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CHANGES TO UNIVERSITY IPR REGULATIONS IN EUROPE AND THE IMPACT ON ACADEMIC PATENTING

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

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Abstract

Most European countries since the end of the 1990s have been moving away from inventor ownership of patent rights towards different systems of institutional ownership. This shift is based on the objectives of policymakers to make conditions similar to those in the US, where the 1980 Bayh–Dole Act allows universities to retain intellectual property rights (IPR) over inventions that come out of federally funded research.

This article challenges the view that direct comparisons with US experience will enable us to predict the effects of the implementation of institutional IPR ownership systems in Europe. We provide an overview of the current state of regulation on academic patent ownership in selected European countries which shows that, despite the changes to institutional ownership that have been implemented, there is wide diversity in national systems and several important differences with the US framework. Our analysis of patterns of ownership of academic patents shows that there has not been a general increase in university patenting since 1990, and seeming increases may be due to more complex dynamics in academic patenting and academic patents ownership. The paper concludes with a discussion of how changes in IPR regulations and management of technology transfer by universities, and public policies supporting technology transfer are affecting academic patenting and research activities in universities.

1. Introduction

Over time in most countries, universities have become responsible for managing the inventions produced by their staff. New regulations, policy incentives and technological opportunities have increased the incidence of technology transfer through patents, which is one of the ways that universities contribute to social and economic innovation and development. The number of university technology transfer offices (TTO) and Intellectual Property (IP) commercialization units has increased in parallel.

While there are numerous issues related to the process of technology transfer, one aspect common to all jurisdictions is the ownership of the intellectual property rights (IPR) on research results. Since the end of the 1990s, most 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 (professors) are owned by the researcher(professor) and not by the institution where the research is carried out; institutional ownership means that the results of publicly-funded research are owned by the institution employing the researcher/professor responsible for the work, and not the individual(s) personally.

In Europe, professor's privilege generally 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 (Kilger and Bartenbach, 2002; PVA-MV, 2003; Iversen, Gulbrandsen and Klitkou, 2007, Lissoni et al., 2009).

The European shift in IP ownership was in line with the objective of policymakers to imitate conditions in the US, where the 1980 Bayh–Dole Act (or University and Small Business Patent Procedures Act) allowed universities to retain IPR on the inventions resulting from federally funded research and for federal government to arrange for the licensing of patents not exploited by academic administrations (march-in right).[1] Subsequent US legislation has extended the scope and duration of patent protection: universities are allowed to grant exclusive patent licenses for the entire life of the patent (Feldman and Stewart, 2006); patent protection has been extended to living organisms and to software (Kortum and Lerner, 1999; Jaffe, 2000); and obstacles to commercial exploitation of the results of research conducted in public laboratories have been removed progressively.

Within the academic community, there is a lack of agreement on the real effects of the Bayh–Dole Act on academic patenting, and several empirical studies suggest that the increase in patenting by US universities in the 1990s was due only in part to this piece of legislation (Mowery et al., 2001; Rafferty, 2008). Nevertheless, most European policymakers appear to be convinced that there is a strong causal link between these phenomena (OECD, 2003), using this evidence as justification for implementing changes to the regulations in IP in several European countries.

We provide an overview of current regulation on academic patent ownership, for a set of European countries, and explore some of the implications of the changing legal landscape. Section 2 provides a review of changes to the regulations on assignment of

[1] Previously, universities had to deal with several funding agencies (NIH, DoD, NASA, NSF, etc.), each of which had different policies on the assignment of IPR (Mowery et al., 2001).

IPR on academic research results since 2000, and discusses the accompanying policy interventions to promote technology transfer. We focus on the quantitative and qualitative implications of these regulatory changes. Section 3 reviews recent data from several sources, on the aggregate dynamics of academic patent ownership in several European countries. Section 4 reviews the recent academic literature on the effects of changes in IPR regulation on the quantity, quality and patterns of ownership of academic patents in Europe. Section 5 provides some conclusions and policy recommendations. The analysis in this paper is limited to patents and does not include other forms of protection such as copyrights, design rights, trademarks.

2. Regulation changes and policy interventions

This section provides an overview of the current situation relating to legal ownership of the patent rights on the results of academic research, for a set of European countries. It discusses how the regulation of these rights has changed since 2000 and examines the university bylaws and government policies introduced to promote technology transfer.

2.1. Changes in national IPR regulations: A taxonomy

Table 1 presents an overview of university ownership of IPR for a group of European countries. For each country, we report whether ownership of the IP produced by academic researchers is vested primarily in the inventor or the institution, and indicates the year when the regulation changed. Some countries have adopted institutional ownership except in the case of certain types of inventions where the inventor retains ownership. Should the inventor fail to exploit the invention within a certain period of time, the institution can claim the IPR. The information in Table 1

shows that in Europe, the system of institutional ownership 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, similar to the situation in the US since the Bayh-Dole Act.

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

Country	*Institution*	*Inventor*
Institutional Ownership before 2000		
Czech Republic	♦ (1990)	
Greece	♦ (1995)	◊
France	♦ (1982)	
Netherlands	♦ (1995)	◊
Spain	♦ (1986)	
Switzerland	♦ (1911)	
UK	♦ (1985)	
Changed from professor's privilege		
Austria	♦ (2002)	
Denmark	♦ (2000)	
Finland	♦ (2007/2010)	◊
Germany	♦ (2002)	◊
Norway	♦ (2002)	
Changed from State ownership (or from no regulation)		
Belgium	♦ (1997/98)	
Hungary	♦ (2006)	
Poland	♦ (2000)	
Slovak Republic	♦ (2000)	
Slovenia	♦ (2006)	
Inventor ownership		
Italy		♦ (2001/2005)
Sweden		♦ (1949)

Source: Table integrating information from OECD (2003), DLA PIPER, Mason Hayes+Currant (2007), Meyer (2010)
◊ : Inventor ownership is assigned on certain types of inventions
In brackets: years in which last change in regulation took place

However, there are differences among countries. Five country groups can be identified based on IPR regulations pre and post 2000. Based on the situation pre 2000, there is a group that includes France, Italy and Greece which favors 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 mean 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 1982, the French government passed the Research Act (Loi d'Orientation et de Programmation), to promote valorization of the results of research and its diffusion (Della Malva, Lissoni and Llerena, 2008). 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 is aimed at increasing universities' awareness of IPR and facilitating IPR commercialization through the creation of technology transfer offices (Azagra-Caro, Carayol and Llerena, 2006) but does not include specific provisions for the allocation of IPR. Thus France has tried to increase institutional ownership of patents rights. Italy also had a similar tradition of institutional ownership; however, since 2000, it has favored professor's privilege, which means that for the most recent decade it falls into the fifth group.

The second group is composed of countries which implemented a strong "professorial rights" system – mainly Germany, Denmark, Finland, Norway and Austria – and which in the early 2000 modified their IPR regulations to introduce institutional ownership. In Germany, for example, pre 2000 university professors, unlike other public and private employees, retained ownership of IPR on their inventions, thanks to a special clause in the law on employee inventions. (Note that in socialist East Germany professorial right did not apply.) In 2002, "professors' privilege" was abolished and universities in Germany have the right to file patents on their

employees' inventions, although if they do 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; von Ledebur, 2009). 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 new law is 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 third 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. 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. In 1985, universities were given the rights to own and commercialize academic inventions, and were allowed to decide whether to do this independently or rely on the services provided by BTG. 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 since 1985, it was only after the UK Department of Trade and Industry published the White Paper *Realising 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. In Spain, 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, 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 fourth group includes countries from Eastern Europe that 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.

The fifth group includes two countries which, despite a trend towards institutional ownership in the countries of the European Union and internationally, have chosen to maintain invention ownership systems based on professor's privilege: Italy and Sweden. Legislation on intellectual property in Italy (Della Malva et al., 2007; Baldini et al., 2010) 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. Employees have the right to demand monetary compensation for any inventions,

according to their importance. 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). 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). In 2005, partly as a result of pressure from a growing group of technology transfer professionals and other stakeholders such as IPR solicitors, the regulation changed. 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. It can be difficult to directly link a financial input to a specific research output. 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. 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. Table 2 presents the taxonomy of changes in National IPR regulations.

Table 2. A taxonomy of changes in national IPR regulations

Group	*Characteristics*	*Countries included*
1	Countries where institutional ownership already existed before 2000, but was not enforced due to weak university autonomy	France Greece Italy (until 2001)
2	Countries which implemented a "professor's privilege" system but switched to institutional ownership after 2000	Germany Denmark Finland Norway Austria
3	Early adopters (and enforcers) of the institutional ownership system	UK Switzerland Spain
4	Countries where IPR ownership was assigned to the State and which switched to institutional ownership after the early 1990s	Former Eastern bloc
5	Countries currently implementing a "professor's privilege" system	Sweden Italy (since 2001)

2.2. Differences within IPR systems

National IPR systems allowing institutional ownership differ substantially. 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.

Another difference is 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.

Belgium, Finland, Germany and Greece have hybrid systems. In Belgium the rights to an invention are vested automatically in the university, but can revert to the inventor if they are not commercialized within a certain time. 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 includes all other inventions (rights are assigned to the inventor and the institution can commercialize them under a non-exclusive license).

There are difference also in the rights of inventors to be compensated for relinquishing their invention rights. In some systems these rights are automatic. Where they are not automatic usually some compensation can be negotiated. In some systems compensation rights depend on the type of invention, and whether or not it resulted from the employee's usual work activities.

The 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 introduced institutional ownership of inventions from privately funded (fully or in part) research or from specific research projects funded by any public institution different from that of the inventor's employer. 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 one.[2]

Thus, national regulations defining ownership of IPR from academic research differ substantially. 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. As Von Ledebur (2008) points out, in the USA academic inventors have never owned the IPR on their inventions: it resided with the government agency. 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. Since the IPR ownership situations in the US and Europe, both before and after changes in IPR legislation, are very different, care must be taken over generalizing on the success and performance of Bayh-Dole Act, to the case of Europe as a whole, and especially to individual countries.

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

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, for example, if the research was conducted jointly with external partners such as private companies. Such cases are usually regulated by university bylaws. In addition, the 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 the creation of a knowledge transfer infrastructure. We discuss these issues in greater detail below.

2.3. 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 regulations by developing internal patent rights regulations and processes for how to enforce them. 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 vary widely, both across countries and also among universities in the same country.

The role of university bylaws in order to regulate IPR ownership and related conditions is particularly important in the UK, Ireland and Switzerland, where there is no strong legislative framework regulating academic patenting, and in Sweden, where

professor's privilege is valid only if researchers and other parties have not agreed alternative rules (Sellenthin, 2006). However, 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 (such as NetVal) which has contributed further to the consolidation of these practices.

2.4. Policy action: Incentives and culture creation

In most countries, regulation changes have been accompanied by the development of policies to support the creation of a knowledge transfer infrastructure. These interventions have been devised and supported at the regional (Italian and UK regions are highly involved in science and technology policy, and the German Landers play a key role in university funding and governance) and national and international (European Commission initiatives) levels.

In Germany, the switch to institutional ownership of academic IPR was complemented by substantial federal subsidies for regional patent exploitation institutions (Patentverwertungsagenturen, PVAs), 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): twenty-one PVAs were established in Germany to cover the patenting activities of

nearly 240 universities and research institutes. Their role is to advise universities and inventors about how to negotiate exploitation contracts with private industry, and to provide financial support in the case of legal disputes (von Ledebur, 2008; Sellenthin, 2006). All universities have their own TTO, which are usually the first points of contact for researchers seeking advice and guidance, checking on the formalities of invention disclosures, and forwarding them to the PVAs. Networking initiatives have been promoted by government to connect research institutes with small and medium-sized enterprises, to support academic spin-offs, and to provide seed money for students and academic staff (Sellenthin, 2006).

In Sweden, numerous organizations to support technology transfer were established in the 1990s (Sellenthin, 2006). A series of technology bridging foundations (Teknikbrostiftelser, TBS) was founded in 1993 to help universities build links with industry and other stakeholders; science parks were established with public funding, and universities set up their own TTO. A recent development is national competence centers which are financed jointly by industry, university and government. 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). 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).

A knowledge transfer infrastructure is being developed in Southern Europe. In Spain, the first TTO were set up in the mid-1980s, earlier than in many other European countries (Azagra-Caro, 2010), and emphasis was on training personnel in technology ownership issues (Represa-Sánchez, Castro-Martínez and Fernández-de-Lucio, 2005). In Portugal, a network of Industrial Property Support Offices, managed by the National Patent Office, was created in 2001 as part of a wider government scheme, which also included financial incentives to assist patent applications and the development of prototypes (Figueiredo Moutinho, Fontes and Mira Goudinho, 2007). 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 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 TTOs. 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.

Despite this variety, we can identify some categories of interventions:

- direct support for knowledge/technology transfer initiatives at universities (e.g. Higher Education Founding Council for England (HEFCE) funding in the UK);
- support for association of practitioners (e.g. the EU-funded Proton network, national TTO networks);
- support for the creation of TTO at local, regional or national level (e.g. the PVA in Germany);
- support for the creation of joint public/private research centers, science parks, incubators (e.g. the competence centers in Sweden).

Because these interventions coincided with the changes in IPR regulations, it is difficult to disentangle their effects. The present situation in Europe based on these changes to the regulation and policy interventions, has been investigated by research that attempts to assess their impact (see Section 4). Before discussing these, we provide some statistical evidence on the European academic patenting and its limitations.

3. Academic patenting: the evidence

It is not easy to assess the impact of regulation changes and policy interventions on the patenting output of European universities. Previous work (Geuna and Nesta, 2006) points to the scarcity of statistical information, and although this is less of a problem, statistical data are collected irregularly.

Here we report and comment on the available data on academic patenting in terms of: (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 available online public database is the Eurostat Science and Technology database.[3] which provides information on patent counts (based on patent application to the European Patent Office (EPO) by priority year at national level) across countries 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).

[3] Accessible from http://epp.eurostat.ec.europa.eu (last accessed 4/10/2010).

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.

The most reliable data are for UK university-owned patents. 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 an 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 this latter is very small, accounting for only 3% to 4% (depending on the year and with the exception of 2008-09, where it was about 6%) 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 percent and 66 percent 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). The only other Europe-wide TTO survey is the CEMI Survey of Technology Transfer Offices[4] for fiscal year 2007, which includes 211 responses from a sample of 351 Western-European universities with at least 200 scientific publications in the period 2004-2006 (Conti and Gaule, 2010). 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

[4] For access to the report and further information on the CEMI survey see http://cemi.epfl.ch/page-30722-en.html (last accessed 5/10/2010).

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 declines then increases 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 from 172, to 323 in 2007 (accounting in 2007 for 462 public research organizations as well as universities) 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 that AUTM sample in 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 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 (Baldini, Grimaldi and Sobrero, 2006) in Italy and France (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 the comparability.

The above information could be biased in terms of both the overall assessment of patenting activities in European universities and the changes over time. Statistics on university-owned patents generally grossly 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). Other analyses of specific European countries provide similar results, e.g. for France (Azagra-Caro, Carayol and Llerena, 2006), Italy (Balconi, Breschi and Lissoni, 2003), Finland (Meyer, Du Plessis and Tukeva, 2005), Belgium (Saragossi and van Pottelsberghe de la Potterie, 2003), Denmark (Lissoni et al., 2009).

There have been more attempts recently to collect statistical information on university-invented patents (patents with an academic inventor but not owned by the

university) 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. This approach underestimates the real relevance of university-invented patents since it is confined to researchers that are still active. Quasi-standardized information is available for Denmark, France, Italy, and Sweden[5] while work is ongoing in The Netherlands and for a sample of UK scientists.[6] We complement the available information with data on 43,000 academic patent applications to the German Patent and Trademark Office (Frietsch et al., 2010)[7] and data on around 5,000 national and 2,000 EPO patent applications (two-thirds of the latter are of German origin) from identifiable academic employees (von Ledebur, Buenstrof and Hummel, 2009).[8] Table 5 combines these data 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 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.

[5] 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).

[6] 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.

[7] 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.

[8] This sample overestimates university ownership since identification of professors is based on the sample of university-owned patents.

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	~	~ 81				5	13	81
UK	9	19	40	41	8	45				40	6	48

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

The information confirms the patterns identified for earlier periods, that the structure of academic patenting ownership in Europe is that the large majority of academic patents are not owned by the university, even for the most recent years. University-invented patents owned by companies are still prominent for all countries; only in the case of the UK do they account for slightly less than 50% along the whole of the period considered, and only in Germany have they decreased in the most recent years. 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. In Germany and Denmark, especially in the period 2002-2006 after the changes in IPR regulations, 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, Buenstrof and Hummel (2009) provide evidence of an overall decrease in the number of academic patents after 2000. The introduction of institutional IPR ownership in 2002 has affected assignment patterns, increasing the share of university-owned patents relative to the share of

inventor-owned patents. Both these studies 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, Buenstrof 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.[9] For Denmark, Lissoni et al. (2009) show that, as is the case in Germany, 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 from 67.6% in 1977-1999 to 72.9% in 2000-2003. Lissoni et al. also note that the "property shift" in academic patents, from individual scientists to universities, has led to diversification of universities' patent portfolios.[10] Della Malva, Lissoni and Llerena (2008), studying the case of France, suggest that, following the introduction of the 1999 Innovation Act, the likelihood of an academic patent being assigned to a university rather than a business increased (taking account of the effect of disciplines and types of universities).

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

[9] 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.

[10] According to Lissoni et al. (2009), before the abolition of professor's privilege, university portfolios included only patents for instruments and pharmaceutical/biotechnological inventions. After this privilege was abolished, the share of patents for instruments remained fairly stable, while the share of pharmaceutical/biotechnological patents declined substantially. Danish universities now own patents for electronics, chemicals/pharmaceuticals, and even fields such as process engineering and consumer goods.

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 ability or inclination to apply for patents on academic discoveries. On the other hand, it might be that it is the university TTOs 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 (university-ownership remains low) 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); however, in a few countries and / or a few disciplines 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, which is in line with a similar decrease in the US.

4. Changes in regulations, academic patenting and academic research

Studying the impact of the changes to IPR ownership regulations involves a complex set of processes: first changes in regulations and policy intervention can affect the quantity and ownership structure of academic patents; second if the changes increase the propensity to patent the results of academic research and lead to more aggressive extraction of profit by TTO professionals, this can affect a range of variables for academic research and other knowledge transfer activities. Since the empirical literature on these issues is large, we limit our inquiry to a set of recent papers providing evidence for Europe.

4.1. Regulation changes and 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, as discussed earlier, the switch to university-ownership systems has been accompanied by other changes which could have helped to trigger an increase in university patenting. The main changes are related to the construction of a knowledge transfer infrastructure based on the universities and TTO, but including bodies such as competence centers and regional patent support offices; and a cultural change towards an "entrepreneurial" university model, that sees it as acceptable for academics to engage in commercially-oriented transactions (Clark, 1998; Etzkowitz, 2002). It is very difficult to disentangle the impacts of these processes. Indications that policy incentives and cultural change are more important than the switch to institutional IPR ownership are supported by the evidence that Italy experienced an increase in university-owned patents despite Italian legislation having moved towards professor's privilege (Baldini, Grimaldi and Sobrero, 2006).

More generally, most empirical studies on European countries agree that the increase in university patent ownership is due to a complex set of interrelated causes, among which a formal patent rights regime plays a limited role, while the activities of TTO and changes in attitudes and the entrepreneurial culture at universities play very important roles (Geuna and Muscio, 2009). Klitkou and Gulbrandsen (2010) point out that patenting and other types of commercialization are influenced not only by national differences in legislation, but also by organizational aspects such as the presence of TTO, the structure of the incentives within universities (rules for distribution of licensing income, engagement in spin-off activity, etc.) and the "entrepreneurial culture" within the institution including peer influence and role models all of which affect individual attitudes to patenting. 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 university bylaws are an important determinant of 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.

Von Ledebur (2009), using German data, finds that experience in patenting activity affects the number of patents that universities apply for (which is consistent with results in Huelsbeck and Menno (2007): cited by the author). Von Ledebur suggests that the switch from professor's privilege to institutional ownership has led to an increase in university patent ownership by universities that established 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.

The role of the TTO in stimulating university patenting activity has been investigated at length, especially in the case of the US where the quality, age, and size of the TTO has been found to influence the university's capability to screen their professors' research for patentable output and to provide inputs to the application process, and also to positively affect the individual willingness to engage in patenting with support from the university. This can perhaps be explained by the fact that patenting activity is not part of a scientists' training and they need to be "educated" about the process involved (Stephan et al., 2007). Well-functioning TTO require well-trained and competitively paid staff, as well as a close relationship with industry based on personal contacts, networks (see literature reviews in von Ledebur, 2008; Figueiredo Moutinho, Fontes and Mira Goudinho, 2007). While the technology transfer infrastructure in Europe is less developed than in the US, it has become considerably larger and more sophisticated since 2000. Some authors suggest that this is due not just to the presence of a TTO (Debackere and Veugelers, 2005; Kenney and Goe, 2004), but rather that the whole university environment needs to be supportive in order to transform awareness of the university's potential contribution to economic development, into appropriate and acceptable structures and processes that allow this contribution to be utilized effectively. For instance, 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.

These empirical analyses seem to be in agreement 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. At the same time, 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, in the form of TTO staffed with progressively more professional staff.

A strand of research explores whether university-owned patents are different from university-invented ones. In the case of Germany, Czarnitzki, Hussinger and Schneider (2009) find that academic patents (whether owned by the university or by the academic inventor) are more "basic" than non-academic ones, since they are less likely to be opposed in court and generate more forward citations, and that business-owned academic patents are not significantly different from non-academic patents, but that university-owned academic patents appear to be more "basic". Studying a dataset of patents involving academics from a large French university, Azagra-Caro, Carayol and Llerena (2006) find that university-owned patents are more responsive to public funding, while non-university-owned patents are more responsive to industry funding, and that disciplinary and institutional differences affect the production of different kinds of patents.

This said, it is important to remember that more patenting activity by a university does not translate automatically into greater knowledge transfer and higher levels of innovation. Only a few papers try to assess whether the increase in university-owned patents has a positive impact on the use of new university inventions by companies. 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, Motobbio 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.

4.2. Academic patenting and academic research

Other research explores the effects of patenting on other variables, especially scientific productivity, nature and quality of academic research, availability of research tools, willingness of industry to collaborate with universities.

The effects of patenting on academic publishing have been investigated in depth, mainly because of the perceived competition between these activities. In theory, patenting can reinforce, complement or reduce publishing (Klitkou and Gulbrandsen, 2010).

- Patenting can reinforce publishing because it may open up new scientific opportunities and lead to new ideas (firm contacts provide learning opportunities, new approaches, and complementary skills and equipment) and create and support research networks. Some authors suggest a "compound Matthew effect" (Van Looy et al., 2004): patenting could lead to greater recognition and more resources, especially from funding agencies, which creates a virtuous circle for the researcher and her or his unit.
- Patenting can complement publishing if scientific opportunities lead to both patenting and publication. Some fine-grained analyses show that patenting is often preceded by "bursts" of publishing activity (Azoulay, Ding and Stewart, 2007; Breschi, Lissoni and Montobbio, 2005). Some researchers indicate that patents may be based on the first draft of a scientific paper, and that the patent application is prepared by a specialized entity (Gulbdrandsen and Smeby, 2005).

- Patenting can reduce publishing because research and commercialization activities may compete for the scientist's limited time, especially since turning academic inventions into commercial products often requires further effort, and the successful commercialization of an invention often requires the direct input of the inventor's in-depth and largely uncodified knowledge of the technology. Also, the legal requirements of the patent application process of delay publication, as does the need to safeguard first-mover advantages vis-à-vis potential competitors. The patenting process also involves a level of secrecy.

In line with the results of studies based on US data, most empirical evidence for Europe supports the reinforcement or complementarity / co-occurrence hypothesis.[11] Some provide confirmation of these earlier results but a more nuanced interpretation. Buenstorf (2009) provide evidence of the co-occurrence of patenting and publication based on a dataset of Max Planck directors in Germany and Klitkou and Gulbrandsen (2010) find similar evidence for a set of Norwegian university-affiliated inventors. Czarnitzki, Glanzel and Hussinger (2007) study the effect of patenting on publication quantity and quality, for 3,135 German professors over the period 1998 to 2002. They find that patent applications are positively correlated with publication quantity and quality. However, they find that heterogeneity in patenting matters: while patenting with not-for-profit organizations does not reduce publication output and even increases citation impact, collaboration with corporations has a negative impact on publication outcome and impact (which contradicts the results found for Italy by Breschi, Lissoni and Montobbio, 2005). Crespi et al. (2010) studying a sample of UK scientists show that (the intensity of) academic patenting complements publishing up

[11] See the *EINT* Special Issue edited by Geuna and Mowery (2007) for an assessment of the situation in Europe and the US.

to a certain level of patenting output, after which they find evidence of a substitution effect. They also find weak evidence of important differences across scientific fields with the more basic oriented fields showing indications of a crowding out effect. In the same paper Crespi et al. (2010) analyze the potential impact of patenting on knowledge exchange with industry, and commercialization, and find a positive correlation between the stock of patents and engagement with other knowledge transfer channels; however they find an inverted U-shaped relationship between patenting and other knowledge transfer channels. The authors suggest that if academic inventors (in the more traditional scientific fields such as Chemistry and Physics) become too involved in patenting, ultimately they publish less, and interact less intensively with companies via other channels. It is interesting that they identify quite similar thresholds for publishing and other channels of interaction with industry.

The above evidence highlights the importance of understanding the development of European academic patenting as a result of the interactions between the changes in of regulations, policy intervention and transformation of the academic culture. These phenomena have had a greater impact on the ownership structure of academic patents than on the overall propensity to patent. Although levels of academic patenting have increased, this is due mainly to the entry of new actors especially in those countries with more recent development of academic patenting; stagnation or overall decrease in academic patenting has occurred in the most advanced countries such as Germany and the UK. The overall increase in academic patenting and the increase in university patent ownership are usually seen as positive indications of a higher contribution of university research to economic development. However, the literature reviewed here indicates that higher university ownership is correlated with lower use of/lower quality academic patents and that the co-occurrence of patenting and publishing can

turn out into substitution depending on the collaboration partners and the level of collaboration. Finally, some evidence (for the UK) indicates that high levels of academic patenting activity may have a negative effect on other channels of knowledge transfer.

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 applies to most European countries. This system has become more prevalent since 1990, after which time many countries switched from systems based on inventor ownership (or systems where ownership was assigned to the state) to institutional ownership.

However, this 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. 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.

Therefore, comparisons with US experience could be misleading and cannot be used to predict the effects of the implementation of institutional IPR ownership systems in Europe, nor to interpret the effects of such systems once implemented. 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.

As the review of the effects of changes in IPR regulations on patent ownership patterns shows, the effects differ across countries and are not clearly attributable to the regulations alone. The evidence presented here, and that from most recent studies, highlight 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; comparability is not strong since AUTM includes mainly research intensive institutions.

Exploring the evolution of university-owned patents provides only part of the picture since statistics on university-owned patents underestimate the patenting activity of academics, especially in the case of Europe. Recent data 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.

Because this pattern may mask important consequences for the relationship between university and industry, more in depth study is required of how IPR ownership issues affect university-industry relationships, and whether increased university IPR ownership is desirable even if it displaces business (compared to individual or other organizations ownership). 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 after the first years the 2000s, which is consistent with the evolution in the US. For example, in Germany the share of academic patents decreased to 4.6% in 2004-2007 from 7.5% in 1996-1999 (Frietsch et al., 2010).

Although there is cross country evidence that university-owned patents have increased, we cannot ascribe this phenomenon only to changes in IPR legislation, since the switch to university-ownership systems has accompanied other important changes such as the building of a knowledge transfer infrastructure and a marked culture change towards as "entrepreneurial" university model, where it is increasingly acceptable for academics to engage in commercially-oriented transactions. For example, university ownership has increased in countries where regulations changed earlier (such as the UK) and in countries such as Italy where ownership is not directly assigned to the university. The review in Section 4 shows that there is some agreement among academics over attributing the increase in university patent ownership to a complex set of interrelated causes, among which the impact of the formal patent rights regime is small while the activities of TTO and the change in entrepreneurial attitudes and the university culture are very important. Policymakers

should not expect significant effects from changes to the legislation alone, and also should not overlook the systemic implications of individual policy interventions aimed at supporting knowledge transfer. The effects of policy measures should be evaluated within a systemic and long-term perspective that takes account of both direct and indirect effects: both patterns of patent ownership and their effect on a broader range of variables for academic research and technology transfer activities (such as scientific productivity, the nature and quality of academic research, the nature and quality of university-industry collaborations).

References

Argyres, N.S.; Liebeskind, J.P. (1998) "Privatizing the intellectual commons: Universities and the commercialization of biotechnology", *Journal of Economic Behavior & Organization*, 35: 427-454.

Azagra-Caro, J.; Carayol, N.; Llerena, P. (2006) "Patent production at a European research university: exploratory evidence at the laboratory level", *Journal of Technology Transfer*, 31: 257–268.

Azagra-Caro (2010) "Do public research organisations own most patents invented by their staff?", *Science and Public Policy*, forthcoming.

Azoulay, P.; Ding, W.; Stewart, T. (2007) "The determinants of faculty patenting behavior: Demographics or opportunities?", *Journal of Economic Behavior & Organization*, 63: 599–623

Balconi, M.; Breschi, S.; Lissoni, F. (2003) "Il trasferimento di conoscenze tecnologiche dall'universita' all'industria in Italia: Nuova evidenza sui brevetti di paternita' dei docenti", in: Bonaccorsi A. (ed.), Il sistema della ricerca pubblica in Italia, Milano: Franco Angeli.

Balderi, C.; Conti, G; Granieri, M; Piccaluga, A. (2009) "'And yet it does move!' University patenting and licensing in Italy. Differences and similarities in the management of technology transfer activities at European level", mimeo.

Baldini, N. (2009) "Implementing Bayh–Dole-like laws- Faculty problems and their impact on university patenting activity", *Research Policy*, 38: 1217–1224.

Baldini, N.; Grimaldi, R.; Sobrero, M. (2006) "Institutional changes and the commercialization of academic knowledge: a study of Italian universities' patenting activities between 1965 and 2002", *Research Policy*, 35(4): 518–532.

Baldini N., Fini R., Grimaldi R., Sobrero M. (2010) "The institutionalisation of university patenting activity in Italy Diffusion and evolution of organisational practices", SSRN--id1632430 paper.

Bielig, A.; Haase, H. (2004) "Patente aus Hochschulen: Die Intellectual Property Rights-Frage", *Zeitschrift fur Wirtschaftspolitik*, 53(2), 228-251.

Breschi, S.; Lissoni, F.; Montobbio, F. (2005). "From publishing to patenting: Do productive scientists turn into academic inventors?" *Revue d'Economie Industrielle*, 0 (110), 75–102.

Buenstorf, G. (2009) "Is commercialization good or bad for science? Individual-level evidence from the Max Planck Society", *Research Policy*, 38:281-292.

Cesaroni, F.; Piccaluga, A. (2003) "Universities and intellectual property rights in Southern European countries", mimeo.

Clark, B. (1998) *Creating entrepreneurial universities. Organizational pathways of transformation.* New York: Pergamon Press.

Conti, A.; Gaule, P. (2010) "Is the US outperforming Europe in university technology licensing?" DRUID Working Paper 10-04.

Crespi, G.; Geuna, A.; Verspagen, B. (2006) "University IPRs and knowledge transfer. Is the IPR ownership model more efficient?" SPRU Electronic Working Paper Series 154.

Crespi, G., D'Este P., Fontana R., Geuna A. (2010) "The impact of academic patenting on university research and its transfer", *Research Policy*, forthcoming.

Czarnitzki, D.; Hussinger, K.; Schneider, C. (2008) "Commercializing academic research: the quality of faculty patenting", ZEW Discussi on Paper No. 08-069.

Czarnitzki, D.; Hussinger, K.; Schneider, C. (2009) "Why challenge the Ivory Tower? New evidence on the basicness of academic patents", *KYKLOS*, 62(4): 488-499.

Debackere, K.; Veugelers, R. (2005) "The role of academic technology transfer organizations in improving industry science links", *Research Policy*, 34: 321–342

Della Malva A., Breschi S., Lissoni F., Montobbio F. (2007) "L'attività brevettuale dei docenti universitari: L'Italia in un confronto internazionale", *Economia e Politica Industriale*, 34(2).

Della Malva A., Lissoni F., Llerena P. (2008) "Institutional change and academic patenting: French universities and the Innovation Act of the 1999" Document de Travail n. 2008-9 BETA, Université Louis Pasteur Strasbourg.

DLA PIPER, Mason Hayes+Currant (2007) "Monitoring and analysis of technology transfer and IPRs and their use – Professor's Privilege". Report for the European Commission (DG research).

DTI (1993) "Realising our potential: A strategy for science, engineering and technology". London, HMSO.

Etzkowitz, H. (2002) *MIT and the rise of entrepreneurial science*. London: Routledge.

Feldman, M.; Stewart, I. (2006) "Knowledge transfer and innovation: A review of the policy relevant literature". Report Prepared for the Ontario Ministry of Research and Innovation.

Figueiredo Moutinho, P.S.; Fontes, M.; Mira Godinho, M. (2007) "Do individual factors matter? A survey of scientists' patenting in portuguese public reserach organizations", *Scientometrics*, 70(2): 355–377

Frietsch, R.; Schmoch, U.; Neuhäusler, P.; Rothengatter, O. (2010) "Patent applications – Structures, trends and recent developments", Studien zum deutschen Innovationssystem Nr. 09-2010, Fraunhofer Institute for Systems and Innovation Research.

Geuna, A.; Mowery, D.C. (2007) "Publishing and patenting in US and European Universities", *Economics of Innovation and New Technology*, 16(2):67-70.

Geuna, A.; Muscio, A. (2009) "The governance of university knowledge transfer: A critical review of the literature", *Minerva*, 47(1): 93-114.

Geuna, A.; Nesta, L.J.J. (2006) "University patenting and its effects on academic research: The emerging European evidence", *Research Policy*, 35(6): 790-807.

Gulbrandsen, M.; Smeby, J. (2005) "Industry Funding and university professors' research performance", Research Policy, 34 : 932–950.

HEFCE (2010) "Higher Education – Business and Community Interaction Survey - 2008-09" Bristol: Higher Education Funding Council of England

Huelsbeck, M.; Menno, D. (2007) "German university patenting and licensing: does policy matter?" Paper for the 2nd Annual Conference of the EPIP Association.

Iversen, E.J.; Gulbrandsen, M.; Klitkou, A. (2007) "A baseline for the impact of academic patenting legislation in Norway", *Scientometrics*, 70(2): 393–414.

Jaffe, A.B. (2000) "The US patent system in transition: policy innovation and the innovation process", *Research Policy*, 29: 531–557.

Kenney, M.; Goe, W.R. (2004) "The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science at U.C. Berkeley and Stanford", *Research Policy*, 33, 691–707.

Kilger, C.; Bartenbach, K. (2002) “New rules for German professors”. *Science* 298(8): 1173-1175.

Klitkou, A.; Gulbrandsen, M. (2010) “The relationship between academic patenting and scientific publishing in Norway”, *Scientometrics*, 82: 93–108.

Kortum, S.; Lerner, J. (1999) “What is behind the recent surge in patenting?” *Research Policy,* 28: 1–22.

Lissoni F., Llerena P., McKelvey M., Sanditov B. (2008) “Academic Patenting in Europe: New evidence from the KEINS database”, *Research Evaluation*, vol. 17 (2): 87-102.

Lissoni, F.; Lotz, P.; Schovsbo, J.; Treccani, A. (2009) “Academic patenting and the professor's privilege: evidence on Denmark from the KEINS database”, *Science and Public Policy*, 36 (8): 595-607.

Lissoni, F.; Montobbio, F.; Seri, R. (2010) Ownership and impact of European University Patents, paper presented at the third DIME-BRICK conference, Torino, April 23-24.

Macdonald, S. (2009) “Seducing the goose. Patenting by UK universities”, University of Sheffield, mimeo.

Meyer, M.S.; Tang, P. (2007) “Exploring the “value” of academic patents: IP management practices in UK universities and their implications for third-stream indicators”, *Scientometrics*, 70: 415-440.

Meyer, M. (2010), “University patenting and IP management approaches in Europe”, Report prepared for the European Patent Office.

Meyer M.; Du Plessis, M.; Tukeva, T. (2005) “Inventive output of academic research: A comparison of two science systems”, Scientometrics, 63(1): 145-161.

Mowery, D.C.; Sampat, B.N. (2005) "The Bayh-Dole Act of 1980 and university–industry technology transfer: A model for other OECD governments?", *The Journal of Technology Transfer*, 30(1-2): 115-127.

Mowery D.C.; Nelson R.R.; Sampat B.N.; Ziedonis A.A. (2001) "The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980", *Research Policy*, 30(1): 99-119.

NUBS (2003). UK University commercialisation survey: financial year 2002. AURIL-Nottingham University Business School (NUBS)-UNICO. ? not in text

OECD (2008) *Compendium of Patent Statistics*, Paris: OCED.

OECD (2003), "Turning science into business. Patenting and licensing at PROs", Paris: OECD.

Piccaluga A., Pietrabissa R. (2010) "International Dynamics of University-Industry Knowledge Transfer" Mimeo.

Proton, 2009, The ProTon Europe sixth annual survey report (fiscal year 2008), Proton Europe.

PVA-MV (2003) "Report on the Abolition of the German Professors Privilege: Overview of changes and challenges". Report prepared for Vinnova, Swedish Agency for Innovation Systems.

Rafferty, M. (2008) "The Bayh–Dole Act and university research and development", *Research Policy*, 37(1): 29-40.

Represa-Sánchez, D.; Castro-Martínez, E.; Fernández-de-Lucio, I. (2005) "Encouraging protection of public research results in Spain". *Jounal of Intellectual Property Rights*, 10: 382-388.

Sampat, B.N.; Mowery, D.C.; Ziedonis, A.A. (2003) "Changes in university patent quality after the Bayh–Dole act: a re-examination", *International Journal of Industrial Organization,* 21: 1371–1390.? Not in text

Saragossi, S.; van Pottelsberghe de la Potterie, B. (2003) "What patent data reveal about universities: the case of Belgium", *Journal of Technology Transfer*, 18: 47–51

Sellenthin M.O. (2006) "Beyond the Ivory Tower. A comparison of patent rights regimes in Sweden and Germany", Linkoping Studies in Arts and Science, No. 355.

Stephan P.A.; Gurmu S.; Sumell A.J.; Black, G. (2007): "Who's patenting in the university? Evidence from a survey of doctorate recipients", *Economics of Innovation and New Technology*, 16: 71–99.

Tang, P. (2008) "Exploiting University Intellectual Property in the UK", London: Intellectual Property Institute.

Van Looy, B.; Ranga, M.; Callaert, J.; Debackere, K; Zimmermann, E. (2004) "Combining entrepreneurial and scientific performance in academia: Towards a compounded and reciprocal Matthew Effect?" *Research Policy*, 33 : 425–441.

Von Ledebur, S. (2008) "Technology transfer offices and university patenting – A review", Jena Economic Research Papers n. 2008-033.

Von Ledebur, S. (2009) "University-owned patents in West and East Germany and the abolition of the professors' privilege" Working papers on Innovation and Space, Marburg University, Papers n. 02-09.

Von Ledebur, S.; Buenstorf, G.; Hummel, H. (2009) "University Patenting in Germany before and after 2002: What role did the professors' privilege play?" Jena Economic Research Papers n. 2009-068.