796	573
Euro area (15 countries)	756	480	311
Denmark	31	17	5
Germany (including ex-GDR from 1991)	252	135	61
Spain	51	32	21
France	117	84	46
Italy	78	46	24
Netherlands	68	61	52
Austria	25	2	3
Sweden	2	5	5
United Kingdom	256	284	245
Norway	7	1	1
Switzerland	79	59	47
United States	1265	1172	1320

Source: Elaboration of Eurostat data

(p): Provisional values for 2006.

⁶ Accessible from <http://epp.eurostat.ec.europa.eu> (last accessed 4/10/2010).

The most reliable national government agency data on university-owned patents are those collected in the UK. These data are used by the Higher Education Funding Councils to allocate third stream funding to universities. The annual HE-BCI survey provides information on disclosures, patent applications, patent granted, licenses, spin-offs, income, etc. Table 4 presents the evolution of a subset of indicators for the period 2003-04 / 2008-09. Patents applied for and granted (both national and international filings but not counting multiple filings of the same patent in different countries) show average increases of some 10% and 7% respectively, while new spin-offs have grown more slowly. Total income from IP increased at about 12% per year generally, excluding the exceptionally good performance of the last year (see note below table). However, if we compare total funding from collaborative research, contract research and consultancy, with income from IP we see that the latter is very small, accounting for only 3% to 4% of other research-related sources. Also, compared to other research related funding sources, such as income from facilities and equipment services (e.g. renting a microscope for an experiment), IP income was between 33% and 66% lower during the whole period (excluding the last year).

Table 4. Summary indicators of IPR related activities in UK universities

	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09*
Patent applications	1,308	1,648	1,536	1,913	1,898	2,097
Patents granted	463	711	577	647	590	653
Formal spin-offs established	167	148	187	226	219	191
Formal spin-offs still active after 3 years	688	661	746	844	923	982
IP income	43	63	63	61	68	124 [§]
Other income	1,508	1,518	1,612	1,829	1,910	2,001

Source: HEBCI Surveys - <http://www.hefce.ac.uk/econsoc/buscom/hebci/>

£Millions

*Survey conducted by the Higher Education Statistics Agency (HESA) with some inconsistencies with previous years, especially with regard to IP income

[§]About 42% of the increase on previous year is due to one UK university selling its share of a well-established company (HEFCE, 2010)

Data on university-owned patents are collected also by national and international TTO associations. Two of them, the European Knowledge Transfer Association (ProTon)

and the Association of European Science and Technology Transfer Professionals (ASTP), have international membership, but neither is representative of the European university population. For example, for the fiscal years 2007 and 2008 ProTon surveyed respectively 323 and 305 European universities (mostly from Denmark, Italy, Spain and the UK), while ASTP included only 140 and 99 responses from the best performers in Europe (Piccaluga and Pietrabissa, 2010; Proton, 2009). Using information from Piccaluga and Pietrabissa (2010) and Proton (2009) we can compile information from five ProTon surveys (from 2004 to 2008) and three ASTP surveys (2006 and 2007). In the ProTon survey, the total number of priority patent application increased from 943, to 3,304 in 2007 (and 2,951 in 2008) mainly due to the entry of new TTO in the survey: the average number of applications per TTO office declined then increased to 10.7 in 2007 (and 10.0 in 2008). The total number of patents granted increased similarly, from 123 in 2004 to 1,173 in 2007 (but was only 710 in 2008) and the number of patents granted per TTO increased from 2.1 to 4.0 in 2007 (but was only 3.4 in 2008). Average licensing revenues per TTO decreased from €375,800 to €212,600 in 2007 (increasing to €246,900 in 2008 driven mainly by the previously described UK performance). The ASTP survey shows important absolute increases (due to the increasing number of respondents) for total patent applications and patents granted, up to 2007, but only a modest increase in the total number of patents per TTO. ASTP data report average licensing revenues for the fiscal year 2007 of €929,200 confirming the sample selection bias of this survey in favor of high performing TTO. Note, though, that although informative, these data should be treated with caution as it is not clear what they represent. Although in the ProTon survey the number of respondents increased this is far from being representative of European universities. It might be interesting to compare these data with data from

the US Association of University Technology Manager (AUTM), although the AUTM sample for fiscal year 2007 included only 194 respondents (mainly research-intensive institutions) out of more than 3,600 higher education institutions in the US. The data for TTO show that US organizations on average have 18.8 patents granted with average licensing revenue per TTO of €10,126,500, much better performance than achieved by European TTO. However, US TTO are performing only slightly better than European TTO for number of spin-offs created – in both absolute numbers and per TTO.

This evidence and that provided by most of published studies, indicate that the total number of patents owned by European universities has increased quite dramatically since 2000. This is also due to the entry of new actors (more universities with active TTO) and improved performance from existing TTO. The increase is greater for countries with more recently established knowledge transfer infrastructures, for example, the number of university-owned patents increased between the mid-1990s and the mid-2000s in Italy and France (Baldini, Grimaldi and Sobrero, 2006; Della Malva, Lissoni and Llerena, 2008). The data also show that the patenting and licensing performance of European TTO is lower than that of the US organizations included in the AUTM survey, but it should be noted that the difference in the samples of institutions included in the various European surveys and the US AUTM survey reduces drastically the comparability.

Due to the special role of university-invented patents in Europe, the above information is biased in terms of both the overall assessment of patenting activities in European universities and the changes over time, affecting in a significant way the

comparison with the USA. Statistics on university-owned patents generally underestimate academics' patenting activity and this is more severe for Europe than for the US (Crespi, Geuna and Verspagen, 2006). For example, Lissoni et al. (2008) show that university-owned patents in France, Italy and Sweden constitute no more than 11% of all academic patents (69% in the US). Statistical information on university-invented patents have been collected in various European countries in recent years, and there is an ongoing effort to standardize the different national databases, based on the guidelines developed for the KEINS database (Lissoni et al., 2008), which matches names of university scientists with the lists of inventors on EPO patent applications.⁷ Quasi-standardized information is available for Denmark, France, Italy, and Sweden⁸ while work is ongoing in The Netherlands and for a sample of UK scientists.⁹ We complement this information with data on 43,000 academic patent applications to the German Patent and Trademark Office (Frietsch et al., 2010).¹⁰

Table 5 combines these data, as well as it is possible, to provide an estimate of shares of academic patents in Europe according to ownership, and changes in the period 1980-2006. Ownership is classified as university-owned, university-invented owned

⁷ This approach underestimates the real relevance of university-invented patents since it is confined to researchers that are still active.

⁸ For further information on current developments see the European Science Foundation supported project Academic Patenting in Europe (<http://www.esf-ape-inv.eu/index.php>).

⁹ We thank Valerio Sterzi for allowing access to information collected by him on a sample of 1,666 EPO academic patents for the period 1978-2002.

¹⁰ We thank Ulrich Schmoch for providing access to German data. The sample of patents for 1990-2007 was built on the basis of the title "Professor" before the name of the inventor. This may underestimate the number of academic patents because it does not take account of academic researchers that do not hold chairs. It may also provide an overestimation since it includes honorary professors no longer working in a higher education institution. Evidence from the data by specific fields/universities indicate that underestimation is the more important phenomenon.

by an individual, and university-invented owned by a company. These categories do not sum to 100 as university-invented patents can also be owned by other organizations such as government, or public research and non-for-profit organizations. We focus on three time periods, with the most recent one 2002-2006 after the change of IPR regulation in Denmark and Germany; we also report the statistics for the period 1994-2001 for which are available in all the seven countries considered.

Table 5. Ownership structure of academic patents in selected countries / years

	1981-1985			1996-2000			2002-2006			1994-2001		
	Owned	Invented		Owned	Invented		Owned	Invented		Owned	Invented	
		Indi	Comp		Indi	Comp		Indi	Comp		Indi	Comp
Dk							20 [#]	6 [#]	73 [#]	11 [°]	20 [°]	66 [°]
F	~ 5	~ 1	~ 25	~ 12	~ 3	~ 60				10	4	61
G	4 [§]	32 [§]	64 [§]	6	35	59	25	19	56	6	34	60
I	~ 3	~ 12	~ 63	~ 11	~ 7	~ 72				10	9	72
NL										26	2	60
Sw	~ 7	~ 27	~ 63	~ 5	~ 12	~ 81				5	13	81
UK	9	19	40	41	8	45				40	6	48

§ : 1990; + : 1991-2001; # : 2000-2003; ° : 1994-2003;

~ : Approximation

The information in Table 5 confirms that the large majority of academic patents in Europe are not owned by universities, even for the most recent years; university-invented patents owned by companies are still prominent in all countries, ranging from 50% to 80% of total academic patents. Only in the case of the UK, since the mid 1990s, universities owns about 40% of the patents invented by their researchers, consistently with the UK being a country which in our typology has a tradition of institutional management of IPR. Looking at the change in time, the share of university-owned patents has increased in all countries. In France and Italy this is due mainly to a decrease in the share of government/other PRO ownership, while in Germany and Denmark, especially in the period 2002-2006, increased university

ownership is linked mainly to lower levels of individual ownership, and lower levels of business ownership in Germany.

For Germany, Frietsch et al. (2010) and von Ledebur, Buenstorf and Hummel (2009). provide evidence of an overall decrease in the number of academic patents after 2000. They find that university owned-patents slightly displaced business-owned patents and, since this affects both first-time and experienced inventors, this might indicate that established science-industry links have been disturbed by the new legislation. Von Ledebur, Buenstorf and Hummel (2009) suggest that the presence of a third party, the university, in IPR negotiations, raises transaction costs for firms and is a deterrent to collaboration.¹¹ For Denmark instead, Lissoni et al. (2009) show that the share of university-owned patents has increased at the expense of individually-owned patents, but the share of business-owned academic patents slightly increased.

Overall, the evidence suggests that the increase in university-owned patents has been at the expense of inventor-owned and other public organization owned patents; the situation for business-owned patents is less straightforward. Company ownership of academic patents remained generally very important after the shift to an institutional IPR ownership system, even where a small displacement effect occurred. Baldini, Grimaldi and Sobrero (2006) suggest that the fact that many patents continue to be assigned to businesses even when universities are legally allowed to retain the IPR on these inventions might be indicative of the smaller bargaining power of European universities compared to US universities, with respect to industry, and of their lack of

¹¹ However, the database used by Von Ledebur, Buenstorf and Hummel does not include academics who have never appeared on a university-owned patent and, thus, may overestimate the displacement effect of university ownership.

ability or inclination to apply for patents on academic discoveries. On the other hand, it might be that it is the university TTO that are making the decision not to proceed with a patent application and to transfer the rights back to the researcher. Finally, inventors can stop the university from taking over the rights to inventions by transferring them to a third party in defiance of the university's rules (Argyres and Liebeskind, 1998) or because the invention was developed through consulting activity.

The above evidence points to the specificities of the European situation compared to the US and to the impossibility of generalizing the results for one country or group of countries, to the rest of Europe, since rules and regulatory frameworks vary widely. The evidence suggests that academic patenting is generally growing driven mainly by an increase in university-owned patents in the followers countries. However, in a few countries, such as Germany, where academic patenting was well established, there is evidence of a decrease or stagnation in overall academic patenting (increase in university-owned patents associated with a decrease in university-invented patents) from the mid 2000s. There is also evidence of a leveling off (and even decrease) in the growth of university-owned patents in countries, such as the UK, which have a longer tradition of institutional ownership. These results may suggest that, consistently with the evidence in the US, university researchers and universities are becoming less prone to rely upon patents as a channel for knowledge transfer.

4. Regulations, policy incentives, cultural change and their impact on academic patenting

Although there is cross country evidence that the number of university-owned patents has increased overall, we cannot ascribe this phenomenon only to changes in IPR legislation because the switch to university-ownership systems has been accompanied by other changes which could have helped to trigger an increase in university patenting.

The changes in IPR regulations have taken place against a changing cultural and organizational background. On the one hand, patenting and knowledge transfer are increasingly acknowledged as legitimate and important academic activities: in the “entrepreneurial” university model, it is acceptable for academics to engage in commercially-oriented transactions (Clark, 1998; Etzkowitz, 2002). On the other hand, policies have been implemented at the regional, national and European Community levels to support the creation of a knowledge transfer infrastructure.

Independently from the group in the typology, all countries have launched support policies. For example, in the first group, the UK adopted a unique approach to technology transfer. Entrepreneurial activities in universities began to increase in the mid-1980s (Meyer and Tang, 2007), when heavy budget cuts forced universities to adopt more proactive approaches to revenue generation, which included the establishment of TTO. In the mid-1990s, government began actively supporting university “third mission” activities (Meyer and Tang, 2007). The main policy instrument was allocation of Higher Education Funding Council funds through calls for tender under various schemes for seed funding and entrepreneurial activity and the creation of official “third stream” funding for knowledge transfer activities, allocated on the basis of knowledge transfer performance measured by the annual Higher

Education-Business and Community Interaction (HE-BCI) survey. In the third group, in Germany the switch to institutional ownership of academic IPR was complemented by substantial federal subsidies for regional patent exploitation institutions, which were seen as a more efficient way to deal with the increased patenting and licensing activities expected with the change in legislation (Bielig and Haase, 2004, cited in von Ledebur et al., 2009). In Norway the switch to institutional ownership was accompanied by the expansion of the universities' and colleges' responsibilities to include "third mission" activities, and by the setting up of a technology transfer infrastructure composed of university TTO, and instruments such as seed capital funding, mostly provided by government (Iversen, Gulbrandsen and Klitkou, 2007). The Danish government also provided substantial funding for the creation of a technology transfer infrastructure following the introduction of institutional ownership (Lissoni et al, 2009). Also in the countries of the fourth and fifth groups where the Professor's privilege was enforced policies supporting university knowledge transfer were developed. In Sweden, numerous organizations to support technology transfer were established in the 1990s: a series of technology bridging foundations was founded to help universities build links with industry and other stakeholders; science parks were established with public funding; national competence centers¹² were financed jointly by industry, university and government; and universities set up their own TTO. In Italy, from the late 1990s, universities began putting in place mechanisms to commercialize research results, ranging from TTO to university incubators. By 2007, almost all Italian universities had a dedicated TTO (Balderi et al., 2009). The evidence that Italy experienced an important increase in university-owned patents despite Italian legislation having moved towards professor's

¹² The patent rights on the results of collaborative research conducted in competence centers are exempt from professor's privilege and are vested in the collaborating firms (Sellenthin, 2006).

privilege is probably the best indication that policy incentives and cultural change are more important than the switch to institutional IPR ownership per se.

A few detailed empirical studies of changes of regulations and policy implementation at the country level confirm this result. Cesaroni and Piccaluga (2003) analyze the patenting activities of Italian, French and Spanish universities and other PRO and show that patent policies are one of the determinants of inter-country and inter-organizational differences. Baldini, Grimaldi and Sobrero (2006) suggest that in Italy university bylaws are an important determinant of patenting activity. Baldini (2009), analyzing the Danish case, suggests that the change from elected researcher-managers to an appointed board consisting of a majority of members from outside academia, and the implementation of performance contracts and quantitative and measurable indicators of a university's work and results, helped the Danish academic community to raise awareness of and increase support for technology transfer among its members and hence played a role in stimulating patenting activity. Della Malva, Lissoni and Llerena (2008) find that the French Innovation Act significantly increased the likelihood of an academic patent being assigned to a university rather than to a company, but also suggest that the opening of a TTO at a university has a stronger and more significant impact on the decision of the university to retain the IPR on its scientists' discoveries. Particularly interesting is the interaction between change of regulation and incentive. Von Ledebur (2009), using German data, suggests that the switch from professor's privilege to institutional ownership has led to an increase in university patent ownership by universities that set up a TTO (and began to patent) only after 2002. Those universities with longer established TTO were patenting more even under the professor's privilege system. This suggest that it was not so much the

change in IPR ownership regulations that led to an increase in university patenting, but that this change motivated universities that previously had not patented, to establish a technology transfer infrastructure.

These empirical analyses highlight that, in Europe, the organizational and cultural changes that have accompanied the changes to the regulations on IPR ownership at universities, have had a major impact on university patenting activity, and an even greater impact than the changes in the regulations on their own (Geuna and Muscio, 2009). The regulation changes and especially the substantial public investment in policies for knowledge transfer, have provided incentives for universities to develop their knowledge transfer support functions.

Finally, but most importantly, it is worth examining whether the increase in university-owned patents has a positive impact on the use of new university inventions by companies. Only very few studies have attempted to perform this analysis. Using citation counts, Czarnitzki, Hussinger and Schneider (2008) show that academic patents have more forward citations compared to non-academic ones and, therefore, appear to generate greater knowledge externalities (i.e. they are of “higher quality”). However, they find that the “quality” of academic patents has declined since the mid-1990s. The authors suggest that changes in funding rules and the increasingly commercial orientation of universities are encouraging academics to patent all their discoveries regardless of their importance, which is leading to “lower quality” patents, a trend that is being reinforced by the abolition of the professor’s privilege. Using forward citations, Lissoni, Montobbio and Seri (2010) show for Denmark, France, Italy, the Netherlands and Sweden that university-owned patents

have a lower hazard rate than company-owned academic patents, indicating a lower number of forward citations (lower “quality”) all else being equal. Finally, Crespi, Geuna and Verspagen (2006) using a set of indicators for the commercialization of innovations show that, in the case of the sample of academic patents included in Patval survey, university-owned patents do not have a higher probability of being used. Consistent with the results in Lissoni, Montobbio and Seri (2010), they find that university-ownership is associated with better use, compared to individual ownership. These three studies provide a consistent and negative picture of the use/quality of academic patents owned by a university compared to academic patents owned by a company (but not by individuals). This should be taken account of when considering the positive assessment usually associated with increased university-owned patents since the changes to the regulations and the policy interventions introduced in various countries.

5. Conclusions

While the characteristics of national university-industry technology transfer are affected by many elements, one of the main ones is the system of rules regulating IPR ownership of the results of academic research. As the review of IPR regulations in Section 2 demonstrates, institutional ownership now applies to most European countries however, the general shift towards institutional ownership has not produced greater homogeneity among IPR ownership systems, since national regulations defining ownership of IPR from academic research vary widely. It has not resulted either in a “one size fits all” adaptation of the US framework, and very few European countries have followed the path taken by the US since the Bayh-Dole Act. Therefore, comparisons with US experience could be misleading and cannot be used to predict

the evolving features of institutional IPR ownership systems in Europe. Ad-hoc analyses of academic IPR ownership patterns in individual European countries (and of their effects on other variables) are necessary in order to understand how these systems are evolving.

The US experiences is also unlikely to provide, on its own, a guide to understand the effects of a shift towards institutional ownership on academic patenting activities. The effects of changes in IPR regulations differ across countries and are not clearly attributable to the regulations alone. The right for universities in many countries to override national regulations in order to negotiate different IPR arrangements with third parties adds further complexity, as does the fact that changes in IPR regulations have taken place against a changing organizational and cultural background, where patenting and knowledge transfer are increasingly acknowledged as legitimate and important academic activities, and where policies have been implemented to support of the creation of a knowledge transfer infrastructure.

The evidence presented in this paper, and that from most recent studies, highlights some common developments in most European countries. First, there are indications that the total number of patents owned by universities increased rapidly in the first 10 years of the new millennium, due to the entry of new actors (more universities with active TTO) and improved performance of existing TTO. Second, the increase has been larger in those countries that were late in developing an infrastructure for knowledge transfer. Third, patenting and licensing performance of European TTO appears lower than that of the US organizations included in the AUTM survey, however comparability is extremely weak since AUTM includes mainly research

intensive institutions and European TTOs manage only a small portion of academic patents. The most recent data (till 2006) on university-invented patents in a selected set of European countries show that university-invented patents owned by businesses still play an extremely important role in all countries. There are indications also that university-owned patents have increased in some countries, at the expense of individually-owned and business-owned (but university-invented) patents. If academic patenting data are corrected to account for university-invented patents, then for some countries with long traditions of academic patenting (such as Germany) and for some scientific/technological fields where academic patenting has been particularly important (such as biotechnology), we find evidence of a leveling off or decrease in the total number of academic patents applications by mid 2000s. Also, in countries with a longer tradition of institutional ownership such as the UK, there is evidence of a leveling off in university patents consistent with the view of TTOs moving away from patenting and emphasizing startups more (Sigel, Veugelers and Wright, 2007).

The typology of national experiences presented in Table 2 can provide some help in analyzing these complex system. In countries where university enforcement of IPR has traditionally been weak – either because of the professor’s privilege or because of the lack of interest in IP commercialization on the part of university institutions – academic inventors have traditionally patented their inventions individually or assigned IPR ownership to collaborating firms. In these contexts, regulations and bylaws enforcing university ownership may increase university-owned patents at the expense of university-invented patents. Care must be taken therefore not to disrupt

pre-existing functioning knowledge transfer relationships between academic inventors and firms.

Moreover, numerous empirical analyses seem to suggest that the key determinant of increasing enforcement of IPR ownership on the part of universities has been not so much the change in IPR ownership in itself, but the creation of an infrastructure for knowledge transfer involving an active role of university institutions. This explains why increases in university-owned patents have taken place also in countries where the IPR ownership regime has not changed (or where it has changed towards professor's privilege). There may be however an indirect effect of the change in regulation where the latter has stimulated the development of a knowledge transfer infrastructure. We believe that detailed country-level studies on the interplay of changes in IPR regulations and in technology transfer policies and university bylaws can further help to disentangle these effects.

This analysis suggests caution in expecting immediate and extensive effects on academic patenting from changes to the legislation alone, and at the same time it advises policymakers not to overlook the systemic implications of individual policy interventions aimed at supporting knowledge transfer. Moreover, it casts doubts on the overall beneficial effects of an increase in university patent ownership in terms of greater contribution of university research to economic development, since the evidence discussed in this paper indicates that higher university ownership is not correlated with higher use of/higher quality academic patents.

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