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# University autonomy, IP legislation and academic patenting: Italy, 1996-2007

***Francesco LISSONI***

*GREThA, CNRS, UMR 5113*
*Université de Bordeaux*

&

***Michele PEZZONI***

*KITeS – Università "L. Bocconi", Milan – Italy*

&

***Bianca POTI***

*CERIS-CNR, Rome – Italy*

&

***Sandra ROMAGNOSI***

*Parco Scientifico Università "Tor Vergata", Rome – Italy*

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**GRETHA UMR CNRS 5113**
Université Montesquieu Bordeaux IV
Avenue Léon Duguit - 33608 PESSAC - FRANCE
Tel : +33 (0)5.56.84.25.75 - Fax : +33 (0)5.56.84.86.47 - www.gretha.fr

### Autonomie des universités, droit intellectuel et brevetage académique: Italie 1996-2007


**Résumé**

*En utilisant des données sur les demandes de brevet à l'Office européen des brevets, nous cherchons les tendances de brevets universitaires en Italie, 1996-2007. Pendant ce temps, les universités italiennes ont passés par un processus de réforme radicale, qui a leur accordé beaucoup plus d'autonomie. Elles ont été aussi confrontées à un changement de législation sur la propriété intellectuelle, qui a introduit le privilège du professeur. Nous constatons que, bien que le nombre absolu de brevets académiques a augmenté, (i) leur poids sur total des brevets par les inventeurs nationaux n'a pas, tandis que (ii) la part des brevets universitaires appartenant à des universités a augmenté. Au moyen d'une série de régressions probit, nous montrons que la probabilité d'observer un brevet académique dépend en grande partie de la technologie considérée et des caractéristiques du système local d'innovation. Après avoir contrôlé ces facteurs, la probabilité conditionnelle d'observer un brevet académique a effectivement diminué au fil du temps. Également au moyen de régressions probit, nous constatons que l'augmentation de la propriété universitaire est expliqué de manière significative mais pas exclusive, par la part croissante du public par rapport au privé dans la R & D et par l'autonomie accrue des universités italiennes, qui a leur permis d'introduire des règlements explicites concernant les inventions de leur personnel. L'introduction du privilège du professeur n'a pas eu d'impact du tout.*


Mots-clés : brevetage académique, autonomie des universités, privilège du professeur

### University autonomy, IP legislation and academic patenting: Italy, 1996-2007


**Abstract**

*Using data on patent applications at European Patent Office, we search for trends in academic patenting in Italy, 1996-2007. During this time, Italian university underwent a radical reform process, which granted them autonomy, and were confronted with a change in IP legislation, which introduced the professor privilege. We find that, although the absolute number of academic patents has increased, (i) their weight on total patenting by domestic inventors has not, while (ii) the share of academic patents owned by universities has increased. By means of a set of probit regressions, we show that the probability to observe an academic patent depends largely on the technology considered and characteristics of the local innovation system. After controlling for these determinants, the conditional probability to observe an academic patent has indeed declined over time. Also by means of probit regressions, we find that the rise of university ownership is explained, significantly albeit not exclusively, by the increasing share of public vs. private R&D and by the increased autonomy of Italian universities, which has allowed them to introduce explicit IP regulations concerning their staff's inventions. The introduction of the professor privilege has had no impact at all.*


Keywords: academic patenting, university autonomy, professor privilege

**JEL: I23, O31, O34**

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# 1. Introduction[1]

Quantitative studies on academic patenting have proliferated over the past few years, first as a result of the impressive growth registered by patents owned by US universities, then as a reaction to policy initiatives aimed at replicating the US experience worldwide (Mowery and Sampat, 2005; Geuna and Rossi, 2011; Lissoni , 2013). In Europe, scholars have been first and foremost concerned with measuring the real extent of university scientists' contribution to inventive activities. Contrary to their US counterparts, European universities have no tradition of reclaiming the intellectual property rights (IPRs) over their scientists' inventions, and often leave them to research sponsors (such as business companies and governmental agencies) or the scientists themselves. Therefore, many efforts have been devoted to identifying "academic patents" by working on the identity and affiliation of inventors, rather than counting those assigned to higher education institutions.

One limitation of this literature so far has been the absence of longitudinal depth, due to the difficulty of assembling and checking data on names and affiliations of university scientists for less recent years. While it is nowadays well established that European academic scientists contribute significantly to inventive activities, we still do not know whether this contribution has changed over time. Nor we know much on the effects of the various reforms pushed through in several European countries with the aim of increasing it. Finally, some evidence exists on universities' increasing propensity to take title over their scientists' inventions, but it is still quite fragmentary (Lissoni et al. 2009; Della Malva et al., 2012; Mejer, 2012).

In this paper we fill these gaps with reference to Italy. Italy has been one the first countries whose academic patenting activity was examined under the angle of inventors' identity, a circumstance that has left us with reliable data going back at least to the mid-1990s (Balconi et al., 2004; Lissoni et al., 2008). Italy is also interesting because its university system, starting 1989, has been transformed quite radically, from a centrally controlled to a semi-autonomous one, with universities now setting their own budget targets and revenue-collecting initiatives, including those concerning technology transfer. In addition, Italy is the only country in Europe to have introduced the "professor privilege" (in 2001), at a time when all countries that had previously adopted it decided for its abolition (Sweden being the only exception)[2].

Our empirical investigation is aimed at:

- ✓ building reliable estimates of academic patenting for the period 1996-2007;
- ✓ testing for the existence of any time trend concerning the weight of academic patenting over total patenting, and the ownership distribution of academic patents;
- ✓ estimating the impact of reforms granting more autonomy to universities and introducing the professor privilege.

We find that the weight of academic over total patenting has remained stable over the years, while the share of university ownership has increased significantly over time. This suggests that any statistics based only on university-owned patents would give the wrong impression of a growing contribution of Italian universities to domestic patenting, which is not the case. In addition, by means of a probit regression

[1] **Acknowledgements:** Inventor data come from APE-INV, the project on "Academic Patenting in Europe" sponsored by the European Science Foundation (http://www.academicpatenting.eu). Participants to the "NameGame" APE-INV workshop series have all contributed to establish a robust methodology for name disambiguation, which has been essential for the creation of the database. Several Italian colleagues have provided us with data they collected over the years: Cinzia Daraio and Andrea Bonaccorsi (Aquameth data), Andrea Piccaluga (NetVal data), Rosa Grimaldi, Riccardo Fini, and Maurizio Sobrero (universities' IP regulations). Paolo Colchonero Freri has provided valuable research assistance.

[2] On the professor privilege, see section 2.

exercise, we show that reforms affecting university have had no impact on the share of academic over total patenting in Italy. A second probit regression exercise shows that the adoption of internal IP regulations by universities, a response to the newly granted autonomy, appears to have increased university patent ownership. The introduction of the professor privilege has produced no effect whatsoever.

In the remainder of the paper we proceed as follows. In section 2 we review the existing literature on academic patenting in Europe, with special emphasis on its relationship with university autonomy. In section 3 we sum up the norms concerning university autonomy introduced in Italy in the 1990s, and their effects on universities' funding patterns, technology transfer initiatives, and IP management. We also discuss the controversial introduction of the professor privilege. Section 4 describes the methodology we followed to obtain our longitudinal database. In the same section, we present *prime facie* evidence based on descriptive statistics. In section 5 we run our regressions and discuss their results. Section 6 concludes.

## 2. Background literature

Dominant conventions define "academic" any patent signed at least by one academic scientist, while working at his/her university, whether the patent is owned by the university, a public research organization (PRO), the scientist, or a business company, either exclusively or jointly with other assignees.. A complementary definition distinguishes between university-invented and university-owned patents (Geuna and Rossi, 2011). The former coincide with academic patents, and the latter with the subset of such patents owned by the universities. In the US, university-owned patents are the largest part of academic patents, and their weight over total domestic patents has increased steadily over the years, especially throughout the 1990s. Besides, university administrations' involvement in decisions concerning IP matters pre-date the 1980s (Mowery and Sampat, 2001; George , 2005).

On the contrary, while European academics have been patenting, at the individual level, throughout the late 19th and the 20th century, their universities did not explicitly address IP issues until the 1990s. This is due to two institutional differences between European and US universities.

First, several European countries were until recently characterized by a peculiar IP regime over academic research, known as “professor privilege”. The norm exempts academic personnel from the duty to disclose and relinquish their inventions to their employers, as it is the case with R&D staff employed by business companies or PROs. The privilege was first introduced in the German patent law in 1957 and later imitated by several other countries, especially German-speaking and Scandinavian ones. Policy concerns over its infrequent use, and the ensuing lack of technology transfer activities, led to its abolition by Denmark in 2000, followed by Germany, Austria, and Finland in the years up to 2004 (OECD , 2003; Lissoni et al., 2009; von Proff et al., 2012; Damsgaard and Thursby, 2012)[3].

Second, European universities never enjoyed the same degree of autonomy of their US counterparts (Ben-David, 1977; Clark, 1993). A full discussion of the concept of university autonomy falls beyond the scope of this paper. Here it will suffice to say that autonomy allows universities to exert some degree of control over their finances (including the freedom to raise revenues from technology transfer activities) and staff (including the freedom to set up clear rules over IP concerning their faculty's inventions, including those on disclosure and rewards).[4]

[3] See Kenney and Patton (2011) for a general discussion of inventor vs. university ownership.

[4] A synthetic definition autonomy is provided by Aghion et al. (2010), who consider two parameters only: (i) whether a university's budget needs to be approved by the state; and (ii) the percentage of the university's budget associated to competing grants, as opposed to block grants. A more complete definition is provided by the European University Association (EUA), which measures autonomy by looking « […] at the ability of universities to decide on:

- organisational structures and institutional governance […]
- financial issues – in particular the different forms of acquiring and allocating funding

A lack of autonomy implies the absence of the administrative tools and skills necessary to take title of and commercialize the professors' inventions. This explains why European universities traditionally resisted being involved in IP management, and often took the shortcut of allowing scientists to take their own decisions, even in the absence of the professor privilege. This applied in particular to those academics engaged in cooperative or contract research with third parties, who often signed blanket agreements leaving all IPRs in their partners' hands. As a result, a large part of academic patents in Europe may go unnoticed by official statistics which classify the origin of the patent according to the applicants' identity, not the inventors'.

Following this clue, a number of recent studies moved to re-classifying patents by inventor, by matching the inventors' names to the names of university scientists[5]. These produced the first estimates of academic patenting in Finland, Belgium, Italy, Norway, France, and Sweden (Meyer , 2003; Saragossi and van Pottelsberghe, 2003; Balconi et al., 2004; Iversen et al., 2007; Lissoni et al. 2008). In all these countries, a significant percentage (from 3% to 8%) of corporate patents was found indeed to cover inventions by academic scientists[6].

Name-matching methodologies for the identification of academic patents tend to produce data with no or little longitudinal depth: while information on inventors come with patent data, for which very long time series are available, information on academic scientists is generally obtained through *ad hoc* requests to universities or governmental institutions, and provided with reference to one year only (say *Y*). When matching the names of scientists active in year *Y* to names of inventors of patents filed in year *Y-t* one misses all patents signed in that year by professors active at the time, but retired before *Y*. The larger *t*, the greater the resulting underestimation (see section 4 below). Still, cross-country comparisons can make sense, under the assumption of similar biases across countries.

Lissoni (2012) compares figures from various sources for data up to around 2001, and conclude that, in Europe, universities are the least important category of assignees of academic patents, with shares around 10% in most countries. Everywhere, the most important category of owners is that of business companies, whose shares range from 61% in France to 80% in Sweden. In countries such as France and Italy universities also trail behind large PROs, whose role in the public science system is (in France) or used to be (in Italy) as important as that of universities. In professor-privilege countries, such as Sweden and Denmark (pre-2000), universities are even less important than individuals (who own respectively 13% and 17% of academic patents).

The highest shares of university-owned academic patents are found in the Netherlands (26%) and in the United Kingdom (22%), whose university systems are the most similar to the US ones (Estermann et al., 2009). This suggests that the ownership distribution of academic inventions depends not only on the national IP legislation, but also on the degree of university autonomy.

Does university autonomy lead not only to a higher share of university-owned academic patents, but also to a larger number of academic patents (relative to all patents in a country)? Evidence on this point is still in its infancy, and too US-centric for lending itself to a generalization. Thursby et al. (2009) indicate

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- staffing matters – in particular the responsibility for terms of employment (which may include IP matters)
- academic matters – in particular the control over student admissions (Estermann and Nokkala, 2009; p.7)

Both Aghion et al. (2010) and the EUA associate universities' greater autonomy to higher efficiency and productivity with respect to their general tasks (teaching, research, and technology transfer). Our paper has not the ambition to test such broad association. For a cross-country comparison of European universities, see Bonaccorsi and Daraio (2007).

[5] For a review of technical problems with disambiguation of inventors' names see Raffo and Lhuillery (2009). See also the NameGame workshop series organized by the APE-INV project: http://www.esf-ape-inv.eu/index.php?page=10 (last access: : August, 2012).

[6] Similar results have been found for Germany, with a more conservative methdology (Schmiemann and Durvy, 2003; ch 4 in OECD, 2003).

that, in the US, the percentage of university-owned academic patents is less than 30%, as opposed to a university-owned share of almost 70%. This implies that the gap between US and European universities in terms of university-invented, rather than university-owned patents, is not very large, albeit positive. Aghion et al. (2010) find a positive relationship, between university autonomy and productivity, the latter measured by the number of patents produced in the university's states, per unit of public funding. For Europe, cross-country comparisons by Lissoni (2012) provide little evidence of a straightforward relationship.

# 3. Italian universities: autonomy and IP legislation

## *3.1 The 1989 institutional reform and its implementation*

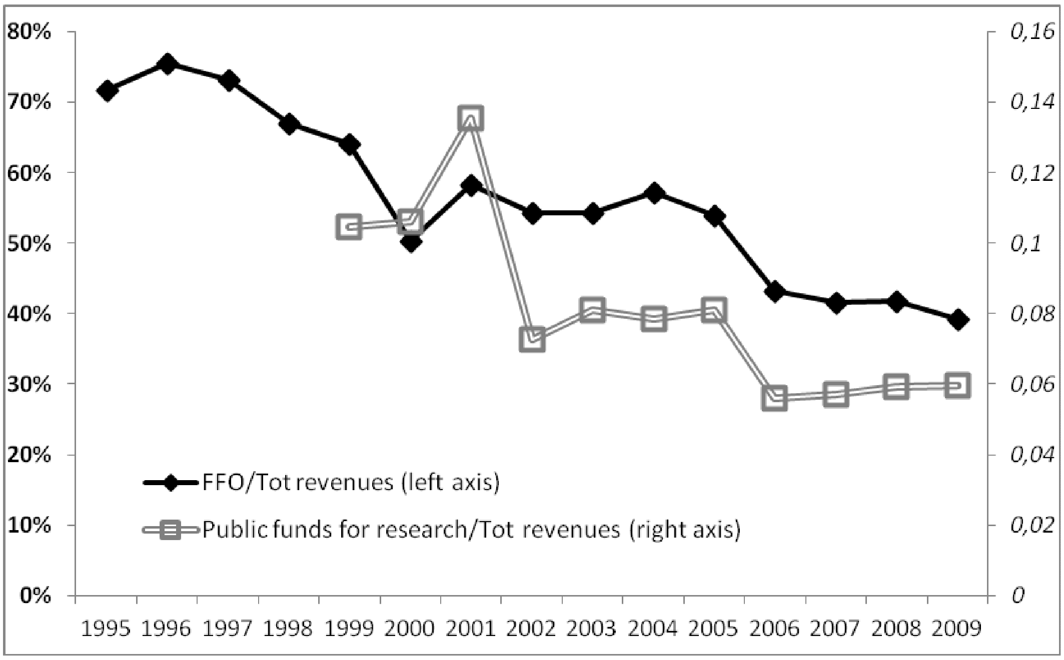
The Italian university system has been for long characterized by a combination of academic corporatism and governmental bureaucracy, and a weak role for the university governance. Until the 1990s, Italian academics were pure civil servants, paid directly by the State, which also regulated their careers and teaching duties. Universities could not actively dispose of their revenues, personnel, and curricula (Giglioli, 1979). In 1989 that a major reform (L168/1989) established new principles concerning the distribution of authority and coordination in the system. It was followed by three further pieces of legislation (L.341/1990; L.537/1993-art.5; and D.M.9/2/1996) that introduced universities' autonomy also with respect to educational offer and financial management. Block grant funding was introduced, with a major fund (FFO, "Fondo di Finanziamento Ordinario") coming to replace direct transfers from the state to professors for wages, and earmarked transfer to universities for all other expenses. A new system of research funding was also introduced, to be allocated on a competitive, peer-reviewed basis..

At the moment of its creation, the FFO block grant amounted to 90% of all universities' revenues. Its allocation rules resulted from a compromise between the wish to allow for gradualism in the transition towards a full autonomy, and that of incentivizing universities to reduce their dependence from state subsidies. Its volume, at constant prices, increased throughout the 1990s, and declined in the 2000s, with the only exceptions of 2004 and 2005 (starting 2008, it has declined also at current prices). A similar trend was followed by public funds for science. At the same time, universities were given permit to raise their own revenues by collecting student fees, participating to international projects, engaging in contract research with industry, getting support from local authorities, and accessing financial credit. As a result, the share of external sources of funding over total revenues has moved from nearly zero in 1994 to around 18% in 2010 (plus 12% from student fees). Conversely, the share of both FFO and public funds for science over universities' total revenues dropped steadily (see figure 1).

While the reform laws of the 1990s mentioned explicitly technology transfer as part of the academic' mission, no clear indication or incentive scheme was introduced (Bonaccorsi and Daraio, 2007). [7]

[7] The only,exceptions were:
- the introduction of a legal notion of "spinoff company" in 1997;
- the introduction of the "professor privilege" concerning IPR matters in 2001 (see section 3.2);
- a short-lived provision of subsidies for the creation of technology transfer offices, from 2005 to 2007.

**Figure 1. Weight of block grants (FFO) and public funds for scientific project funds (SCIENCE) over universities' total revenues, 1995-2009**




Sources: own elaborations on AQUAMETH and CNSVU data

These reforms may have generated some incentives for universities to engage in technology commercialization, as part of a more general drive towards getting additional resources to compensate for declining block grants and research funds. However, the available literature suggests a rather heterogeneous fund raising strategy, which included the collection of student fees (also through the introduction of continuos learning programmes) and negotiations for local authorities' support (ch. 7 in Bonaccorsi and Daraio, 2007; Moscati and Vaira, 2008). As a consequence, we cannot state *a priori* whether more autonomy translated into more academic patenting.

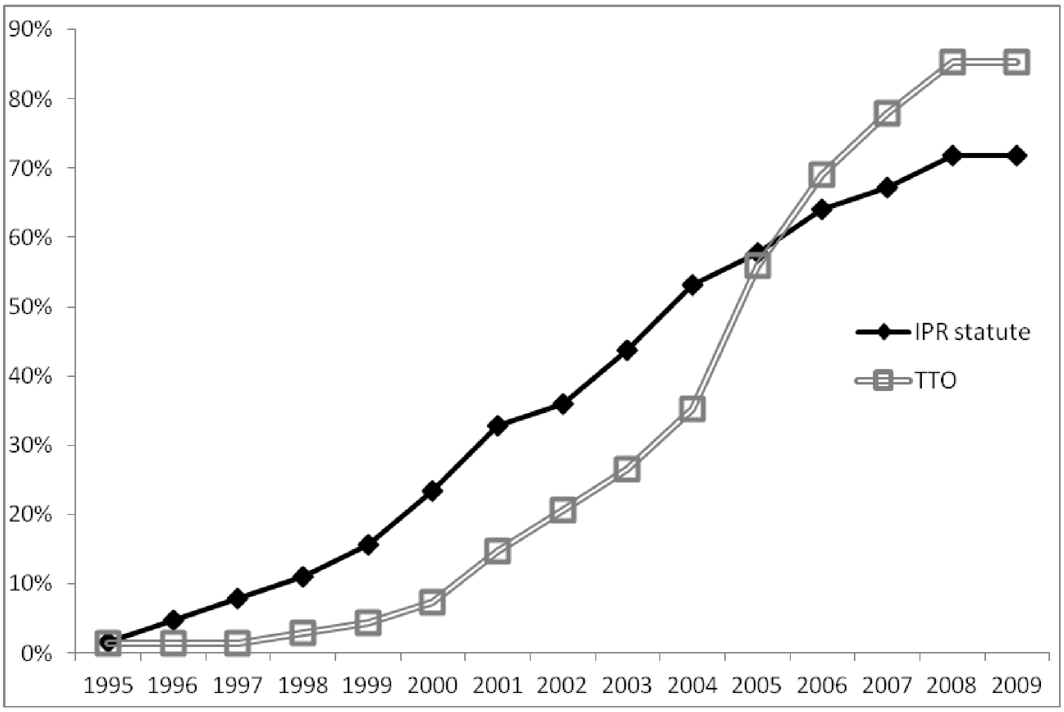
As for our second research question (concerning changes in universities' control over their IP), autonomy has been certainly relevant, as it gave universities the right to establish explicit IP and technology transfer policies, to which we now turn our attention.

## 3.2 Autonomy and the IP regime of academic inventions

In our period of interest, patent matters in Italy were regulated by a "law on inventions" dating back to pre-republican times (RD1127/1939). The law did not include any specific provision for university professors, so academic inventions could be presumed to belong to the inventor's employer. However, it was not clear whether the latter was the university or the State, nor any legal norm existed to compel disclosure. In this vacuum, academic inventors either retained tacitly the property of inventions, or negotiated it with companies and funding agencies sponsoring their research (Balconi et al., 2004; Baldini et al., 2006).

After being granted autonomy, several universities introduced explicit IP regulations. They did so in the absence of clear policy guidelines. As explained by Baldini et al. (2010), the first universities to move on were the University of Bologna and the Polytechnic of Milan (two large universities with traditional strong ties to industry) and the Scuola Superiore Sant'Anna (a smaller but prestigious institute dedicated to research and graduate studies). Other universities followed, by imitating one or the other of these IP statutes, in quite a rapid succession (see figure 2).

**Figure 2 – Diffusion of technology transfer offices (TTOs) and IP statutes, all Italy (1995-2009)**




Sources: own elaborations on NETVAL survey and CNSVU

At the same time, universities began transforming the organization of technology transfer activities, from a discretionary function in the hands of Rectors to one performed by specific offices (TTOs), with a dedicated budget and funded by the University internal resources (Potì and Romagnosi, 2010). Here, too, we observe an epidemic phenomenon of imitation, although a slower one, and with little correlation to that concerning IP regulations[8].

When policy-makers finally turned their attention to IP matters concerning academic inventions, in 2001, they did so in quite an extemporaneous fashion, by inserting a 10-lines article in the annual Budget Law (L383/2001, art.7). The article introduced in Italy the “professor privilege". This novelty had not been anticipated by any consultation with universities, was loosely motivated by the necessity to overcome the latter's (presumed) lack of initiative with respect to technology commercialization, and betrayed little or no knowledge of invention processes as they actually occur in academic science. In particular, it did not consider the very common case in which academic scientists and business firms collaborate on the same invention (would the professor privilege apply in this case? would it apply only to inventors from the university, or also to their co-inventors from industry?), and clashed against the general trend towards granting universities more control over their staff's activities (see Granieri , 2010; esp. chapters 1 and 6).

Baldini et al. (2010, 2012) illustrate at length the universities' negative reaction to this legislative change . Only a very few institutions complied immediately with it, by adapting their IP statutes, while others amended their regulations in the direction of circumventing the new law (even at the risk of violating it) and keeping IP for the university[9].

[8] Our data (available on request) show little correlation between diffusion rates of TTOs and IPR regulations at the regional level, which we explain as follows: establishing a TTO requires some financial resources, while approving an IPR regulation may be inexpensive, but politically complex. Besides, TTO activties may well go beyond or not include IP management.

[9] Notwithstanding this diffused criticism, the norm on the professor privilege was maintained in the new Code of Industrial Property, introduced in 2005, with limited amendements (Granieri ., 2010).

Summing up, explicit policy support for the commercialization of academic research results in Italy has been at best limited, and possibly disjointed or in counter-tendency with respect to university reform. As a consequence, we expect to observe that academic patenting in Italy has been unaffected by the introduction of the professor privilege. On the contrary, we expect to observe some impact from the adoption IP regulations onto the ownership distribution of academic patents, in particular an increase in university ownership. The same applies to the introduction of TTOs.

# 4. Data

## *4.1 Methodology and sample*

The main database used in our regression exercise consists of patent applications filed at EPO, the European Patent Office, with priority dates comprised between 1996 and 2006. The data were collected over the years by CESPRI and then KITES, two research centres of Bocconi University, Milan. Several research projects supported the data collection effort, the most important ones being KEINS and APE-INV, from which as many databases of the same name were derived.

The KEINS database methodology consisted of 3 steps (Lissoni et al., 2006):

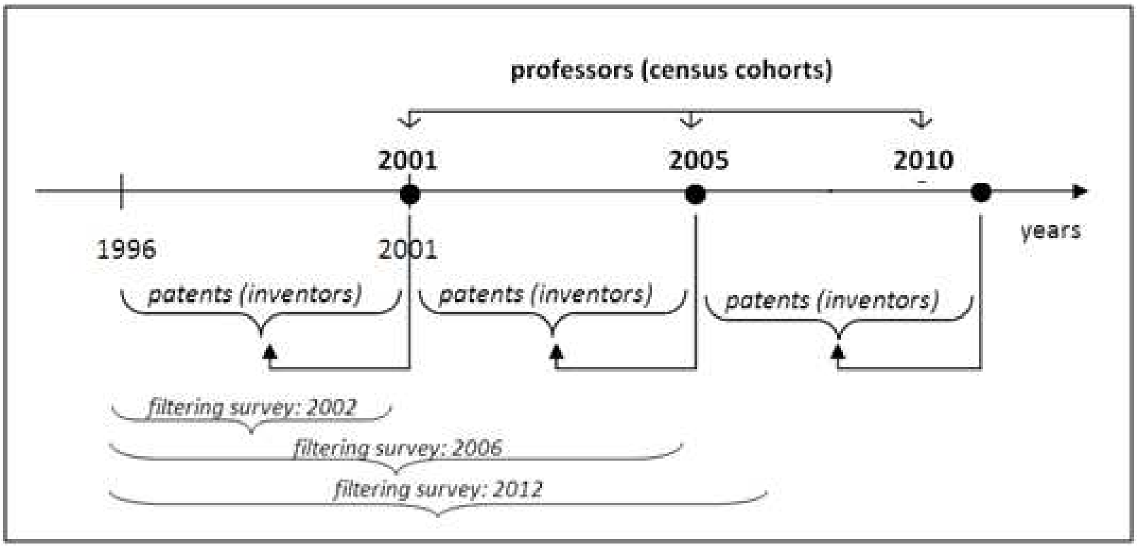
1. *Disambiguation* of inventors' names and addresses.
2. Name *matching* between disambiguated inventors and academic personnel, the latter's names made available, in 2000 and 2005 by the Italian Ministry of Education. This step produced a number of "professor-patent" pairs obtained by attributing to each professor the patents signed by the matched inventors.
3. *Filtering* of "professor-patent" pairs, on the basis of both automatic criteria, manual checking, and a telephone survey (with around 80% response rate).

The APE-INV project improved the disambiguation and matching algorithms used by KEINS in order to extend the database both geographically and over time[10]. For Italy, we extracted the patents with at least one Italian inventor, and re-matched all of them to professors from the 2000 and 2005 lists and a new list for 2009. For the filtering stage, we exploited available information on the patents' assignee and/or from the KEINS database, and then run an e-mail survey of remaining professor-patent pairs.

Figure 3 illustrate the advantage of having three cohorts of professors available for the matching step, plus the additional advantage of having a large amount of data already filtered by previous research. Both advantages go in the direction of improving the reliability of the longitudinal dimension of data. When having just one cohort of professors (year *Y*), we end up underestimating the number of academic patents for any year $Y$-$t$ , especially for large values of $t$. With more cohorts at hand (say three of them: $Y_1$, $Y_2$, $Y_3$; from less to more recent), we may decide to match professors from cohort $Y_i$ $(i=1,2,3)$ to inventors of patents from years comprised between $Y_i$ and $Y_i$ -$t$, ,and keep $t$ reasonably low (5 years, in our case; this allows us to presume that most professors in cohort $Y_i$ were already active in university, and not too many left it).

[10] The APE-INV methodology is fully described in Lissoni and Pezzoni (2011). Notice that KEINS matching algorithms were meant to be very precise and conservative, while the APE-INV algorithms allows for variations both in surnames and names in order to increase recall.

**Figure 3 - Identification of academic inventors and patents: data collection methodology**




Notice that while this strategy helps solving problems at the matching stage, it leaves unsolved the problems at the filtering stage. This is because surveying professors who are present only in early cohorts (say, years $Y_1$ or $Y_2$) may be difficult: they may have retired or left the academy, so there is no way to reach them. It is at this point that data from early research turns out to be useful, as they come from surveys run at a time when most professors from these cohorts could still be reached.

Summing up, professor-inventor matches were obtained as follows: we name-matched professors active in 2001 to inventors of patents with priority dates 1996-2001, and professors active in 2005 and 2009 to inventors of patents with priority dates from 2001-2005 and 2006-2010, respectively. This resulted in 10118 professor-patent pairs to be investigated at the filtering stage (for a total of 3775 professors and 6484 patents). Table 1 provide the key statistics.

Automatic and manual checking, plus information from KEINS, allowed us to filter out 763 pairs and to confirm as valid 2501 pairs. For the remaining 6854 pairs we set up an e-mail survey, which consisted in presenting the respondent (professor) with the list of matched patents and the request to confirm/deny them as his/her.

Table 1 shows that:

1 1430 pairs (line d) involved a professor whose e-mail could not be retrieved ("unreachable"), mostly in the case of professors active only in 2001;

2 5424 (lines b+c) were "reachable" and we obtained a 37,5% response rate, that is responses for 2036 (b) pairs and no-responses for 3388 (c);

3 993 (b1) out of the 2036 (b) responses were positive (the professor confirmed the patent to be his/her), while the remaining 1043 (b2) were negative.

**Table 1 – Professor-patent pairs: results of filtering stage and subsequent estimates [(§)]**

| | | Prof-patent pairs | | Professors | Patents |
|---|---|---|---|---|---|
| | | nr | % | nr | nr |
| a) | Automatic/Manual check | 3264 | 32.3% | 1540 | 2145 |
| | *of which:* | | | | |
| *a1)* | *- confirmed* | *2501* | | *1356* | *1479* |
| *a2)* | *- rejected* | *763* | | *217* | *693* |
| b) | E-mail survey (responses) | 2036 | 20,1% | 643 | 1829 |
| | *of which:* | | | | |
| *b1)* | *- confirmed* | *993* | | *412* | *899* |
| *b2)* | *- rejected* | *1043* | | *262* | *968* |
| c) | E-mail survey (no responses) | 3388 | 33,5 % | 1124 | 2820 |
| | *of which:* | | | | |
| *c1)* | *- confirmed [(*)]* | *1249* | | *472* | *1012* |
| *c2)* | *-rejected [(*)]* | *278* | | *87* | *236* |
| *c3)* | *- confirmed (estimate)* | | *Depends on type of estimate* | | |
| *c4)* | *- rejected (estimate)* | | *Depends on type of estimate* | | |
| d) | Unreachable | 1430 | 14,1 % | 750 | 1190 |
| | *of which:* | | | | |
| *d1)* | *- confirmed (estimate)* | | *Depends on type of estimate* | | |
| *d2)* | *- rejected (estimate)* | | *Depends on type of estimate* | | |
| | Total [(i)] | 10118 | 100% | 3775 [(+)] | 6484 |
| | *of which:* | | | | |
| | *- confirmed (lower bound estimate) [(ii)]* | *4743* | *46,9%* | *2199* | *2679* |
| | *- confirmed (intermediate estimate) [(iii)]* | *5204* | *51,0%* | *2399* | *3093* |
| | *- confirmed (upper bound estimate) [(iv)]* | *5733* | *56,7%* | *2602* | *3535* |

[(*)] For several no-responses, information was available from responses by other professors (who provided information on co-inventors) or prior research (see footnote 18)

[(+)] Differently from prof-patent pairs, total nr of professors and total nr of patents may differ from a+b+c+d, due to the possibility of having more than one patent for each professor and vice versa

**[(§)]** Prof.s active in 2001, 2005 and 2009 matched to patents with priority dates, respectively, in: 96-00; 01-05; 06-09

[(i)] sum of rows (a) (b) (c) (d); [(ii)] nr: sum of rows (a1) (b1) (c1); % of Total;

[(iii)] nr: sum of rows (a1) (b1) (c1) (d1); % of Total; [(iv)] nr: sum of rows (a1) (b1) (c1) (c3) (d1); % of Total

This left us with 4743 confirmed professor-patent pairs, for a total of 2199 academic inventors (professors) and 2679 patents. We use these figure as a "lower bound" estimate of the number of academic patents in Italy for the period considered, based on the assumption that all unreachable and no-response cases are equivalent to negative responses. This estimate is subject to time-related bias. In fact, "unreachable" and no-response cases are all related to patents owned by business firms, individuals and other non-university entities, so that "lower bound" data would return biased estimates of the ownership distribution. In addition, to the extent that "unreachable" cases include a high proportion of patents from the 1990s (as opposed to more recent patents), we could also observe a bias with respect to the time distribution of academic patents (negative bias for early years and positive bias of any estimated time trend).

- This suggested us to produce also an "intermediate" and an "upper bound" estimates of the number of academic patents. We did so by means of two different probit regression exercises, which take advantage of the peculiarity of our data. The first exercise concerns "unreachable" professor-patent pairs, and returned a total of 461 (out of 1430) positive predictions (247 academic inventors and 420 academic patents). These were added to the lower bound data to obtain a total of 5204 confirmed patent-professor pairs "intermediate" estimate.

- The second exercise concerned no-responses, and returned 529 (out of 1861) positively predicted pairs to add to the "intermediate" confirmed pairs, for a total of 5733 confirmed pairs (2602 academic inventors and 3535 academic patents). This is our "upper bound" estimate. Details on the regression and prediction exercises are reported in the Appendix.

## 4.2 Patent data: descriptive analysis

Figure 4 reports the number of academic patents according to our lower bound, intermediate, and upper bound estimates. Data for years after 2007 are not reported, as they are truncated due to publication delays; also data for 2007 have to be treated with caution, due to some right truncation problems. We notice that our intermediate estimate is closer to the upper bound in early years and to the lower bound in recent ones. This is because intermediate estimates correct the lower bound with respect of "unreachable" professor-patent pairs, which are mainly concentrated in early years, but do not correct for no-responses, which are concentrated in recent ones.

**Figure 4 – Nr of academic patents, 1996-2007; upper, intermediate & lower bound estimates**

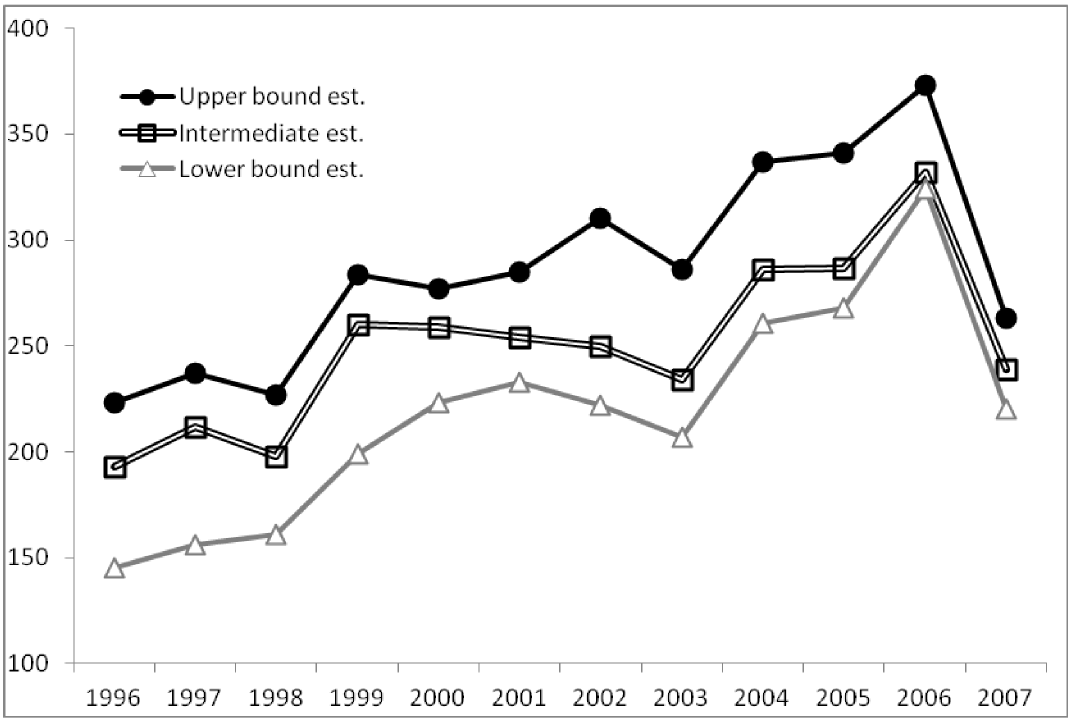



Figure 5 reports the same data, but as percentages over the total number of patents by Italian inventors. The figure also reports estimated time trends, in the form of linear regressions (based on years 1996-2006, that is excluding observations for 2007). According to the type of estimate considered, the

1996-2006 average share of academic patents is between 4.5% and 7%, two figures which are compatible with previous findings. We notice that lower bound estimates suggest the existence of a positive and significant trend, which is absent when considering the intermediate and upper bound estimates. This is in line with our expectation to observe a positive time trend bias when using lower bound estimates.

**Figure 5 Share of academic patents over all patents by Italian inventors, 1996-2006; upper, intermediate & lower bound estimates (% values)**

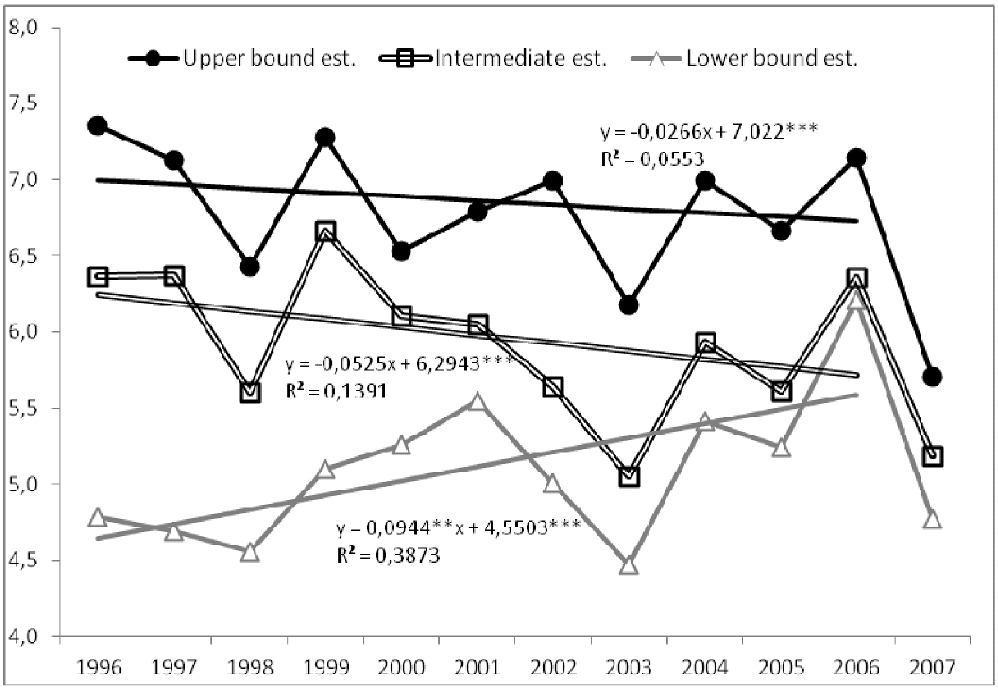



**Figure 6 Share of academic patents over all patents by domestic inventors, 1996-2007 – by technical field and subperiod; upper bound estimates (% values)**

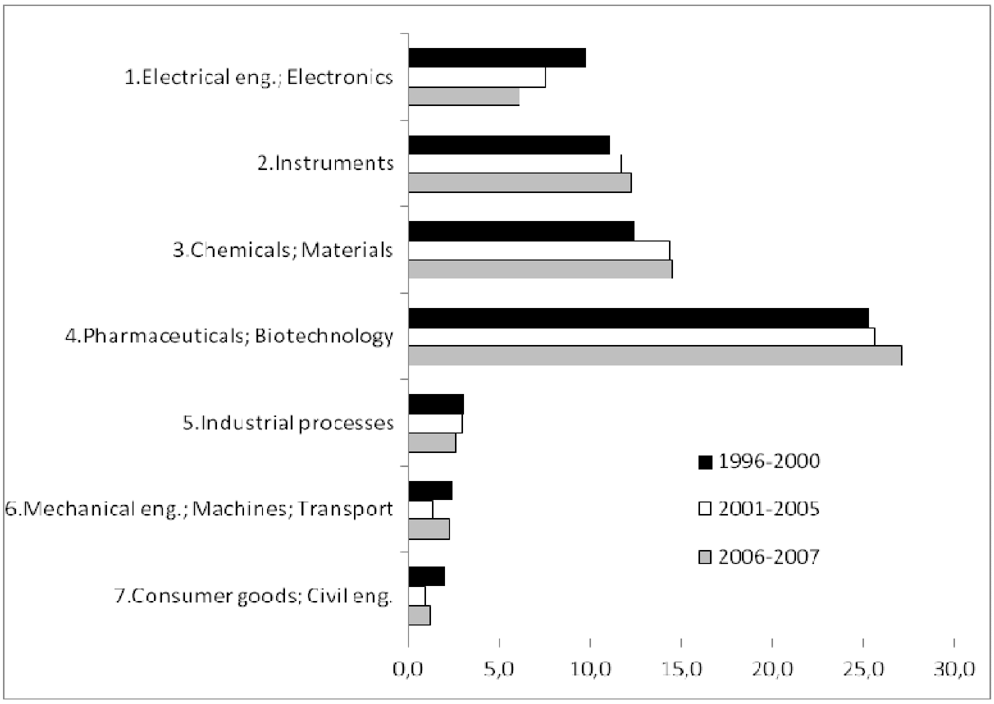



Figure 6 also confirms previous findings on the technological concentration of academic patenting, in science-based fields such as Electrical Engineering & Electronics, Scientific and Measurement Instruments, Chemicals & Materials, and, above all, in Pharmaceuticals & Biotechnologies. Notice however that the time trend is not the same for each field, with a marked decline in Electrical Engineering & Electronics, and a slight increase in the other relevant fields.

Academic patenting also appears to be quite concentrated by university, with a C4 index around 27% and no clear trend (see the second column of table 2). The Herfindhal index appears to be moderately declining, with values comprised between 310 and 390 (in a 0-10000 scale; data available on request). These figures are explained by the presence of four universities with higher-than-5% individual shares of all academic patents, followed by 6 other institutions with higher-than-3% shares (for a C10 index almost equal to 50%; 60 universities have at least one patent).

Almost all of the top 10 universities are located in Northern and Central regions, which host the most R&D intensive firms and industries. The main exceptions are the very large regional university of Naples and the university of Catania (in Sicily), host of some R&D facilities of STM, a large semiconductor multinational and the largest holder of Italian academic patents.

**Table 2– Distribution and ownership of academic patents by university (top ten vs. others), 1996-2007; upper bound estimates**

| | | | Ownership (% share by type of owner) | | | | |
|---|---|---|---|---|---|---|---|
| | nr patents | % patents | University | Company | Individual | Gov't & PROs | Foreign univ & PRO |
| Milano | 331 | 7,7 | 14,6 | 72,8 | 4,3 | 5,2 | 3,2 |
| Politecnico Milano | 290 | 6,7 | 25,9 | 67,5 | 3,4 | 2,2 | 0,9 |
| Bologna | 288 | 6,7 | 17,0 | 66,4 | 7,5 | 5,0 | 4,1 |
| Roma "Sapienza" | 241 | 5,6 | 27,0 | 58,9 | 4,8 | 7,0 | 2,2 |
| Firenze | 169 | 3,9 | 18,4 | 61,1 | 12,4 | 5,4 | 2,7 |
| Napoli "Federico II" | 169 | 3,9 | 11,8 | 64,7 | 11,2 | 4,3 | 8,0 |
| Padova | 168 | 3,9 | 10,1 | 70,4 | 10,1 | 6,7 | 2,8 |
| Pisa | 164 | 3,8 | 11,0 | 72,7 | 10,5 | 3,5 | 2,3 |
| Catania | 158 | 3,7 | 7,8 | 83,1 | 3,0 | 5,4 | 0,6 |
| Torino | 156 | 3,6 | 15,2 | 69,0 | 9,9 | 2,9 | 2,9 |
| *Total top 10 universities* | *2134* | *49,4* | *18,4* | *74,1* | *7,7* | *5,2* | *3,2* |
| *Other universities with ≥50 patents (1)* | *1488* | *34,4* | *22,0* | *71,2* | *7,9* | *8,1* | *3,0* |
| *Other universities with >1 patent (2)* | *699* | *16,2* | *13,4* | *52,6* | *10,4* | *11,0* | *4,4* |

(1) Ferrara, Pavia, Modena & Reggio, Roma "Tor Vergata", Politecnico Torino, Genova, Parma, Perugia, Milano-Bicocca, Siena, Palermo, Bari, Udine, Trieste, Brescia, Salerno, Cagliari,

(2) Milano "S.Raffaele", Napoli 2, Milano "Cattolica", L'aquila, Lecce, Pisa "S.Anna", Calabria, Verona, Politecnica Marche, Messina, Piemonte Orientale, Insubria, Urbino, Trento, Catanzaro, Roma 3, Venezia, Camerino, Sassari, Bergamo, Chieti-Pescara, Molise, Politecnico Di Bari, Tuscia, Trieste "Sissa", Roma "Campus Bio-Medico", Sannio, Basilicata, Pisa "Normale", Mediterranea, Foggia, Teramo,

Columns from third to last of table 2 provide information on the ownership of academic patents, by university. This is classified according to the type of owner, with double counting of patents owned by subjects belonging to different categories (but no double counting of patents owned by more than one subjects, if all from the same category)[11]. We notice that, in all cases, the largest share of academic patents is owned by business companies, with universities a distant second. We also notice quite a remarkable heterogeneity, with the university of Rome and the polytechnic of Milan holding over a quarter of their scientists' patents, and the university of Catania less than 10%.

[11] Ownership information dates back not to the filing or priority date of the patent, but to information contained in the 2010 edition of PatStat. This suggests that some change of property may have occurred, (Sterzi, 2012). Consultation of alternative sources suggests them to be around 5%.

Figure 7 provides information on aggregate time trends concerning academic patent ownership (for upper bound estimates; notice also that in this case we include 2007 in the linear regressions). Two very visible trend emerge, a negative one for company ownership, and a positive one for university ownership. This is in line with our expectation of an increasing control exerted by universities on IP over their scientists' inventions, as a result of their increasing autonomy.

**Figure 7 – Ownership of academic patents 1996-2007; upper bound estimates**

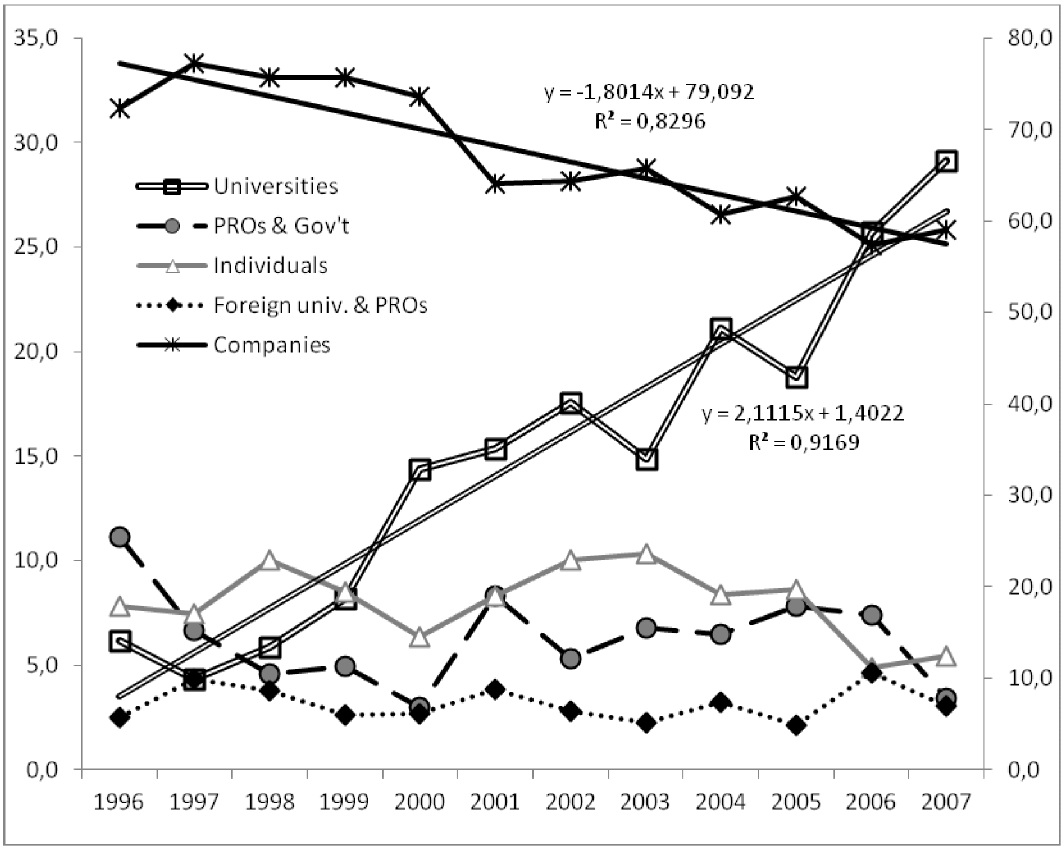



Table 3 provides summary information on ownership distribution as measured on the basis on upper bound, intermediate, and lower bound estimates of the academic patenting phenomenon. We first notice that time trends do not differ much, but the same cannot be said for levels. Lower bound estimates of university ownership are considerably higher than intermediate estimates, which in turn are higher than upper bound estimates; the reverse is true for all the other ownership categories, especially company ownership. This goes in the direction of confirming the existing of bias in lower bound and, to a lesser extent, intermediate estimates of university ownership.

**Table 3 – Ownership of academic patents 1996-2007, by subperiod; upper bound, intermediate, and upper bound estimates**

| | Upper bound estimates | | | Intermediate estimates | | | Lower bound estimates | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1996 | 2002 | 2007 | 1996 | 2002 | 2007 | 1996 | 2002 | 2007 |
| Universities | 6,2 | 17,5 | 29,2 | 7,1 | 21,1 | 31,7 | 9,1 | 23,4 | 34,1 |
| PROs & Gov't | 11,2 | 5,3 | 3,4 | 12,7 | 6,4 | 3,7 | 16,5 | 7,1 | 4,0 |
| Individuals | 7,9 | 10,0 | 5,4 | 9,0 | 9,1 | 5,9 | 9,8 | 8,6 | 6,0 |
| Foreign univ. & PROs | 2,5 | 2,8 | 3,1 | 2,8 | 2,7 | 3,0 | 3,0 | 3,0 | 3,2 |
| Companies | 72,3 | 64,3 | 59,0 | 68,4 | 60,7 | 55,7 | 61,6 | 58,0 | 52,8 |

Finally, table 4 shows that the share of university ownership, albeit always increasing, varies greatly across technological fields. When considering the most important fields, university ownership is the highest in Scientific Instruments and Pharmaceuticals & Biotechnology, and the lowest in the Chemicals & Materials and Electrical Engineering/Electronics. These differences are intuitively explained by differences in funding (with business funding being larger in Chemicals and Electronics) and in the strategic value of patents (with Chemical and Electronic patents being valued by companies, but not universities as defensive assets, and patents in Scientific Instruments and Pharma & Biotech also valuable as a source of royalties, to which universities are also interested).

**Table 4 - Share of university-owned academic patents, 1996-2007 – by technical field and subperiod; upper & lower bound estimates (% values)**

| | Upper bound estimates | | | Lower bound estimates | | |
|---|---|---|---|---|---|---|
| | 1996-2000 | 2001-2005 | 2006-2007 | 1996-2000 | 2001-2005 | 2006-2007 |
| 1.Electrical eng.; Electronics | 3,6 | 13,7 | 34,4 | 5,7 | 19,4 | 41,8 |
| 2.Instruments | 13,0 | 22,9 | 42,0 | 18,1 | 29,6 | 49,0 |
| 3.Chemicals; Materials | 7,7 | 19,7 | 25,3 | 9,8 | 23,3 | 28,3 |
| 4.Pharmaceuticals; Biotech. | 11,7 | 22,1 | 25,9 | 13,5 | 27,2 | 30,2 |
| 5.Industrial processes | 10,5 | 22,0 | 48,3 | 16,0 | 26,2 | 50,9 |
| 6.Mechanical eng.;Machines;Transport | 3,8 | 18,7 | 25,0 | 7,8 | 26,4 | 28,0 |
| 7.Consumer goods; Civil eng. | 1,6 | 16,2 | 50,0 | 4,3 | 25,0 | 52,2 |

## 4.3 Explanatory variables

Data on universities come from a variety of sources. Financial data have been made available online by CNSVU (a ministerial observatory) since 1999. The quality of these data varies greatly from year to year and across universities, so that visual inspection and reclassification are necessary. As these task were performed by the Aquameth project for years until 2004, we relied on Aquameth data for 1999-2004, and integrated them with our own elaborations for successive years (Daraio, 2011). In particular, we built two variables (FFO_RATIO and SCIENCE_RATIO) that respectively measure, for each university, the weight of block grants (FFO) and of scientific project funds (from public agencies, both Italian and international) on total revenues. In several instances, either FFO_RATIO or SCIENCE_RATIO turned out to be greater than 1, which is impossible, due to inconsistencies in the raw data. In these cases, we did not include the observations in the regressions.

Data on the adoption of IPR regulation come from a survey run by Baldini et al. (2010), which covered 65 universities out of 83 ones now active in Italy[12]. We refer generically to such regulations as "IPR statute", and record the year of adoption, for each university, of the first statute (over the years, several universities replaced the original statutes with new ones). On this basis we build a dummy variable (FIRST_STATUTE) that takes value 1 on the adoption year and the following ones.

Data on technology transfer offices come from different sources (several CNSVU surveys, and a survey run by NETVAL, an association of Italian TTOs), and are quite contradictory, which required us to take some rather arbitrary decisions. As a consequence, we opted for assigning to each university a few alternative "TTO opening dates", and select for our analysis the lowest one (for example, for the university of Florence we have three dates - 2003, 2004, and 2007 – and select 2003). On this basis, we created a TTO dummy that takes value 1 on the adoption year and the following ones.

All the university-level variables were also used to build regional-level variables, namely:

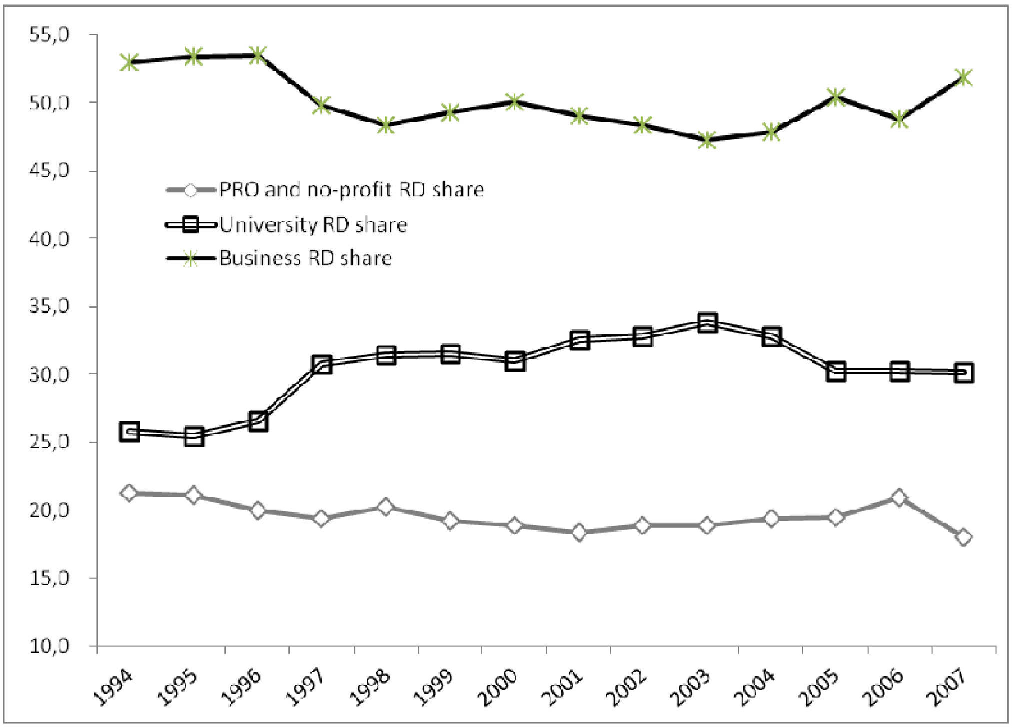
[12] None of the universities not covered by Baldini et al.'s survey, host academic inventors, as in most cases they have no medical, engineering, or scientific faculty..

- FFO_RATIO_REGION: total amount of block grants (FFO) received by universities in a region, as % of total revenues collected by the same universities, for each year 1999-2006;
- SCIENCE_RATIO_REGION: total amount of scientific project funding received by universities in a region, as % of total revenues collected by the same universities, 1999-2006;
- FIRST_STATUTE_REGION: share of universities in the region having adopted an IP statute, 1996-2006;
- TTO_REGION: share of universities in the region having already opened a TTO, for each year 1996-2006;
- NR_UNIVERSITIES_REGION: the number of respondents to the CNSVU survey, for each year 1996-2006 (it proxies for the number of universities active in each year)
- Additional variables at the regional level come from ISTAT (the Italian National Institute of Statistics), namely:
- BERD/GDP: business R&D over GDP in each region, for each year 1996-2006;
- RD_SHARE_PAUNI: share of R&D expenses by the Public Administration and the Universities in each region, for each year 1996-2006.

Summary statistics for all these variables are reported in the Appendix.

In section 3 we have already discussed the decline, at the national level, of both the FFO_RATIO and the SCIENCE_RATIO. Summary statistics by region (available on request) suggest that the decline has been common to all regions. Overall, we find little correlation between the business R&D intensity of a region and the reliance of its universities on block grants. This lends support to our suspect that non-FFO revenues can be quite heterogeneous.

**Figure 8 R&D shares of firms, universities and PROs, all Italy; 1994-2007**




Source: ISTAT

Moving to R&D data, we remark that, at the national level, the R&D/GDP ratio has increased, over our period of interest, from around 1% to around 1,2% (data available on request). This has been largely due to the increase of university R&D, whose share of national R&D has moved from around 25% to almost 35% from the mid-1990s to the mid 2000s, and declined to 30% in 2005-2007 (figure 8). Increasing reliance on university R&D may be expected to increase the share of academic patenting, relative to domestic patenting, a trend which however we do not observe (see above). This leaves open the possibility that other factors may have stepped in to compensate for it.

# 5. Econometric analysis and discussion

## *5.1 Specification*

In what follows we run two probit regressions, where the dependent variables are, respectively, the probability to observe an academic patent, and the probability to observe university-ownership, conditional on the patent to be academic. We run the two regressions both separately and as related steps in a Heckman selection model. Accordingly, we will refer to them as STEP1 and STEP2, both when run independently and when run jointly. We also run alternative specifications of STEP2, in which the dependent variable is the probability to observe, respectively, an individual-owned and a company-owned patent, conditional on the patent to be academic. Our main exercises will make use of upper bound estimate data, with regressions on intermediate and lower bound estimate data used as robustness checks.

Observations in regression STEP1 are EPO patent applications signed by at least one Italian inventor, with priority dates 1996-2007 for a total of 51504 patents. The dependent variable is a dummy taking value 1 for academic patents (around 7% of observations), and 0 for non-academic ones. Regressors include:

- *Year dummies*: they are meant to capture any trend left after controlling for other determinants of academic patenting (in particular,,the introduction of the professor privilege, whose year of introduction, 2001, is our reference).
- *Technology dummies*: as several patents fall in more than one technological fields, we keep all dummies in the regression, with no reference case.
- *Other characteristics of patents*: the total number of inventors listed on the patent (N_INV), the share of backward citations to non-patent literature (SHARE_NPL), and the total number of backward citations (TOT_CIT). We expect a positive sign in all cases: other things being equal, the higher the number of inventors on a patent the higher the probability to observe an academic among the inventors (this is a pure statistical effect; see Lissoni et al., 2013); non-patent literature citations are a common indicator of science-intensiveness of a patent; and the total number of citations is an indicator of patent quality, which some literature suggest to be higher for academic patents, relative to non-academic ones.
- *Average financial conditions of universities*, in the inventor's region, as represented by FFO_RATIO_REGION and SCIENCE_RATIO_REGION. We test here the hypothesis that universities less dependent from block grants (low FFO_RATIO) contribute more to (local) academic patenting. The hypothesis sound reasonable to the extent that a low FFO_RATIO is due to a high share of revenues from collaboration with industry. However, we are cautious in that respect, in the light of the discussion conducted in section 3. As for SCIENCE_RATIO_REGION, we expect it to be a sign of high scientific standing, positively correlated to academic patenting.
- *IP and technology transfer policies of universities* in the inventor's region, as measured by the diffusion of IP statutes and TTOs (respectively, FIRST_STATUTE_REGION and TTO_REGION), both expected to affect positively the dependent variable. In order to control for the number of universities in the region, we consider the number of universities locally active in each year, as reported by the CNSVU (NR_UNIVERSITIES_REGION). Due to missing values for some peripheral regions in a few years, when considering these variables observations drop to 50875.
- *Regional R&D structure*, as measured by the Business R&D intensity of the local economy (BERD/GDP) and the regional innovation system's dependence on public R&D (RD_SHARE_PAUNI).

We expect RD_SHARE_PAUNI to be positively correlated to academic patenting, as it indicates how much the local inventive activity depends upon the academics' contributions. BERD/GDP is also expected to have a positive sign, to the extent that it signals the importance, in the local innovation system, of science-intensive industries, which typically interact in a sustained way with universities.

- *Regional dummies*: they control for heterogeneity across regions besides the R&D structure and the diffusion of IP statutes and TTOs. All variables *co*ncerning the average financial conditions of universities, the IP and technology transfer policies of universities, and regional R&D structures are inserted with 1-year lags, following classic findings on R&D-patent lag structure (Hall et al., 1986; Griliches , 1990). Regressions with no lags or 2-year lags produce very similar results (available on request). In case of multiple inventors from different regions for the same patent, we use the cross-regional average values for continuous variables and multiple dummies.

Observations in regression STEP2 are a subset of those in STEP1, namely academic patents (3443 observations). We never run STEP2 separately from STEP1, but always as part of a Heckman two-step regression; this leads to losing some observations, due to missing values either in the first or second step. We estimate the probability of an academic patent to be owned or co-owned by the inventor's university: the dependent variable takes value 1 if the patent assignee is a university or, in case of multiple assignees, if at least one of them is a university. We will refer to this regression as STEP2-university, to distinguish it from complementary regressions that estimate the probability, respectively, of individual and company ownership (STEP2-individual and STEP2-company). Notice that universities own 610 out of the 3443 academic patents considered in STEP2 regressions (that is 17.7%), 80 of which in co-ownership with either PROs or governmental agencies (13%), business companies (18.7%), foreign universities and public or not-for-profit institutions (5.5%) or individuals (1.5%). By no means then, we can consider the dependent variable in STEP2-university as indicating universities' exclusive control of the patents. For this reasons, we decided to opt for three different probit regressions (each with a different type of ownership as the dependent variable), instead of a multinomial logit, which would have been more suitable in case of mutually exclusive types of ownership.

The explanatory variables of STEP2 regressions include:

- Year dummies, technological dummies and other characteristics of the patent (as in STEP1).
- Characteristics of the R&D system on the university's region (as in STEP1). We expect to observe a positive sign of RD_SHARE_PAUNI in the STEP2-university regression.
- University-level variables, namely:
- FIRST_STATUTE and TTO as described in section 4; in case of inventors from different universities, we take the highest value). We expect the estimated coefficient for FIRST_STATUTE to take a positive value in STEP2-university regression and a negative one in STEP2-individual and STEP2-company. The same for TTO, although with some researvations, due to the quality of the data and the fact that the presence of a TTO may not be as indicative of the university having an explicit IP policy.
- FFO_RATIO and SCIENCE_RATIO. We expect the former to affect negatively (positively) the dependent variable in STEP2-university (STEP2-company) regression.. The opposite hold for the latter. None of them should affect the STEP2-individual regression.
- University dummies, but only for the universities with at least 50 patents (dummies for universities with fewer patents would have resulted in completely determined cases and blocked convergence of likelihood estimation)

As in STEP1, in case of multiple inventors from different universities for the same patent, we consider the cross-region averages, for all regions listed on the patent, and multiple dummies.

## 5.2 Results

Table 5 presents the results of regression STEP1 for three specifications, which include, respectively: only the year dummies (column 1); all variables, with the exception of FFO_RATIO_REGION and SCIENCE_RATIO_REGION (column 2); all variables, including FFO_RATIO_REGION and SCIENCE_RATIO_REGION, at the cost of eliminating observations for years 1996-1999, due to missing values, and several other observations, due to unreliability of financial data.

Results from column (1) can be directly compared to figure 5, as the sign of coefficients reflect differences between the share of academic patents in 2001 and in other years. Moving to column (2), we notice that the sign and significance of year dummies' coefficients change. In particular, coefficients for years before 2000 become all positive and (with one exception only) significant; while all other coefficients become negative, and significant in two cases. This suggests the existence of some sort of negative trend, which we interpret as follows: given the relationship between academic patenting and its determinants, changes in the latter should have led to an increase of the share of academic patents, which failed instead to materialize (we do not consider here 2007, whose negative sign and large absolute value are explained by right truncation).

Among the most significant determinants of the probability of a patent to be academic, with similar values of the coefficients in specifications (2) and (3) we have: the technology dummies (sign and magnitude of coefficients is in line with the descriptive analysis), the characteristics of the patent (in particular, the share of non-patent literature citations), and the structure of regional R&D (with both the business R&D intensity and the share of R&D performed by universities and public administrations having positive and significant coefficients).

On the contrary, none of the variables related to the universities' characteristics seem to matter: neither the regional diffusion rates of IP regulations and TTOs, nor the share of revenues due to block grants or public funds for research (FFO_RATIO_REGION and SCIENCE_RATIO_REGION).

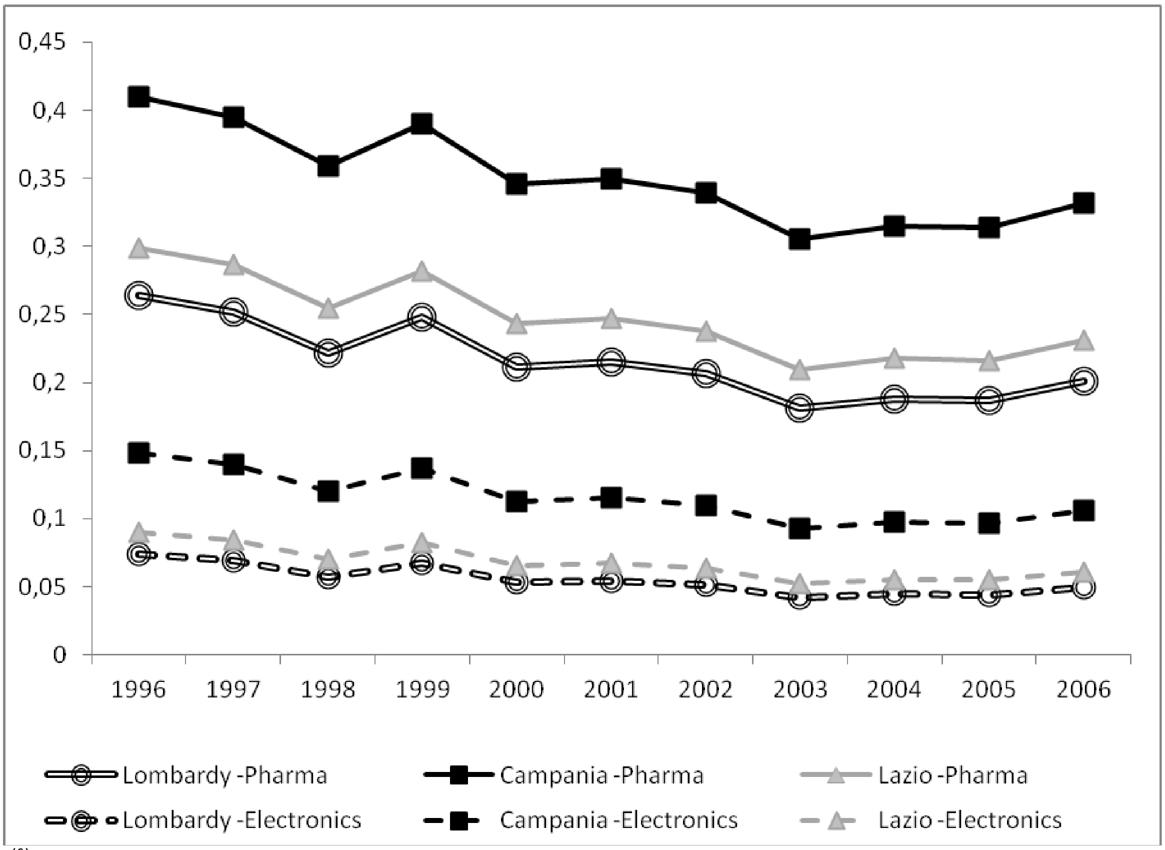
**Table 5 – STEP1 probit regression (dep. variable: probability of a patent to be academic; upper bound data)**

| | (1) | (2) | (3) |
|---|---|---|---|
| Year 1996 | 0.042 (0.045) | 0.16*** (0.056) | |
| Year 1997 | 0.025 (0.044) | 0.12** (0.054) | |
| Year 1998 | -0.028 (0.044) | 0.024 (0.052) | |
| Year 1999 | 0.036 (0.042) | 0.11** (0.050) | |
| Year 2000 | -0.020 (0.042) | -0.012 (0.049) | -0.067 (0.063) |
| Year 2002 | 0.016 (0.041) | -0.028 (0.050) | -0.053 (0.057) |
| Year 2003 | -0.048 (0.041) | -0.12** (0.053) | -0.13** (0.059) |
| Year 2004 | 0.015 (0.040) | -0.096* (0.055) | -0.10 (0.062) |
| Year 2005 | -0.009 (0.040) | -0.100 (0.065) | -0.10 (0.077) |
| Year 2006 | 0.027 (0.039) | -0.050 (0.073) | -0.03 (0.088) |
| Year 2007 | -0.088** (0.042) | -0.18** (0.080) | -0.15 (0.10) |
| Electrical Eng.; Electronics | | 0.046 (0.032) | -0.031 (0.042) |
| Scientific instruments; Measurement | | 0.31*** (0.028) | 0.32*** (0.036) |
| Chemicals; Materials | | 0.095*** (0.028) | 0.029 (0.036) |
| Pharmaceuticals; Biotechnology | | 0.57*** (0.031) | 0.58*** (0.039) |
| Industrial Processes | | -0.31*** (0.031) | -0.31*** (0.041) |
| Mechanical Eng.; Machines; Transport | | -0.40*** (0.036) | -0.46*** (0.047) |
| Consumer goods; Civil Eng. | | -0.45*** (0.043) | -0.64*** (0.063) |
| N_INV (nr of inventors) | | 0.15*** (0.0058) | 0.15*** (0.0072) |
| SHARE_NPL (non-patent literature) | | 0.41*** (0.026) | 0.49*** (0.032) |
| TOT_CIT (nr of citations) | | 0.009*** (0.001) | 0.012*** (0.0019) |
| TTO_REGION (regional diffusion TTOs) | | -0.001 (0.083) | 0.10 (0.10) |
| STATUTE_REGION (regional diffusion IP statutes) | | 0.10 (0.066) | -0.044 (0.086) |
| NR_UNIVERSITIES_REGION | | 0.016 (0.012) | 0.033** (0.016) |
| BERD/GDP (regional BERD/GDP) | | 0.41** (0.17) | 0.57** (0.23) |
| RD_SHARE_PAUNI (% of R&D by public admin. & univ., in region) | | 1.09*** (0.29) | 1.61*** (0.41) |
| FFO_RATIO_REGION (block grant as % of univ.'s revenues, regional avg) | | | 0.25 (0.21) |
| SCIENCE_RATIO_REGION (public research funds % of univ.'s revenues, regional avg) | | | 0.41 (0.42) |
| Constant | -1.49*** (0.030) | -3.27*** (0.24) | -3.82*** (0.34) |
| Regional dummies | N | Y | Y |
| Observations | 51,054 | 50,875 | 33,808 |
| Pseudo R2 | 0.00072 | 0.24 | 0.25 |

Standard errors in parentheses - *** p<0.01, ** p<0.05, * p<0.1

Figure 9 reports the predicted probability of a patent to be academic for the three largest Italian regions, respectively of the North, Centre and South of the country, in two of the most important fields of academic patenting (Electronics and Pharma-Biotech), based on estimates in column (2) of table 4. The decline of academic contribution to patenting is quite visible (trends are the same for all regions and technologies by construction, as we did not include interaction effects in the regression). The figure also suggests that regional differences are quite large (when compared to the size of the time trend), and inversely correlated to the industrial and R&D strength of the region. The probability of a patent to be academic is the highest in Campania, where the mean share of R&D by universities and PROs was 0,62 (vs. 0,68 in Lazio and 0,29 in Lombardy) and the mean BERD/GDP ratio was 0,41 (0,54 in Lazio and 0,81 in Lombardy). Notice that neither Lazio nor Lombardy have a significant regional dummy, while Campania has a significant and positive one (estimated coefficient =0,44). These data suggest that differences in predicted probability between Campania and Lazio, whose R&D structures are pretty similar, are entirely explained by the regional dummy for Campania, while the differences between Lazio and Lombardy depend on their R&D structure. Figure 9 then indicates that differences due to regional dummies may be larger than those due to the R&D structure of regions; and that the impact of RD_SHARE_PAUNI appears to be greater than that of BERD/GDP (Lazio's higher value for the former more than compensate its lower value for the latter).

**Figure 9 Academic patenting in selected regions and technologies: predicted probabilities, 1995-2006 (§)**




(§) Predicted probability in year t, for technology k and region z, estimated at the following values
continuous variables N_INV, SHARE_NPL, and TOT_CIT: mean values 1996-2007, for technology k
continuous variables: TTO_REGION, STATUTE_REGION, NR_UNIVERSITIES, BERD_GDP and RD_SHARE_PAUNI: mean values 1996-2007, for region z
dummy variables set at one for year t, technology k, and region z; zero otherwise

**Table 6 – Heckman probit regressions (STEP1, unreported; STEP2: prob. of an academic patent to be owned by university/individual/company) – upper bound estimate data**

| | University ownership | | Individual ownership | | Company ownership | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Year 1996 | -0.20 (0.17) | | -0.034 (0.18) | | -0.019 (0.14) | |
| Year 1997 | -0.48*** (0.18) | | -0.18 (0.17) | | 0.29** (0.13) | |
| Year 1998 | -0.41** (0.17) | | 0.034 (0.16) | | 0.23* (0.13) | |
| Year 1999 | -0.29** (0.15) | | -0.13 (0.16) | | 0.30** (0.12) | |
| Year 2000 | -0.011 (0.13) | -0.14 (0.16) | -0.14 (0.16) | -0.35 (0.23) | 0.28** (0.12) | 0.40** (0.16) |
| Year 2002 | 0.16 (0.13) | 0.16 (0.14) | 0.24 (0.15) | 0.20 (0.18) | 0.095 (0.12) | 0.014 (0.14) |
| Year 2003 | -0.048 (0.14) | 0.077 (0.16) | 0.21 (0.15) | 0.29 (0.20) | 0.063 (0.12) | -0.13 (0.15) |
| Year 2004 | 0.087 (0.13) | 0.20 (0.14) | -0.001 (0.16) | -0.098 (0.19) | 0.066 (0.12) | -0.11 (0.14) |
| Year 2005 | -0.047 (0.14) | 0.12 (0.15) | 0.047 (0.16) | 0.0038 (0.20) | 0.12 (0.12) | -0.063 (0.15) |
| Year 2006 | 0.28** (0.14) | 0.51*** (0.16) | -0.23 (0.18) | -0.16 (0.22) | 0.033 (0.12) | -0.25 (0.16) |
| Year 2007 | 0.36** (0.15) | 0.65*** (0.19) | -0.20 (0.19) | -0.084 (0.26) | 0.056 (0.13) | -0.39** (0.18) |
| Electrical Eng.; Electronics | -0.17* (0.093) | -0.14 (0.10) | -0.61*** (0.12) | -0.47*** (0.17) | 0.45*** (0.084) | 0.31*** (0.11) |
| Scientific instruments; Measurement | 0.29*** (0.078) | 0.47*** (0.084) | -0.074 (0.095) | -0.060 (0.14) | -0.17** (0.071) | -0.34*** (0.096) |
| Chemicals; Materials | -0.038 (0.072) | -0.0097 (0.083) | -0.43*** (0.090) | -0.32** (0.13) | 0.25*** (0.065) | 0.19** (0.087) |
| Pharmaceuticals; Biotechnology | 0.13 (0.094) | 0.42** (0.099) | -0.20* (0.11) | -0.15 (0.16) | -0.052 (0.088) | -0.24** (0.12) |
| Industrial Processes | 0.25** (0.099) | 0.23* (0.13) | 0.14 (0.12) | 0.13 (0.16) | -0.036 (0.092) | -0.18 (0.13) |
| Mechanical Eng.; Machines; Transport | -0.090 (0.14) | -0.19 (0.16) | 0.091 (0.15) | 0.0097 (0.23) | 0.24** (0.12) | 0.23 (0.17) |
| Consumer goods; Civil Eng. | -0.017 (0.17) | 0.069 (0.23) | 0.41*** (0.16) | 0.28 (0.29) | 0.018 (0.15) | -0.064 (0.23) |
| N_INV (nr of inventors) | 0.009 (0.018) | 0.06 (0.027) | -0.19*** (0.028) | -0.19*** (0.036) | 0.050** (0.023) | 0.073** (0.035) |
| SHARE_NPL non-patent literature) | 0.62*** (0.091) | 0.81*** (0.094) | 0.12 (0.11) | 0.097 (0.17) | -0.54*** (0.079) | -0.68*** (0.11) |
| TOT_CIT (nr of citations) | -0.001 (0.003) | 0.0044 (0.0042) | -0.0002 (0.004) | -0.0017 (0.0055) | 0.0003 (0.003) | 0.00090 (0.0045) |
| BERD/GDP (regional BERD/GDP) | -0.079 (0.26) | -0.26 (0.31) | -0.58* (0.30) | -0.48 (0.43) | 0.22 (0.23) | 0.098 (0.32) |
| RD_SHARE_PAUNI (% of R&D by public administration & universities, in region) | 0.42 (0.40) | 0.12 (0.49) | 0.023 (0.47) | 0.14 (0.66) | -0.98*** (0.35) | -0.99** (0.49) |
| FIRST_STATUTE (IP regulation in place) | 0.35*** (0.083) | 0.13 (0.1) | -0.058 (0.094) | -0.019 (0.13) | -0.22*** (0.072) | -0.18* (0.10) |
| TTO (TTO in place) | -0.087 (0.085) | -0.25** (0.1) | 0.032 (0.097) | 0.059 (0.13) | 0.008 (0.075) | 0.064 (0.10) |
| FFO_RATIO (block grant as % of revenues) | | 1.05 (1.24) | | -0.41 (1.57) | | 0.50 (1.19) |
| FFO_RATIO_sq | | -0.70 (1.23) | | 0.65 (1.55) | | -0.84 (1.17) |
| SCIENCE_RATIO (research as % revenues) | | 1.61 (1.48) | | 0.44 (1.70) | | -2.57* (1.32) |
| SCIENCE_RATIO _sq | | -5.54 (3.63) | | -0.73 (3.02) | | 4.94* (2.56) |
| Constant | -1.90*** (0.52) | -3.17*** (0.65) | 0.32 (0.68) | 0.13 (1.04) | 1.29** (0.51) | 1.93** (0.79) |
| University dummies [($)] | Y | Y | Y | Y | Y | Y |
| Heckman Rho | 0.066 (0.15) | 0.62** (0.29) | -0.32* (0.18) | -0.38 (0.26) | -0.17 (0.15) | -0.21 (0.23) |
| Observations (STEP1; STEP2) | 50793; 3356 [(#)] | 33620; 1894 | 50793; 3356 | 33620; 1894 | 50793; 3356 | 33620; 1894 |
| Pseudo R2 [(£)] | 0.14 | 0.10 | 0.13 | 0.12 | 0.093 | 0.089 |

Standard errors in parentheses - *** p<0.01, ** p<0.05, * p<0.1

[($)] only for universities with >50 patents (all other universities as reference case) ;[(£)] computed for STEP2 as stand-alone regression; [(#)]The nr. of observations is slightly less than that reported in section 5.1, because some of the regressors have missing values. In particular regional financial data for some regions for some years are missing.

Table 6 presents the results of STEP2 regressions The dependent variable is the probability, conditional on the patent to be academic, of either university ownership (columns 1 and 2), individual ownership (columns 3 and 4), or company ownership (columns 5 and 6). Odd columns refer to specifications for the complete period of observations (1996-2007), while even columns include variables on universities' financial conditions, at the cost of excluding years in which they are not available (1996-1999).

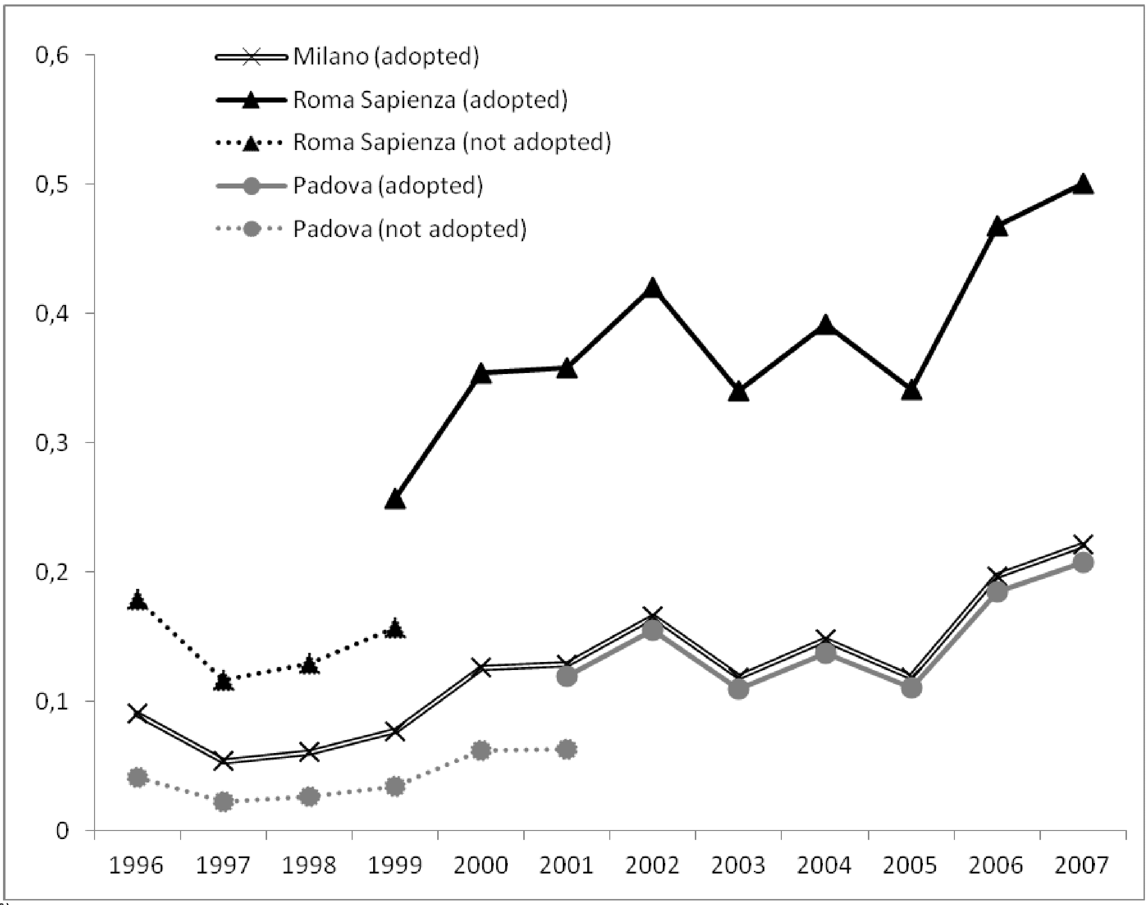
Year dummies in column (1) confirm the existence of some sort of positive trend in university ownership, with three significantly negative coefficients before 2001 and two positive and significant coefficients in the following period. However, several post-2001 coefficients are not significant and even take a negative sign. This suggests that our regressors may indeed explain away part of the trend.

Technology dummies confirm that university ownership tends to be quite high in Scientific Instruments. As for Pharma & Biotech we get similar, but weaker results, the coefficient being significant only in specification (2). Among the other characteristics of the patent, the share of citations to non-patent literature is the only one to exhibit a significant, and positive sign. This is intuitively explained as follows: a high share of non-patent literature citations indicates that the research underlying the patent is more of a fundamental type, possibly financed by the public purse rather than a company, and therefore more easily appropriable by the university. Finally, a positive determinant of university ownership is the adoption of an IP regulation, whose coefficient is positive and significant in specification (1), and maintains its sign in specification (2). Notice that, the university dummies we have inserted in the regression control for fixed effects), so that our result can be interpreted in a causal way, as indicative of a change in the university' strategic attitude towards patenting, made possible by the newly gained autonomy. As for the presence of TTOs, this looks irrelevant (column 1) or, worse, negatively correlated to university ownership (a result which we cannot entirely explain, but looks relatively weak; see column 2).

Neither the R&D structure of the university's region, nor the university's financial conditions seem to bear any effect on the probability of university ownership (quadratic effects for FFO_RATIO and SCIENCE_RATIO, were included after failing to observe any significant linear effect).

Figure 10 reports the predicted probabilities of university ownership for three universities in the top ten list of table 2, for Pharma-Biotech academic patents, over the period 1996-2007 (during which two universities adopted an IPR statute). The positive trend is quite visible and we notice that its overall magnitude is considerable: in the case of the university of Milan (which adopted its IPR statute before 1996), the probability of university ownership doubles in the period considered. Differences in the size of the trend across university are due to the in-built nonlinearity of the probit model we used (such that the impact of year dummies is the larger, the larger the probability), not to university-specific determinants (none of which is interacted with time). We can also appreciate the impact of the adoption of an IPR statute, which explains entirely the difference between the universities of Padova and Milan, and the increased difference, after 2000, between these universities and that of Rome "La Sapienza". Notice that neither the dummies for Milan and Padova are significant, while that for Rome "La Sapienza" is positive and significant.

**Figure 10 University-ownership of academic patents in Pharma-Biotech, before/after the adoption of an IPR statute: predicted probabilities for selected universities, 1995-2006 (§)**




(§) Predicted probability in year t, at university k, for the following values of regressors:
continuous variables N_INV, SHARE_NPL, and TOT_CIT: mean values 1996-2007, for Pharma-Biotech
continuous variables BERD_GDP and RD_SHARE_PAUNI: local mean values 1996-2007 (Milan: 0,78; 0,32 / Rome: 0,53; 0,62 / Padova: 0,46; 0,49)
dummy variables FIRST_STATUTE and TTO set at one for university k in the adoption year and the following; zero in the adoption year and previous
other dummy variables set at one for year t, Pharma-Biotech, and university k; zero otherwise

Moving to individual ownership (columns 3 and 4) we notice that no increase occurred after the introduction of the professor privilege (no year dummy is significant, although the coefficients for 2002 and 2003, right after the introduction of the privilege, are positive and the largest in absolute value, which may suggest some effect limited both in size and time). We also notice that individually-owned academic patents are more likely to be found not in science-based fields, but in Consumer Goods, which suggest they do not derive from any main line of academic research, but from extemporaneous inventive efforts.

Finally, we observe that estimates of the Heckman Rho are not significant in the university ownership and company ownership regressions, which suggest that no correlation exists between the probability of a patent to be academic, and to be owned either by university or company. On the contrary estimates of the Heckman Rho are negative and significant in the case of individual ownership, which suggests that individually-owned academic patents are different from the typical academic patent. We infer that they result from individual scientists' personal initiatives, quite detached from core research and collaboration projects with industry. As such, they are a residual category within academic patenting.

## 5.3 Robustness check

Table 7 replicates STEP1 regressions with values for the dependent variable coming respectively from lower bound and intermediate estimates of academic patenting. Results for patent characteristics (technology dummies, number of inventors, and citation-related variables) are the same as those obtained with upper bound data. The same applies to the sign of coefficients for BERD/GDP and RD_SHARE_PAUNI, although absolute values are smaller in the case of lower bound estimates (and significance for BERD/GDP is lost). Notice also that, having controlled for all these regressors, no trend is no more detectable.

Regressions based on lower bound estimates exhibit positive and significant signs for STATUTE_REGION (and negative, and in one case significant, for TTO_REGION). Also the coefficient for NR_UNIVERSITIES_REGION is positive and significant. The strength of results for STATUTE_REGION may derive from the bias of lower bound estimates, whose share of university-owned academic patents is artificially high. As we know (from previous sections) that such share grows when universities introduce IP regulations, we may conclude that the estimated coefficient for STATUTE_REGION in columns (1) and (2) is positively biased. The same applies to columns (3) and (4), as intermediate estimates correct only in part for errors in lower bound estimate data.

Tables 8 replicates the Heckman probit regressions, with university ownership of academic patents as the dependent variable. In this case, the results are almost identical to those obtained with upper bound estimate data.

**Table 7 – STEP1 probit regression (dep. variable: probability of a patent to be academic; lower bound and intermediate estimate data)**

| | Lower bound | | Intermediate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Year 1996 | 0.015 (0.063) | | 0.13** (0.058) | |
| Year 1997 | -0.025 (0.061) | | 0.11** (0.055) | |
| Year 1998 | -0.049 (0.058) | | 0.015 (0.054) | |
| Year 1999 | 0.011 (0.055) | | 0.12** (0.051) | |
| Year 2000 | -0.018 (0.053) | -0.049 (0.068) | 0.021 (0.050) | 0.0057 (0.065) |
| Year 2002 | -0.100* (0.055) | -0.18*** (0.063) | -0.079 (0.052) | -0.12** (0.060) |
| Year 2003 | -0.14** (0.058) | -0.20*** (0.065) | -0.14*** (0.055) | -0.16** (0.062) |
| Year 2004 | -0.080 (0.060) | -0.11* (0.067) | -0.093 (0.057) | -0.096 (0.065) |
| Year 2005 | -0.029 (0.072) | -0.085 (0.084) | -0.079 (0.068) | -0.081 (0.081) |
| Year 2006 | 0.11 (0.080) | 0.056 (0.094) | 0.019 (0.076) | 0.026 (0.091) |
| Year 2007 | -0.037 (0.088) | -0.087 (0.11) | -0.096 (0.083) | -0.094 (0.10) |
| Electrical Eng.; Electronics | 0.046 (0.036) | -0.0011 (0.045) | 0.054 (0.033) | -0.017 (0.043) |
| Scientific instruments; Measurement | 0.33*** (0.031) | 0.36*** (0.039) | 0.31*** (0.029) | 0.34*** (0.037) |
| Chemicals; Materials | 0.15*** (0.030) | 0.11*** (0.038) | 0.13*** (0.029) | 0.096*** (0.037) |
| Pharmaceuticals; Biotechnology | 0.60*** (0.033) | 0.61*** (0.041) | 0.57*** (0.031) | 0.58*** (0.040) |
| Industrial Processes | -0.26*** (0.034) | -0.22*** (0.043) | -0.24*** (0.032) | -0.22*** (0.041) |
| Mechanical Eng.; Machines; Transport | -0.41*** (0.041) | -0.40*** (0.052) | -0.34*** (0.037) | -0.35*** (0.048) |
| Consumer goods; Civil Eng. | -0.51*** (0.053) | -0.57*** (0.069) | -0.39*** (0.045) | -0.56*** (0.065) |
| N_INV | 0.16*** (0.0061) | 0.16*** (0.0075) | 0.15*** (0.0059) | 0.16*** (0.0074) |
| SHARE_NPL | 0.41*** (0.029) | 0.49*** (0.035) | 0.40*** (0.027) | 0.48*** (0.034) |
| TOT_CIT | 0.009*** (0.001) | 0.0095*** (0.0019) | 0.009*** (0.001) | 0.011*** (0.0019) |
| TTO_REGION | -0.23** (0.092) | -0.023 (0.11) | -0.12 (0.087) | 0.021 (0.11) |
| STATUTE_REGION | 0.17** (0.073) | 0.056 (0.094) | 0.11* (0.068) | 0.0060 (0.090) |
| NR_UNIVERSITIES_REGION | 0.038*** (0.013) | 0.041** (0.017) | 0.025** (0.012) | 0.031* (0.016) |
| BERD/GDP | 0.28 (0.18) | 0.52** (0.24) | 0.39** (0.17) | 0.59** (0.23) |
| RD_SHARE_PAUNI | 0.88*** (0.31) | 1.47*** (0.43) | 1.06*** (0.29) | 1.57*** (0.42) |
| FFO_RATIO_REGION | | 0.14 (0.23) | | 0.033 (0.22) |
| SCIENCE_RATIO_REGION | | 0.93** (0.45) | | 0.94** (0.43) |
| Constant | -3.33*** (0.26) | -3.93*** (0.36) | -3.35*** (0.25) | -3.87*** (0.35) |
| | | | | |
| Regional dummies | Y | Y | Y | Y |
| Observations | 50,875 | 33808 | 50,875 | 33808 |
| Pseudo R2 | 0.26 | 0.25 | 0.23 | 0.24 |

Standard errors in parentheses - *** p<0.01, ** p<0.05, * p<0.1

**Table 8 – Heckman probit regressions (STEP1, unreported; STEP2: probability of an academic patent to be owned by university) – lower bound and intermediate estimate data**

| | Lower bound | | Intermediate | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Year 1996 | -0.19 (0.19) | | -0.21 (0.18) | |
| Year 1997 | -0.47** (0.19) | | -0.49*** (0.18) | |
| Year 1998 | -0.41** (0.18) | | -0.41** (0.18) | |
| Year 1999 | -0.24 (0.16) | | -0.30** (0.15) | |
| Year 2000 | -0.001 (0.14) | -0.22 (0.17) | -0.044 (0.14) | -0.21 (0.17) |
| Year 2002 | 0.27* (0.14) | 0.21 (0.15) | 0.23* (0.13) | 0.20 (0.15) |
| Year 2003 | -0.001 (0.15) | 0.030 (0.17) | -0.001 (0.14) | 0.069 (0.17) |
| Year 2004 | 0.14 (0.14) | 0.22 (0.15) | 0.13 (0.14) | 0.21(0.15) |
| Year 2005 | -0.023 (0.15) | 0.13 (0.16) | -0.006 (0.15) | 0.12 (0.16) |
| Year 2006 | 0.29** (0.15) | 0.53*** (0.17) | 0.31** (0.14) | 0.52*** (0.17) |
| Year 2007 | 0.37** (0.16) | 0.67*** (0.20) | 0.35** (0.15) | 0.64*** (0.20) |
| Electrical Eng.; Electronics | -0.19* (0.10) | -0.021 (0.11) | -0.17* (0.097) | 0.015 (0.11) |
| Scientific instruments; Measurement | 0.28*** (0.084) | 0.47*** (0.090) | 0.29*** (0.082) | 0.47*** (0.090) |
| Chemicals; Materials | -0.098 (0.078) | -0.063 (0.092) | -0.080 (0.075) | -0.051 (0.091) |
| Pharmaceuticals; Biotechnology | 0.056 (0.10) | 0.36*** (0.11) | 0.094 (0.098) | 0.38*** (0.11) |
| Industrial Processes | 0.16 (0.10) | 0.20 (0.13) | 0.18* (0.099) | 0.22* (0.13) |
| Mechanical Eng.; Machines; Transport | -0.13 (0.15) | -0.22 (0.16) | -0.16 (0.14) | -0.22 (0.16) |
| Consumer goods; Civil Eng. | 0.056 (0.20) | 0.10 (0.24) | -0.054 (0.17) | 0.12 (0.24) |
| N_INV | -0.010 (0.021) | 0.041 (0.030) | -0.004 (0.020) | 0.043 (0.031) |
| SHARE_NPL | 0.67*** (0.098) | 0.84*** (0.10) | 0.62*** (0.096) | 0.80*** (0.10) |
| TOT_CIT | -0.001 (0.0037) | 0.0053 (0.0051) | -0.001 (0.0034) | 0.0030 (0.0044) |
| BERD/GDP | -0.17 (0.29) | -0.24 (0.33) | -0.11 (0.27) | -0.29 (0.33) |
| RD_SHARE_PAUNI | 0.26 (0.44) | 0.12 (0.52) | 0.29 (0.42) | -0.025 (0.53) |
| FIRST_STATUTE | 0.30*** (0.089) | 0.092 (0.11) | 0.35*** (0.086) | 0.12 (0.11) |
| TTO | -0.065 (0.091) | -0.28** (0.11) | -0.060 (0.088) | -0.27** (0.11) |
| FFO_RATIO | | 0.78 (1.32) | | 1.03 (1.34) |
| FFO_RATIO_sq | | -0.079 (1.29) | | -0.46 (1.31) |
| SCIENCE_RATIO | | 0.30 (1.60) | | 0.75 (1.57) |
| SCIENCE_RATIO _sq | | -3.71 (3.94) | | -4.70 (3.80) |
| Constant | -1.58*** (0.59) | -2.94*** (0.73) | -1.58*** (0.57) | -2.79*** (0.77) |
| University dummies [(§)] | Y | Y | Y | Y |
| Heckman Rho | 0.10 (0.16) | 0.62** (0.28) | 0.034 (0.15) | 0.52* (0.28) |
| Observations (STEP1; STEP2) | 50809 ; 2550 | 33647 ; 1505 | 50805 ; 2929 | 33639 ; 1640 |
| Pseudo R2 [(£)] | . | . | . | . |

Standard errors in parentheses - *** p<0.01, ** p<0.05, * p<0.1

[(§)] only for universities with >50 patents (all other universities as reference case)

[(£)] computed for STEP2 as stand-alone regression

# 6. Discussion and conclusions

This paper has proposed the very first longitudinal analysis of academic patenting in Italy (and possibly Europe). We found that, from 1996 to 2006, the share of academic patenting over total Italian patenting at the EPO has remained stable. Conditional on the typical characteristics of academic patents (all derived from close ties to science of the underlying research), on the regional distribution of R&D activities, and on the evolution over time of the Italian R&D system (in particular, the increasing share of R&D performed by universities), the trend appears to be negative. This suggests that, *ceteris paribus*, Italian universities have increasing difficulties to contribute to inventive activities, at least those subject to patenting.

As for the determinants of academic patenting, we find that its share over total patenting is the result of two contrasting forces: on one side, the R&D intensity of the local (regional) economy ; on the other, the local share of public R&D (by universities plus PROs), which is the highest in less advanced, non-R&D intensive regions. Both variables bear a positive and significant sign, which suggests that academic patents may be very heterogeneous: some may originate from academics' collaboration with industry, others from purely academic research, which in Southern Italian region is the main (or only) source of patents. This suggests a high heterogeneity in the quality and exploitation of these patents.

The most noticeable time trend we uncovered concerns the ownership distribution of academic patents, with universities reclaiming an ever-increasing share of academic patents, and the consequent decline of the share of academic patents held exclusively by business companies (the largest category of academic patent owners). University ownership is explained by the characteristics of the patents, the local share of public R&D, and the introduction, in most universities, of specific IP regulations. The latter was an institutional innovation made possible by the newly conquered autonomy, often adopted in the absence of clear ministerial directives, or even in contrast with them (especially with the introduction of the professor privilege). For universities with similar characteristics, the presence/absence of an IP statute may explain entirely the observed differences in the propensity to reclaim IP ownership. University-ownership is the highest in regions with low levels of business R&D (high shares of public R&D over total R&D), regardless the adoption of IP statutes. This suggests that university ownership depends first and foremost on the nature of research funds (public vs. private), with universities' strategies (as measured by the adoption of an IP statutes and a few, significant university dummies) coming second.

The introduction of dedicated Technology Transfer Offices (TTOs) seems not to have exerted any positive influence. However, our TTO data hide a great heterogeneity in terms of size, experience, and, possibly, IP strategies.

A strong policy conclusion concerns the introduction of the professor privilege, which has failed to increase academic patenting and has not even increased individual ownership. In the latter respect, it has been effectively neutralized by universities, through the introduction of IP statutes. Its irrelevance suggests that its abolition, as requested by most stakeholders, would certainly cause no harm; possibly, it would help simplifying universities' and companies' management of IP assets originating from academic inventions.

As for the observed tendency of universities to increase their patent portfolios, we are not yet in a position to evaluate its effects in terms of financial returns to the universities, and impact on innovation levels in Italy. For that, we need to collect more data, this time concerning the value of academic patents. Some existing evidence for the subperiod 1996-2001, however, suggest that, in the case of Italy, university-owned patents are less cited than company-owned academic patents and non-academic ones (Lissoni and Montobbio, 2013). This may imply that Italian universities, in the

1990s, were doing a bad job with picking up the right inventions, or with managing effectively the related patents. If this was still true, they should not be encouraged to expand their patent portfolios. The same research, however, provides opposite evidence for Dutch universities, whose history of autonomy and experience in handling IP is longer than that of their Italian counterparts. It is then possible that, nowadays, Italian universities have gained enough autonomy and experience for improving their selection and management skill concerning patentable inventions. Our main research objective for the immediate future consists in testing this hypothesis.

Finally, we found no evidence of a relationship between the overall phenomenon of academic patenting and the universities' decreasing reliance on block grants and public research funds. Our results are not very strong, due to the poor quality of the available data. This is the main limitation of our paper, due both to universities' lack of accuracy in compiling the information requested by CNSVU, and to the great heterogeneity of sources of revenues, different from block grants and public research funds, which no available statistics can capture. This will require collecting more data from individual universities, an effort that will force us possibly to concentrate on a few selected cases.

# Appendix

## A1. Upper bound and intermediate estimates of academic patenting

Observations in the two regressions refer to professor-patent pairs in which professors were, respectively, non-respondent and unreachable, but for whose patents information was available from previous research or manual checking (the professors were included in the survey due to other patents attributed to them, based on inventor-professor name matching, for which information was not available). Regressors were selected in a stepwise fashion. They include:

- the professor's age in the patent's priority year (age effect);
- the professor's year of birth (cohort effect); a dummy taking value 1 for non-perfect homonymy (the professor's and the inventor's names are not identical);
- a dummy with value 1 when the matched professor and inventor come from different regions (for the former, we consider the university's region; for the latter, his/her address as reported on the patent);
- the number of non-patent literature citations on the patent;
- two dummies taking value 1, respectively, if the patent is classified only in non-science based technology fields and if the patent is classified both in science based and in non-science based fields (patents classified only in science-based fields are the reference case);
- a dummy taking value 1 if the professor's discipline has ministerial code ICAR, which include both engineers and urbanists (the former being technologists, the latter mainly social scientists);
- a dummy taking value 1 if the professor did not result to be active in the patent's priority year.

Probit regressions were run, with clustered errors (on professors). Estimated coefficients were then applied to, respectively, all no-response and unreachable professor-patent pairs in order to predict their probability to be confirmed (academic patent). The probability threshold for confirmation was set respectively at 0.85 and 0.5, in order to maximise precision (minimise the % of false positives). This choice is explained by our wish not to inflate our estimates of the academic patenting phenomenon.

**Table A1. Regressions and results for no-respondent and unreachable professor-patent pair**

| | **No response** | **Unreachable** |
|---|---|---|
| **REGRESSION RESULTS** | | |
| Professor's age | -0.071** (0.029) | -0.13*** (0.038) |
| Professor's year of birth | -0.088*** (0.027) | -0.21*** (0.048) |
| Different name | -0.59* (0.34) | |
| Different region | -1.14*** (0.24) | -1.41*** (0.42) |
| NPL citations | 0.044* (0.024) | 0.21** (0.10) |
| No science-based technology | -0.99*** (0.25) | |
| Science & No science-based technology | -0.68*** (0.24) | |
| ICAR discipline | -1.72** (0.70) | -1.48* (0.77) |
| Not active professor | -1.48*** (0.27) | -1.70** (0.82) |
| Constant | 177*** (54.4) | 412*** (95.4) |
| *Observations (tot;academic=1)* | *850 ; 655* | *160 ; 121* |
| **ESTIMATES** | | |
| Predicted academic =1 | 738 | 115 |
| Predicted academic =0 | 112 | 34 |
| % correctly classified | 86,70% | 93,13% |
| % false positives | 2,29% | 4,96% |
| % false negatives | 50,26% | 12,82% |
| *Probability threshold set at:* | *0,85* | *0,5* |

Standard errors in parentheses - *** p<0.01, ** p<0.05, * p<0.1

## A2. Descriptive statistics for regressions STEP1 and STEP2

We report here the complete descriptive statistics for the STEP1 regression's dependent variable (with values for the dependent variables for both lower bound, intermediate, and upper bound estimates) and regressors. We also report the complete descriptive statistics for the STEP2 regression, but only for upper bound estimate data, for reasons of space (data for lower bound and intermediate are available on request). Notice that in the STEP1 regression, the number of observations is the same from whatever estimate we draw values for the dependent variable. On the contrary, in STEP2 the type of estimate affects the number of observations, as it changes the counting of academic patents.

**Table A2 - STEP1 regression: descriptive statistics**

| | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Dependent variable (Academic patent):** | | | | | |
| upper_bound | 51054 | 0,067 | 0,251 | 0 | 1 |
| intermediate | 51054 | 0,059 | 0,235 | 0 | 1 |
| lower_bound | 51054 | 0,051 | 0,221 | 0 | 1 |
| **Regressors:** | | | | | |
| Year 1996 | 51054 | 0,059 | 0,236 | 0 | 1 |
| Year 1997 | 51054 | 0,065 | 0,247 | 0 | 1 |
| Year 1998 | 51054 | 0,069 | 0,254 | 0 | 1 |
| Year 1999 | 51054 | 0,076 | 0,266 | 0 | 1 |
| Year 2000 | 51054 | 0,083 | 0,276 | 0 | 1 |
| Year 2002 | 51054 | 0,087 | 0,282 | 0 | 1 |
| Year 2003 | 51054 | 0,091 | 0,287 | 0 | 1 |
| Year 2004 | 51054 | 0,094 | 0,292 | 0 | 1 |
| Year 2005 | 51054 | 0,100 | 0,300 | 0 | 1 |
| Year 2006 | 51054 | 0,102 | 0,303 | 0 | 1 |
| Year 2007 | 51054 | 0,090 | 0,287 | 0 | 1 |
| 1.Electrical eng.; Electronics | 51054 | 0,172 | 0,378 | 0 | 1 |
| 2.Instruments | 51054 | 0,150 | 0,357 | 0 | 1 |
| 3.Chemicals; Materials | 51054 | 0,136 | 0,342 | 0 | 1 |
| 4.Pharmaceuticals; Biotech. | 51054 | 0,099 | 0,299 | 0 | 1 |
| 5.Industrial processes | 51054 | 0,253 | 0,435 | 0 | 1 |
| 6.Mechanical eng.; Machines; Transport | 51054 | 0,243 | 0,429 | 0 | 1 |
| 7.Consumer goods; Civil eng. | 51054 | 0,186 | 0,389 | 0 | 1 |
| N_INV | 51054 | 2,097 | 1,587 | 1 | 49 |
| SHARE_NPL | 51054 | 0,368 | 0,418 | 0 | 1 |
| TOT_CIT | 51054 | 4,010 | 6,859 | 0 | 217 |
| TTO_REGION | 50931 | 0,517 | 0,332 | 0 | 1 |
| STATUTE_REGION | 50875 | 0,395 | 0,323 | 0 | 1 |
| NR_UNIVERSITIES_REGION | 50931 | 7,077 | 4,024 | 1 | 12 |
| BERD/GDP | 50930 | 0,665 | 0,339 | 0 | 1,48 |
| RD_SHARE_PAUNI | 50927 | 0,424 | 0,181 | 0,033 | 1 |
| FFO_RATIO_REGION | 33809 | 0.504 | 0.115 | 0.294 | 0.840 |
| SCIENCE_RATIO_REGION | 33808 | 0.093 | 0.043 | 0.025 | 0.534 |

Regional dummies (obs=51054):

| | Mean | Std. Dev. | | Mean | Std. Dev. |
|---|---|---|---|---|---|
| Abruzzo | 0,019 | 0,137 | Piemonte | 0,140 | 0,347 |
| Basilicata | 0,003 | 0,054 | Puglia | 0,013 | 0,113 |
| Calabria | 0,004 | 0,062 | Sardegna | 0,005 | 0,068 |
| Campania | 0,020 | 0,141 | Sicily | 0,019 | 0,135 |
| Emilia-Romagna | 0,175 | 0,380 | Toscana | 0,065 | 0,246 |
| Friuli VG | 0,036 | 0,186 | Trentino AA | 0,015 | 0,123 |
| Lazio | 0,059 | 0,236 | Umbria | 0,011 | 0,105 |
| Liguria | 0,028 | 0,164 | Val d'Aosta | 0,002 | 0,042 |
| Lombardia | 0,354 | 0,478 | Veneto | 0,134 | 0,340 |
| Marche | 0,024 | 0,153 | Unknown region | 0,219 | 0,414 |
| Molise | 0,001 | 0,029 | | | |

## Table A3 - STEP2 regression: descriptive statistics (for upper bound estimate of academic patenting)

| | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Dependent variables (Patent ownership):** | | | | | |
| University | 3443 | 0,177 | 0,382 | 0 | 1 |
| Individual | 3443 | 0,087 | 0,282 | 0 | 1 |
| Company | 3443 | 0,731 | 0,443 | 0 | 1 |
| **Regressors:** | | | | | |
| Year 1996 | 3443 | 0,065 | 0,246 | 0 | 1 |
| Year 1997 | 3443 | 0,069 | 0,253 | 0 | 1 |
| Year 1998 | 3443 | 0,066 | 0,248 | 0 | 1 |
| Year 1999 | 3443 | 0,082 | 0,275 | 0 | 1 |
| Year 2000 | 3443 | 0,080 | 0,272 | 0 | 1 |
| Year 2002 | 3443 | 0,090 | 0,286 | 0 | 1 |
| Year 2003 | 3443 | 0,083 | 0,276 | 0 | 1 |
| Year 2004 | 3443 | 0,098 | 0,297 | 0 | 1 |
| Year 2005 | 3443 | 0,099 | 0,299 | 0 | 1 |
| Year 2006 | 3443 | 0,108 | 0,311 | 0 | 1 |
| Year 2007 | 3443 | 0,076 | 0,266 | 0 | 1 |
| 1.Electrical eng.; Electronics | 3443 | 0,207 | 0,405 | 0 | 1 |
| 2.Instruments | 3443 | 0,256 | 0,437 | 0 | 1 |
| 3.Chemicals; Materials | 3443 | 0,275 | 0,446 | 0 | 1 |
| 4.Pharmaceuticals; Biotech. | 3443 | 0,380 | 0,486 | 0 | 1 |
| 5.Industrial processes | 3443 | 0,110 | 0,313 | 0 | 1 |
| 6.Mechanical eng.; Machines; Transport | 3443 | 0,069 | 0,253 | 0 | 1 |
| 7.Consumer goods; Civil eng. | 3443 | 0,036 | 0,186 | 0 | 1 |
| N_INV | 3443 | 3,680 | 2,331 | 1 | 49 |
| SHARE_NPL | 3443 | 0,600 | 0,396 | 0 | 1 |
| TOT_CIT | 3443 | 7,255 | 10,570 | 0 | 200 |
| BERD/GDP | 3438 | 0,602 | 0,309 | 0 | 1,48 |
| RD_SHARE_PAUNI | 3438 | 0,484 | 0,203 | 0,145 | 1 |
| STATUTE | 3443 | 0,643 | 0,479 | 0 | 1 |
| TTO | 3361 | 0,476 | 0,499 | 0 | 1 |
| FFO_RATIO | 2007 | 0.578 | 0.136 | 0.028 | 1 |
| SCIENCE_RATIO | 1975 | 0.104 | 0.068 | 0.001 | 0.759 |

University dummies (obs=3343):

| | Mean | Std. Dev. | | Mean | Std. Dev. |
|---|---|---|---|---|---|
| Bari-Politecnico | 0,017 | 0,131 | Palermo | 0,025 | 0,155 |
| Bologna | 0,092 | 0,290 | Parma | 0,035 | 0,184 |
| Catania | 0,047 | 0,212 | Pavia | 0,048 | 0,214 |
| Ferrara | 0,040 | 0,195 | Perugia | 0,028 | 0,165 |
| Firenze | 0,056 | 0,230 | Pisa | 0,054 | 0,227 |
| Genova | 0,032 | 0,176 | Roma "La Sapienza" | 0,078 | 0,267 |
| Milano-Bicocca | 0,026 | 0,160 | Roma "Tor Vergata" | 0,037 | 0,189 |
| Milano | 0,105 | 0,307 | Siena | 0,029 | 0,169 |
| Milano-Politecnico | 0,085 | 0,279 | Torino | 0,048 | 0,213 |
| Modena | 0,039 | 0,193 | Torino-Poilitecnico | 0,034 | 0,181 |
| Napoli "Federico II" | 0,049 | 0,215 | Udine | 0,017 | 0,128 |
| Padova | 0,055 | 0,229 | | | |

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Avenue Léon Duguit
33608 PESSAC - FRANCE
Tel : +33 (0)5.56.84.25.75
Fax : +33 (0)5.56.84.86.47

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