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ACADEMIC PATENTING IN BELGIUM: METHODOLOGY AND EVIDENCE

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Academic Patenting in Belgium: Methodology and Evidence.

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Abstract

Universities are increasingly being called upon to contribute to economic development and competitiveness. This study aims to assess contribution of academic scientists working at universities located in the French-speaking Community of Belgium to patented technology. Matching names of academic scientists to inventors listed on patent applications filed at the EPO between 1994-2007, we find that 9-12% of academics working in science are inventors, among them 23% are woman. Academic scientists are listed as inventors on 6.5% of the EPO patent applications filed by residents of the French-speaking Community of Belgium. Universities are applicants on only 33.3% of patents invented by their scientists but this share has increased significantly in recent years. These results are then compared with similar trends in other European countries and in the United States.

Keywords: academic patenting, universities, Europe, matching
JEL Classification: I23, O34, O52

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1 Introduction

Universities are seen as crucial economic driver in developing and transferring knowledge to the commercial marketplace. This third role of universities has been underlined in the European (European Commission, 1995) and national science and technology policies (OECD, 1999). One way to assess the technological performance of universities is by looking at university patents. Patent is an intellectual property right relating to the invention in technological field (Dernis et al., 2001) and indicators based on patent statistics are widely used to assess inventive performance of countries, regions and firms.

Comparing simple patent counts across different legal and administrative environments is not a straightforward exercise and may result is a biased assessment (Dernis et al., 2001). In case of university patenting the potential bias hinges on its definition. Until recently the focus has been on *university-owned* patents, which classifies patents developed in academic environment as those where university is an applicant. This definition undermines the scope of technological performance of universities as patenting activity of academics goes beyond what is captured by *university-owned* patents. Inventions originating from academic research can be owned by parties other than universities: business sector, government agencies, public research institutions or scholars themselves. Classifying university patents by ownership does not take into account these contributions and thus create a downward bias on the scope of technology developed at higher education institutions (Azagra-Caro et al., 2003; Meyer, 2003; Saragossi and van Pottelsberghe, 2003).

In order to get more adequate picture of patenting at universities a broader definition of *university-invented* patents has been put forward. In contrast to *university-owned* definition, *university-invented* definition relates to patents invented by academics (i.e. patents which list at least one researcher employed by the university among inventors). The latter is insensitive to the variety of national policies towards ownership of academic inventions and to different institutional features of universities. It therefore allows counting more adequately the scope of (patentable) technologies originating from academic environment.

Applying the definition of *university-invented* patents, the aim of this article is to document patenting activities at universities belonging to the French Community of Belgium (*Communaute Francaise*) and located in the Walloon-Brussels region. Following Lissoni et al. (2006) academic inventors are identified by matching names of professors and researchers currently in service with the names of inventors listed on European Patent applications. The results of the matching – the list of academic inventors and their patents - are compared to trends in academic patenting observed in other European countries (Lissoni et al., 2008; Lissoni, 2012). Finally, differences are discussed following the determinants of patenting at universities: (i) scientific productivity and excellence; (ii) technological performance of the regions; (iii) national policies towards ownership of patents invented at universities and (iv) organization of technology transfer office.

This article is structured as follows. Section 2 briefly reviews the determinants of university patenting performance. Section 3 introduces Belgian context of the study and introduces universities and IP policies of French Community of Belgium. Section 4 presents data and matching techniques applied to identify academic inventors. Limitations to matching methodology are discussed accordingly. Section 5 comments matching results by comparing them with respective trends observed in other countries. Section 6 concludes.

2 Determinants of academic patenting

During the last decade, a rich branch of the literature has been developed exploring determinants of university patenting performance.[1] It considers wide range of factors - from regulatory developments at national level, institutional characteristics of universities to technological performance of regions– to explain the volume of patenting as well as its value as measured in terms of licensing and spin-off performance.

2.1 Scientific productivity and excellence

The ability of an academic scholar to patent is determined by her scientific excellence and technological opportunities of her field of investigation. There is strong evidence that academics are overrepresented among the most productive in science (Azoulay et al., 2007; Breschi et al., 2007; Stephan et al., 2007). Scientific productivity and excellence increases probability to file a patent application (e.g. Breschi et al., 2005; Azoulay et al., 2007). This positive link between publishing and patenting comes from the fact that both activities share the same objective to push knowledge frontier forward. This relationship holds when considering productivity of the laboratory (Carayol and Matt, 2004) or even university (Curi et al., 2012). The technological opportunities, however, differ between scientific fields. The presence of bio-medicine and engineering faculties contributes to higher levels of university patenting (van Looy et al., 2011; Curi et al., 2012) and licensing (Lach and Schankerman, 2008).

While scientific productivity increases the propensity to patent, the industry proximity in research drives patent ownership. For the sample of Italian 592 academic inventors and their non-patenting peers, Breschi et al. (2005) have shown that scientific collaboration with a patenting company increases the probability of industry ownership. Higher shares of industry funding also increases the likelihood of the patent to be owned by the industry as found in Meissner (2011) for the sample of 479 tenured academic (patenting and non-patenting) from 10 universities in the United Kingdom.

2.2 Technological performance

The technological performance of the region, i.e. the level of research and development spending, is another factor studies in literature on the determinants

[1] C.f. Siegel et al. (2007) and Geuna and Muscio (2009) for review.

of academic patenting and licensing. For the sample of 105 entrepreneurial universities in Europe, van Looy et al. (2011) do not find R&D to be a significant factor explaining differences in propensity to patent between universities. There is, however, some evidence that the composition of R&D rather than its absolute value matters for patenting. In their assessment of technology transfer at French universities Curi et al. (2012) find a positive relationship between private R&D and the number of patent filings. Still, universities located in regions with higher levels of R&D expenditures are found to be more efficient in technology transfer as they generate higher number of licensing agreements (Friedman and Silberman, 2003; Chapple et al., 2005).

Higher levels of business R&D spending indicate the presence of high-tech industries, which are also science-inventive.[2] These industries rely on advancements in scientific knowledge in their product development and collaboration with universities improves their market performance. Thus positive relationship between regional R&D and patenting/licensing might be due to the spill-over effects from private R&D through collaboration and partnerships with universities.

2.3 IP legislative framework

The differences across countries in the number of university patent filings can be explain by different legislative frameworks for regulating the IPR ownership of publicly funded research. For the sample of 109 patenting universities in six European countries van Looy (2009) shows that countries with adopted institutional ownership (i.e. where the universities have the right to the invention from publicly funded research) have a significantly higher number of patent filings by the universities than countries with a professor privilege regime (i.e. where the assignment of the patent is to faculty member and not universities). Similar conclusion but with respect to share of university-owned patents in university-invented patent portfolio has been drawn in Lissoni (2012).

2.4 Technology transfer office

The role of Technology Transfer Offices (TTOs) is to assist its researchers in disseminating research results to commercial sector. One of the TTO activities, in this respect, is the management of intellectual property resulting from the scientific inquiry of its researchers. The performance of TTO in generating patents and licenses is determined by its structure, organization and regulation of patenting activity (Siegel et al., 2007; Geuna and Muscio, 2009). Older

[2]Two definitions of Definition of "science-intensive technologies": (1) technologies developed at universities (Veugelers et al., 2012) university ownership for patents applied at the EPO: (a) share of university patents in a given technology field or relative weight of university patenting – defined as share of university patenting in given technology than share of university patents in all patent applications. (2) Science intensity in patents measured as number of non-patent citations in patent applications (e.g. van Looy et al., 2003). According the both definitions "science intensive technologies" are: pharmaceuticals; measurement and control; basic chemicals and medical equipment.

and larger TTOs are found to generate higher number of patents and licensing agreements (e.g. Thursby et al., 2001; Thursby and Kemp, 2002; Curi et al., 2012). The presence of qualified employees with business skills and academic background further improves TTO efficiency (Siegel et al., 2003; Chapple et al., 2005). So do transparent rules on innovation disclosures and conflicts of interests (Caldera and Debande, 2010) as well as conditions of royalty sharing agreements (Siegel et al., 2003).

More generally, the organization and performance of TTOs depend on the institutional autonomy of universities. Private schools are more flexible in setting organizational structures, enjoy freedom over financing and staffing and have a legitimacy needed to implement and execute performance schemes. When comparing with public, private universities file more patent applications and generate more licensing agreements (Thursby and Kemp, 2002; Caldera and Debande, 2010). Incentive effects embedded in royalty shares are stronger in private than in public universities. For the latter higher levels of R&D contracts and the size of the faculty seems to drive licensing performance (Lach and Schankerman, 2008). Still, there is a lot of heterogeneity across countries in the scope of autonomy they give to the public universities (Estermann et al., 2011).

3 The Belgian case

Before discussing methodological aspect of identifying academic inventors. This section provides a background of technological and scientific performance of Belgium with the special focus on the Brussels-Walloon region. Rules guiding the management of intellectual property rights are discussed accordingly.

3.1 Technological and scientific performance

Belgium is a small, open economy. In terms of R&D intensity, measured as R&D expenditures as percentage of GDP or per capital, it is considered as high technology country classified above EU27 average (see Table 1). It belongs to the group of European countries (along with UK and Nordic Countries) where innovation/R&D system is dominated by the business enterprise sector both in terms of R&D performance and financing (the share of the business sector of total R&D is above the EU27 average). High level of business enterprise intramural R&D expenditure in Belgium figure is dominated by few large companies and multinationals.

Table 2 shows technological specialization of Belgium across industries along two dimensions: the distribution of business R&D and revealed technological advantage. The latter is measured as a share of EPO patent applications in a given technological field in the total country EPO patent applications relative to the share of EPO patent applications in given technology in the total number of EPO patent application.

Table 1: R&D financing and performance in Belgium (1994-2007)

	GERD per capita		GERD as % GDP		%GERD financ. by ind.		%GERD perform. by b.s.	
	1994-2000	2001-2007	1994-2000	2001-2007	1994-2000	2001-2007	1994-2000	2001-2007
SE	820	1212	3.44	3.69	66.87	65.77	74.6	74.24
DK	494	820	1.96	2.5	52.01	60.47	61.8	68.54
FR	486	626	2.22	2.15	51.04	52.05	62.12	62.9
BE	437	603	1.81	1.9	66.19	60.76	71.35	69.85
NL	477	652	1.96	1.89	47.07	47.57	53.69	53.19
UK	408	554	1.84	1.75	48.64	44.07	65.27	63.17
IT	232	318	1.01	1.11	42.82	40.7	51.05	49.06
EU-27	328	461	1.68	1.75	53.66	54.11	62.61	62.88

Note: Countries are ordered according to decreasing value of R&D spending as percentage of GDP in years 2001-2007. Source: OECD Statistic Database.

R&D activity in high-tech industries is concentrated in two sectors Radio, TV and communications equipment and Pharmaceuticals. For medium high-tech, the majority of R&D in this category (60%) is performed by Chemical industry. R&D expenditures in medium low-tech group are equally distributed across industries belonging to this group. Finally, for low-tech industry R&D activity is concentrated in Food, beverages and Textiles industries. Two last columns in Table 2 show the normalized index of revealed technological advantage – relative technological specialization - which points specialization in Chemicals and Pharmaceuticals. Along with chemicals and pharmaceuticals, van Beuzekom and Arundel (2009) reports technological specialization of Belgium in the field of biotechnology. Share of biotechnology R&D out of total business sector R&D is 13.1% which make it second after Ireland (21.7%).[3] Revealed technological specialization of Belgium in biotechnology (as measured with PCT applications) is one of the highest in Europe and is rank just behind Denmark.

Universities in Belgium have long research traditions dating the nineteenth century. The average number of scientific publications per 10,000 inhabitants in Belgium is 13.0, which is well above EU27 average (7.4), the USA (9.9) or Japan (6.1). According to Third European Report on S&T Indicators (European Commission, 2003) the relative science specialization of Belgium lies in life sciences (biological sciences, pharmacology, basic life sciences, biomedical science, and clinical research) as well as in instruments & instrumentation.[4] The

[3]The world average is 6.14%.

[4]Specialization or relative activity is measured as relative shares of country publication output within a given field in the European total (i.e. only European publications are considered). In addition to life sciences and instruments, Belgium specializes in mathematics.

Table 2: Business intramural R&D and relative technological advantage in Belgian industries

		%BERD		RTA	
ISIC rev. 3		1994-2000	2001-2007	1994-2000	2001-2007
	High-tech	34.73%	40.69%		
35	Aerospace	1.56%	1.99%	-0.25	-0.19
30	Office, accounting and computing machinery	0.23%	0.45%	-0.25	-0.25
32	Radio, TV and communications equipment	15.27%	12.26%	-0.26	-0.11
33	Precision and optical instruments	1.79%	2.41%	-0.14	-0.14
2423	Pharmaceuticals	15.89%	23.59%	0.06	0.03
	Medium high-tech	26.88%	20.02%		
24	Chemicals excl. pharmaceuticals	19.16%	12.29%	0.37	0.38
29	Non-electrical machines	1.76%	2.20%	-0.03	-0.02
31	Electrical machinery and apparatus	3.15%	3.03%	-0.21	-0.35
34	Motor vehicles, trailers and semi-trailers	2.81%	2.51%	-0.26	-0.25
	Medium low-tech	9.50%	7.62%		
23	Refineries	2.02%	0.92%	0.13	-0.06
25	Rubber and plastic products	2.26%	2.59%	0.19	0.23
26	Other non-metallic mineral products	1.87%	1.29%	0.2	0.36
27	Iron and steel and non-ferrous metals	2.32%	1.87%	0.14	0.15
28	Metal products	1.03%	0.96%	-0.14	-0.01
	Low-tech	4.55%	4.59%		
15	Food, beverages	2.59%	2.75%	0.28	0.37
16	Tabaco products	0.03%	0.09%	n.a.	-0.97
17	Textiles	1.24%	1.07%	0.33	0.03
18	Wearing apparel	0.15%	0.12%	-0.46	-0.89
19	Leather articles	0.08%	0.09%	-0.83	-0.75
20	Wood & wood products	0.09%	0.13%	-0.06	0.04
21	Paper	0.31%	0.26%	0.37	0.27
36	Manufacturing, n.e.c.; Recycling	0.05%	0.07%	-0.03	0.03

Note: Own calculations based on OECD data for BERD. Revealed technological advantage is calculated as share of EPO patent applications in a given technological field (Schmoch, 2008) out of the total country EPO patent applications relative to the share of all EPO patent applications in given technology out of the total number of all EPO patent application. RTA is then normalized with values larger than zero indicating relative specialization.

impact scores are particularly high in health (clinical medicine) and agriculture (see Table 5.3 in Tijssen et al. (2010)).

Universities are important partners for local industry. According to the Second European Community Innovation Survey, universities are second most important type of collaborators for Belgian companies (after the firms within the group) which attract higher number of joint research projects with universities (53%) when comparing to EU average (38%). Furthermore, they more frequently use information from universities in their innovative efforts when comparing to EU average (Cincera and Capron, 2003).

3.2 The French Community

Since the state reform of 1993 Belgium is a federal State with highly autonomous regions - Brussels-Capital, Walloon and Flanders - and Communities – the French Community, the Flemish Community and the German-speaking Community. There is no single Belgian research and innovation system as communities and regions are responsible for scientific research with the federal authority being responsible for a limited number of scientific policy fields.

With respect to technological performance, Walloon has the highest R&D intensity (2.1% in 2007), followed by Flanders (1.99%) and Brussels-Capital (1.38%). Still, only one third of business R&D is performed in the Walloon-Brussels region (36% in 1994-2007). While, Flanders appears to specialize more in the manufacture of instruments, Walloon-Brussels are mainly concerned with the chemical and pharmaceutical industries (Capron and Cincera, 1999).

There are six French speaking universities located in Walloon-Brussels-Capital regions. These are: Université catholique de Louvain (UCL), the Facultés Universitaires Notre-Dame de la Paix in Namur (FUNDP); Université libre de Bruxelles (ULB); Université de Mons (UMONS) and Université de Liège (ULG) with Gembloux Agro-Bio Tech campus (Faculté Universitaire des Sciences Agronomiques de Gembloux)[5] and Facultés universitaires Saint-Louis in Brussels (FUSL) which is the pole of humanities in Brussels. In what follows we will only focus on the five universities for which key figures are summarized in Table 3.

Three - UCL, ULB and ULG - jointly with three Flemish universities - University Gent, KULeuven and Vrije Universiteit Brussel - account for 80% of students in Belgium. They are also the largest in terms of academic personnel and research output. All universities have scientific and engineering departments and with the exception of FUNDP also medical schools and university hospitals.[6]

Looking at Top 10 most important and actively publishing research institutions in Belgium (European Commission, 2003), ULB and UCL appear as the ones with the most output in clinical research (more than 25% of total university output); ULG has the highest impact in chemistry while ULB receives the

[5]Since 2009 Gembloux Agro-Bio Tech became an integral part of the University of Liege.

[6]University hospital Clinique Saint-Luc of UCL (established in 1976); Institut Jules Bordet (1939) and Hôpital Erasme (1968) of ULB; Centre Hospitalier Universitaire de Liège (1985) and CHU Ambroise Pare of UMONS (1990).

Table 3: Universities in French Community: Key figures (2002)

	UCL	ULB	ULG	FUNDP	UMONS
Establishment year	1834	1834	1817	1831	1837
Medical school	1	1	1	0	1
# Academic staff (Total)	1,500	1,970	2,100	218	160
# Students	19,499	18,153	13,378	4,205	2,192
Scientific prod. (1991-2001)	9,149	9,472	10,674	2,011	1,619
Technology Transfer					
First univ.-owned EPO filing	1983	1988	1981	1997	1998
TTO Established	1983	1991	1997	1999	1997

Source: SCOPUS Database for the number of publications and Statistics of Le Conseil des Recteurs de la Communauté française de Belgique for the numer of students.

highest number of citations in the field of physics & astronomy.

In 1998 French Community (Flanders on year earlier) put forward a decree which gave public research organizations (i.e. universities and the National found for Scientific Research (FNRS)) right to file patents over research founded by the Region and to commercially exploit them. In this way Belgium moved from the system with no regulation to the system with the institutional IP ownership. Furthermore, the decree has backed up financial support for the staffing and cost of patent filings. Sharing of profits in Walloon has been left to the internal regulations of universities. Universities have adopted "three-thirds" rule (or MIT rule) which allocate equal shares of the profits to the institution, the laboratory and the researchers involved (Martial and Morant, 2012).

The adoption of the decrate by French Community of Belgium[7] was followed by the agreement between the universities and FNRS who gave universities, where an FNRS researcher works, the ownership of any scientific results and the right to exploit them according to the university internal rules. Finally, it entitled FNRS to share any profits that arise from successful commercialization (Martial and Morant, 2012). In this respect French Community of Belgium IP regime differs from the French one which gave both universities and national research centers (CNRS) the right to manage IP. The latter may handicaps valorisation efforts since a single invention need to be managed by several institutions.

Table 3 shows two focal dates in patenting: the year of first university patent application and the year of TTO establishment. ULB and UCL have been active in technology transfer before the official decorate giving universities the right to manage IPR was put forward. UCL has been supporting technology transfer since 1983 and ULB since 1991. Interestingly ULG was active in patenting long before establishing a TTO. As of 2002 services of all TTO were beyond

[7]Program-decree 17/12/1997 (B.S. 27/01/1998 p. 1940).

the management of intellectual property rights and also include legal support to contract research; administrative, financial and support for contract research (with the exception of ULG) and support for spin-off creation (van Looy et al., 2011).

Given these characteristics one may expect the high involvment of academics, working in the Walloon-Brussels region, in technology transfer by means of patents. On one hand, the technological specialization of the region in chemistry, pharmaceutical and biotechnology as well as close university-industry relationship my lead to the number of university-invented but business owned patents. On the other, scientific specialization of universities in life sciences, early establishment of technology transfer offices and adoption of the institutional IPR regime by local government may contribute to higher number of patent filings by universities.

4 In search for academic inventors

Identification of *academic invented patents* is a challenging task. It requires to identify or search for scholar's names among inventors listed on patent applications. This challenge has been addressed in Lissoni et al. (2006) for patents invented by Italian, French and Swedish professors, Iversen et al. (2007) for academics patenting in Norway, Raffo and Lhuillery (2009) for Swiss professors working at Ecole Polytechnique Fédérale de Lausanne (EPFL), along with Czarnitzki et al. (2009) and Schomoch and Schulze (2010) for German scholars. All these methodological efforts has been recently put jointly in the context of Academic Patenting in Europe which aims at measuring the extent of patenting by academics in Europe.[8]

Three different ways for identification and search can be found in this literature. In order to identify academic inventors working at universities in Italy, France and Sweden Lissoni et al. (2006) use as a reference the external list of full time professors which is then matched to the inventor names on the EPO patent application. Czarnitzki et al. (2009) do not use any external list of names but simply define academic inventors as those with the person title Prof./Dr. listed on the patent application. Schomoch and Schulze (2010) present another approach. They first search within the SCOPUS database for authors with affiliation at universities in Germany and then, similar to Lissoni et al. (2006), match names of these authors to inventor names as listed on patent application. Our approach follows that of Lissoni et al. (2006).

4.1 Sources of data

The starting point for the identification of academic inventors was to assemble a list of professors working at five Universities belonging to French Community of Belgium: UCL, ULB, ULG, MONS and FUNDP. Administrator at this universities were approached with the request to provide information about academic

[8] C.f. http://www.esf-ape-inv.eu/.

and scientific personnel that they currently employ. In addition to the list of names, the request asked for the academic and scientific rank, gender, current residence address, birthday, as well as faculty, department and lab assignment. Only ULB and ULG provided complete data. MONS, UCL and FUNDP refused to share any information due to confidentiality reasons. For them, the list of names of academic and scientific personnel together with their affiliation and rank has been collected from their official Internet websites.[9] Then, scientific disciplines were assigned based on current faculty assignment. The final list of professors (PROFLIST) contains 2,363 professors and researchers. Table 4 summarizes the content of this database.

Table 4: Content of the Belgian PROFLIST database

	UCL	ULB	ULG	MONS	FUNDP
# of obs.	853	641	571	187	112
Name and Surname	YES	YES	YES	YES	YES
Gender	YES	YES	YES	YES	YES
Address	NO	YES	YES	NO	NO
Birthday	NO	YES	YES	NO	NO
ACA / SCI Grade	YES	YES	YES	YES	YES
KEINS Discipline	YES	YES	YES	YES	YES

Information on patent applications has been collected from the EP-INV database, developed and managed at KITES, that contains all application filed at the European Patent Office since 1978 reclassified by the name of the applicant and the inventor name. From EP-INV a list of 36,000 patents for which at least one of the inventors is a Belgian resident (EP-INV-BE) has been recovered.

4.2 Matching and filtering

Identification of potential academic inventors was carried in two steps. First, names and addresses in both PROFLIST and EP-IN-BE databases have been standardized. Uncommon characters have been modified and unnecessary punctuation deleted.[10] Then surname and first name appearing in the PROFLIST have been matched to those in EP-INV-BE allowing for one spelling mistake (Levenshtein edit distance).[11] Similar matching techniques have been adopted in Lissoni et al. (2006), Raffo and Lhuillery (2009) and in Tang and Walsh

[9]See www.uclouvain.be/6197.html for the personnel directory at UCL and www.fundp.ac.be/universite/personnes for the information concerning personnel employed at FUNDP. UMH personnel directory does not include the information on academic rank that I recover further from the university official website http://portail.umons.ac.be/EN/Pages/default.aspx.

[10]SAS codes developed by Ernest Miguelez are used in phrasing step.

[11]Matching a filtering is done using SAS software.

(2010). These simple scholar-inventor name matches need to be further validated in order to remove ambiguities and homonyms.

Filtering stage attempts to identify and retain *true* academic-inventor matches in APE-BE. Filtering method takes into account similarity scores obtained using Lissoni et al. (2006) methodology. Setting up similarity threshold equal to 20, in order to minimize error type 2, we are left with a list with 381 Belgian professors names matched to 872 inventors in EP-INV.[12] In order to verify the matches information on *inpadoc* patent families and addresses is used. Inpadoc patent family, is defined as a group of patent documents having exactly the same priority number or combination of priorities. I assume that two inventors with the same name and surname listed on patents belonging to the same *inpadoc* family are the same persons and therefore they are given the same inventor id. Then, information on inventor's correspondence address given in the patent application is matched to scholar's residence address as provided by the university.

Matching residence address with correspondence address given in the patent application tends to underestimate the number of correct matches. The precision rate can be high, as persons with the same name and address are the same person, but the recall rate may be low, as patent application lists either inventor's residence or business (university) address. Furthermore, as we go further in the past, considering only current residence address may limit the number of retained matches, due to geographical mobility of people.

To address these problems, the filtering method is developed which not only uses external source of residence addresses but also explores content of APE-BE database. First, external information on residence address is used and matched to correspondence address provided in a patent application. Is the address be the same in the matched pairs, this pair is said to be *true*. I assume further that a person that appears on a patent applied by public research institution located in Belgium or its spin-off company and a person with the same name in the PROFLIST are the same person. Information on their correspondence addresses given in the patent applications is then stored and used to validate the remaining matches.

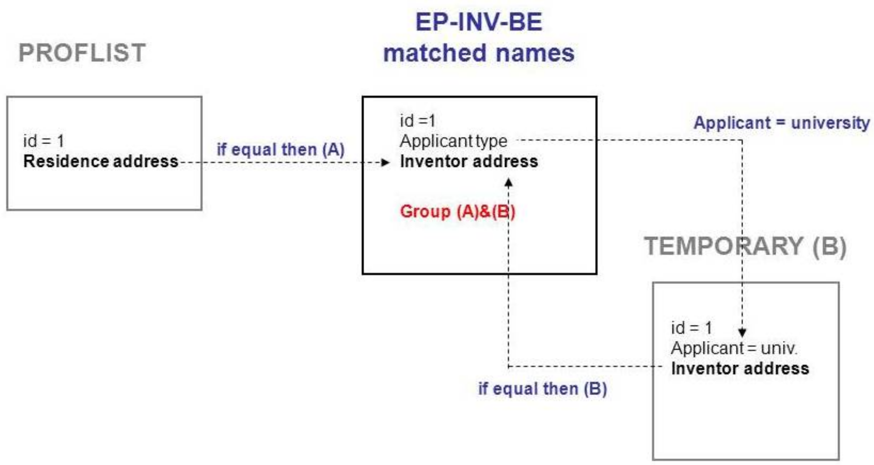
In practice, the filtering algorithm assigns matched inventor-scholar pairs of names to four groups:

Group A: Personal address from PROFLIST exactly matches the address of inventor from EP-INV-BE with exactly the same name;

Group B: Inventor address on the patent in EP-INV-BE applied by public

[12]For each two inventors with exactly the same name (18,244 matches within EP-INV), we calculated the similarity threshold based on the biographical information and technological content of the patent. The score ranges from -10 to 350 and its distribution is highly skewed with median = 10, mode value 0 and mean = 15.96. Verifying 2% of the matches we decided to set a similarity threshold equal to 20 in order to minimize error type 2 (false positive matches). For the construction of the weights assign to different patent attributes cf. Lissoni et al. (2006) Table 1 p.6. We found 381 scholar-inventors matches are listed on 1313 patents filled at the European Patent Office (1136 patent families)

Figure 1: Group assignment used in filtering step



research institution based in Belgium matches the address of inventor in EP-INV-BE with the same name;

Group C: Inventor address on the patent in EP-INV-BE applied by Belgian university spin-off matches the address of inventor in EP-INV-BE with the same name;

Group D: The correspondence address of matched inventor is a university campus address;

Matches that are assigned to one of the four groups are considered *valid (true)* and *are being retained*. Figure 1 illustrates an example of group assignment.

This filtering method is close to the one developed in Schomoch and Schulze (2010) who construct their algorithm based on geographical distance between the university where the researcher is affiliated (currently working) and inventor address in the patent application. However, their method may result in higher recall but lower precision rates when comparing to the presented algorithm.

Table 5 provides statistics on group assignment for three selected universities: ULB, ULG and UCL. For ULB 26.1% of retained matches are assign to group C, while 9.4% are assign to both B and C. For ULB and ULG information on residence address is available that allows assessing the importance of this information in the filtering process. Statistics show that 50% of the matches are retained based on the assignment to group A only that is considering only the information on residence address. However, the great majority of matched pairs assigned to A (approx. 90%) would have been captured anyway by being assigned to other groups. In other words, 10% of validated matches would have been excluded if information on residence address has not been provided. This

Table 5: Percent of retained matches by group assignment

ULB				
	A	B	C	D
A	9.5%			
B	24.4%	26.1%		
C	19.9%	9.4%	7.1%	
D		1.1%	0.4%	2.1%
Total	53.8%	36.6%	7.5%	2.1%

ULG				
	A	B	C	D
A	12.4%			
B	43.1%	34.7%		
C	2.2%	2.2%	1.8%	
D		3.3%		0.4%
Total	57.7%	40.2%	1.8%	0.4%

UCL				
	A	B	C	D
A				
B		51.1%		
C		2.9%	0.4%	
D		16.5%		29.1%
Total		70.5%	0.4%	29.1%

Notes: Own calculations.

finding implies that for the remaining three universities, for which no information on residence address is available, the share of patents owned either by private companies of foreign public research institutions can be underestimated.

For UCL no information on private address is available. 70% of the retained matches belong to group B (61% in case of ULB and 83.3% for ULG). In the remaining 30% the address of inventor correspond to the address of de Duve Institute. De Duve Institute is a multidisciplinary biomedical research institute at UCL, which hosts several laboratories of the faculty of medicine and the Brussels branch of the Ludwig Institute for Cancer Research.

The final check of the matched pairs have been done manually, controlling for the compatibility between scientific discipline of the scholar and patent's IPC classes.[13] Out of 381 professors filtering algorithm retained 294 academic inventors who contributed to the development of 526 patent families.

4.3 Limitations

The identification method which relies on an external list has two main drawbacks.

First, the timing of professor list, the point in time to which it refers, is crucial. How far backwards in in time, from that year, one considers patent applications will have an impact on the number of academic inventors. On one hand, as the distribution of patents across scholars is skewed and there are only few serial inventors, going backwards will increase the number of academic inventors. For example, in this sample among of 2,364 academics we identified

[13]Lissoni et al. (2006) applies discipline filter based on incompatible disciplines.

294 academic inventors listed on patents applied during 1978-2007. This number goes down to 206 if we consider more recent 2001-2007 applications. On the other hand, going backward in time one misses those academics that were inventors but are no longer university employers as in meantime they moved to industry, other academic institution or retired. There are therefore, more inventors identified for recent years (206 for applications filed in 2001-2007) than for earlier periods (134 for 1994-2000).

Second, the number of identified inventors will depend on the propensity to patent at the patent office which applications are considered. Due to high cost of patenting at the EPO university may file priority at national patent office or at the USPTO. Such national patent application may be abandon before its second filing at the EPO. Thus, the higher propensity to file at the EPO, the more academic inventors may be identified.[14]

With these limitations in mind, the next section will discuss results referring to the sample of academic inventors identified on EPO patent applications filed in years 1994-2007 with the split into two periods 1994-2000 and 2001-2007.

5 Results

272 academics and researchers in service at universities in French Community of Belgium are listed as inventors on 567 patent applications (460 patent families) filed at the European Patent Office during 1994-2007. This amounts to 6.5% of the EPO patent applications filed by the residents of Walloon-Brussels regions in the same period.[15] Table 6 provides comparable statistics for four other European countries and the United States.

Belgium along with Sweden and United States are the countries with the highest share of university-invented patents. They are followed by France, the Netherlands and Italy. This pattern reflects (regional) differences in supply and demand structures for high-tech innovations. Similar to Belgium Sweden has a relative specialization in life sciences with particular strength in pharmacology and clinical medicine. The Netherlands exhibits more diverse specialization profile but lacks relative strengths in the life sciences (European Commission, 2003). On the demand size, in contrast to the Netherlands Belgium and Sweden are countries with the R&D system clearly dominated by the business sector (as illustrated in Table 1). France and Italy are large and diverse economies, specialized in variety of scientific fields but with some preference for physics. Still, France has higher levels of R&D spending and particular that of business R&D when comparing to Italy which could explain higher contribution of

[14]For some country differences in propensity to patent at the EPO see Table 5.15 in the Appendix 5A.

[15]As reference we use estimates of EPO applications by inventor(s)'s country(ies) of residence at the regional level (TL3) provided by OECD Statistic Database. These estimates are fractional counts based on priority filings. We thus compare the fraction of EPO filings by Walloon and Brussels residence for years 1994-2007 (6873.8847) with the fractional count of the Belgian residents on academic invented patents (550.7444). The share for years 1994-2007 is 6.5%; for 1994-2000 equals 6.74%; and for 2001-2007 equals 6.26%.

Table 6: Share of university-invented and university-owned patents in total country EPO applications

	BE-FC*	SE	US	FR*	NL	IT
UNIV-INV	6.50%	6.20%	6.00%	5.13% (3.45%)	4.30%	4.00%
UNIV-OWNED	3.10%	0.30%	4.00%	0.30%	1.00%	0.40%

Note: Own estimates for French Community of Belgium. Fig. 3 in Lissoni (2012) for other countries - EPO application in years 1994-2002. There are two shares of academic patenting provided for France. The number refers to patent applications file by both university and CNRS researcher, the number in brackets considers only contribution of the former.

university-invented patents in France.

Interestingly to note, the relevance of Belgian, Swedish and French academic invented patents in total of country residence is very close to that of the United States. As pointed in Lissoni (2012), this trend stands in contrast with the criticism that the relative contribution of European universities to patenting is much lower than that in the United States. The criticism is based on the number of university-owned patents which share in all patent applications is indeed much lower in Europe that in the United States (second line in Table 4). In Belgium it amounts to 3% of patents filed by the residence and below 1% in other European countries while it is 4% in the United States.

Table 7: Ownership of academic patents (1994-2002)

	BE-FC	NL	UK	DK	IT	FR	SE	US
Universities	33.2	26.4	21.5	11.2	10.5	10.2	4.9	68.7
Companies	42.2	60.5	67.1	66.5	72	61.4	81.1	24.2
Individual	2.5	1.9	5.4	19.7	8.9	3.6	13.5	5.3
Gov&PRO(*)	22.1	11.2	6.1	2.6	8.6	24.8	0.5	1.7

Note: (*) Gov&PRO stands for patents owned either by governments or public research organizations. Shares for are calculated based on the fractional count. Data source for other countries Fig. 2 in Lissoni (2012).

5.1 Patent ownership

Table 7 provides further insights into the ownership structure of *university-invented* patents in Europe and in the United States. As discussed in Section 2, two phenomena seems to drive differences in university-ownership across countries: (i) rules guiding intellectual property ownership and (ii) the performance of the TTO. As TTO organizational models are very diverse (Schoen et al., 2011), we take more general approach here and discuss the country differences in the degree of autonomy given to universities.

Table 8: Autonomy scores

	NL	UK	DK	IT	FR	SE
Organizational	med-high	high	high	med-low	med-low	med-low
Financial	med-high	high	med-high	med-high	med-low	med-low
Staffing	med-high	high	high	med-low	med-low	high
Academic	med-low	high	med-low	med-low	low	med-high

Note: The autonomy scorecard project monitors legislative framework in which universities operate. High = universities has a lot of freedom to decide; low = universities lack freedom in this area. Source: EUA, 2011.

United States has been the pioneering country to officially give right to universities to file and manage patents over the publicly funded research (Bayh-Dole Act of 1980) thus its high share of university owned patents (68.7%). In Europe, the rules guiding ownership of intellectual property over publically funded research are diverse, although there is some convergence happening. While France and United Kingdom introduced institutional (i.e. university ownership) in 1980s, the Netherlands and Belgium did it only in 1990s (Geuna and Rossi, 2011). In Nordic countries and Germany traditionally it was the professor who was the primary owner of the invention (i.e. "professor privilege"). While such as system still remains in Sweden, Denmark moved to institutional ownership in 2000. These regulatory differences partly explain why there is relatively high university ownership in Belgium, the Netherlands and UK and rather low university ownership along with relatively high individual-ownership in Denmark and Sweden.

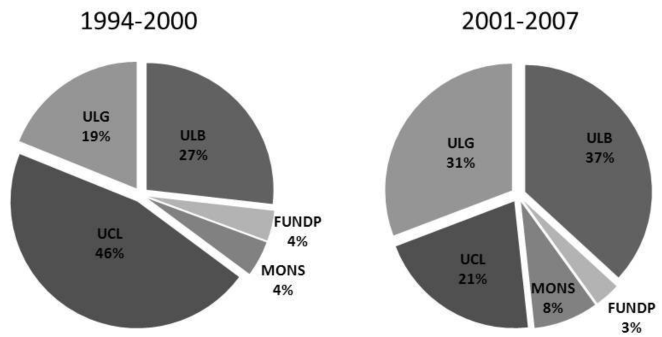
Lower rates in university-owned patents in Italy and France, despite the early adoption of the institutional patent ownership in these countries, could be explained by the low levels of autonomy at their higher education institutions - see Table 8 for the scores. According to recent University Autonomy Report of 2011 (Estermann et al., 2011) French universities score medium low in all dimensions of university autonomy: organizational, financial, staffing and academic. Italian universities are in a similar position to the French ones but they enjoy more financial autonomy.[16] Earlier EUA report (Estermann and Nokkala, 2009) has shown that universities in French Community of Belgium have more organizational and financial autonomy than those in Italy and France.

Finally in two countries - France and Belgium - more than 20% of university-

[16] The ranking of organizational, financial, staffing and financial autonomy has been developed for 26 European countries but not for Belgium (Estermann et al., 2011). The autonomy of universities is Belgium is however presented in earlier report of EUA (Estermann and Nokkala, 2009) with made the distinction between French and Flemish communities.

invented patents are owned either by government or public research organization. In France, intellectual property rights coming from public research can be owned and managed either by universities or public research organizations (such as CNRS). The relationship between universities and PRO is however close as researchers and academics work together in joint labs and double affiliations are frequent. Such an institutional framework results in the high share (24.8%) of academic-invented patents is owned by public research organization. This is not the case in French Community of Belgium where patents filed over research conducted by FNRS researchers are managed by the university. 22.1% of PRO ownership is anecdotal evidence and will be discussed later.

Figure 2: Distribution of academic invented patents



Note: Own calculations, fractional count based on inventor affiliation.

Figure 2 shows the distribution of academic invented patents for years 1994-2000 and 2001-2007. 90% of university-invented patents have been developed by academics working at three largest universities – UCL, ULB and ULG. In the first period UCL academics were the most active in generating inventions, followed by ULB (27%) and ULG (19%). In the second period, the relative shares of three biggest universities has equalized. The implementation of institutional IP ownership adopted by French Community in 1997 contributed also to the change in the ownership structure of academic invented patents. In the period before 2001 only about 26% of university-invented patents were owned by universities, this share nearly doubled in subsequent period and it seems to converge to that in the United States.

There are differences across universities in patent ownership structure (see Table 9). First, high (51%) PRO ownership of patents invented at UCL can be explained by research collaboration in the field of cancer immunology between two UCL research laboratories - de Duve Institute and the Brussels Branch of the Ludwig Institute for Cancer Research.[17] Patents coming from this research

[17]Founded in 1971 LICR is a global non-profit organization committed to improving the understanding and control of cancer though integrated laboratory and clinical discovery. It is concentrated at ten research locations: two each in Australia, Sweden and the USA; and one

Table 9: Ownership of academic patents at universities in Belgium

	UCL	ULB	ULG	FUNDP	MONS	Total*
			1994-2000			
University	27%	15%	34%	23%	32%	26%
Industry	20%	73%	52%	63%	63%	42%
Individual	2%	4%	8%	0%	0%	4%
PRO	51%	8%	7%	13%	5%	28%
			2001-2007			
University	57%	48%	61%	73%	42%	54%
Industry	29%	46%	36%	27%	43%	38%
Individual	0%	1%	0%	0%	0%	0%
PRO	14%	6%	3%	0%	15%	8%

Note: Shares are calculated based on fractional count. Academic invented at university X are defined as patent with at least one academic inventor with affiliation of that university. PRO refers to public research organization in Belgium or abroad.

collaboration were filed by New York Branch of Ludwig Institute for Cancer Research. Second, at ULB the shares of university-owned patents are below average which is surprising given that ULB has a TTO in place since 1992. Further analysis of the ownership structure however shows that more than 20% of LB-invented patents are owned by ULB spin-offs (20% in 1994-2000 and 27% in 2001-2007). In a similar vein, in the second period 30% of MONS-invented patents were owned by spin-off.[18] This pattern reflects strong links between spin-offs and scientific communities of ULB and MONS.

5.2 Academic inventors

Among 2,364 academic and research staff working at French universities in Walloon-Brussels region 272 are listed as inventors on at least one patent application at the EPO during 1994-2007. In other worlds 12% of current academic and research staff were at least once involved the development of patented technology. This share is however biased, as discussed earlier in this acticle, and depends on how far one goes backwards in time when identifying academic inventors. Considering only period 1994-2000 we find a share of 6% while looking at period 2001-2007 this share is 9% (see last two lines in Table 10).

Even if considering only most recent years 2001-2007 the share of academic inventors in all academics in service in French Community of Belgium is above that in other European countries: 4.42% for academics working in Italy, 6.04% in

each in Belgium, Brazil, Switzerland and the UK. The LICR engages leading scientists and clinicians in an integrated laboratory and clinical research effort to understand and confront the global challenge of cancer.

[18]For remaining universities share of spin-off owned patents were not more than 5%.

France, 4.86% in Sweden.[19] Still, it is relative close to 7.2% found in Denmark. Both, Belgium and Denmark, are small economies, specialized in biotechnology industry (van Beuzekom and Arundel, 2009) and with the share of business enterprise in intramural R&D expenditure above EU average. Their scientific specialization lies in life-sciences which characterized by the high share of academic inventors (Azoulay et al., 2009).[20] Notable, both countries have above average impact score in health and agriculture (Tijssen et al., 2010).

Table 10: Distribution of academic inventors across scientific disciplines

	# Prof	# Inv	Share
	(1)	(2)	(2)/(1)
Chemical sciences	194	50	26%
Biological sciences	348	62	18%
Engineering	407	48	12%
Medical sciences	835	89	11%
Agricultural and veterinary sciences	136	12	9%
Physical sciences	126	5	4%
Math and information science	202	4	2%
Earth sciences	116	2	2%
Total (1994-2007)	2,364	272	12%
Sub-total (1994-2000)	2,364	134	6%
Sub-total (2001-2007)	2,364	206	9%

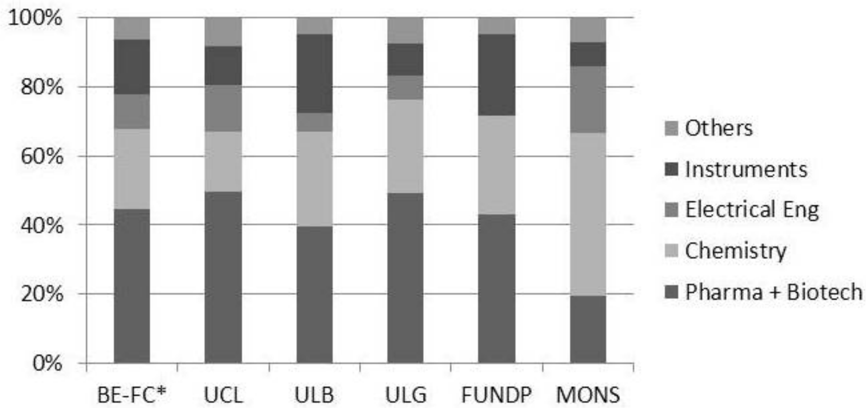
The scientific profile of academic inventors is reflected in the technological profile of their inventions as shown in Figure 3; 45% of patents have been filed in the field of pharmaceuticals and biotechnology and 23% in chemistry. Once more this profile resembles that of Denmark (c.f. Fig. 1 in Lissoni (2012)) where more than 50% of academic invented patents are filed in the field of pharmaceuticals and biotechnology but also that of France which has high share of chemistry patents (25.3%) in its academic patent portfolio. The technological profile across universities in Belgium is similar with the exception of Mons University where chemistry patents dominate. This pattern reflects Mons specialization new materials.

Finally, the available data allow us to explore gender differences in academic patenting. Among 2,364 academics 546 are females (23%). 9% of females and 12% of males are academic inventors. Table 11 shows propensity to patent across gender. Females have lower propensity to patent (file 2.23 patent application

[19]The shares include the number of unchecked professors. For methodological details see Lissoni et al. (2006).

[20]For the sample of 3,862 PhD graduates in the field of life sciences, defined as biotechnology related fields, and employed at universities in the United States Azoulay et al. (2009) found 473 academic inventors (12.2%) who file at least one patent application at USPTO between 1976-2004.

Figure 3: Distribution of academic patents across technological fields



on average) than men (3.26) and there are much less serial inventors among females as only 24% of women, when compared to 35% of men, filed more than two patent applications. The share of female inventors in female academics is high when compared to 5.65% found in Ding et al. (2006) for the sample of academics working in the field of life sciences at universities in the United States. On the contrary the share of male inventors is very close to 13% found in the same study. Ding et al. (2006) also points that males are more prone to file multiple patent applications when compared to woman.

Table 11: Propensity to patent across gender

	# Inv	Mean # patents	% Inv with < 3 patents	Max # patents
		1994-2007		
Male	222	3.26	0.65	33
Female	50	2.26	0.76	9
		2001-2007		
Male	170	2.44	0.73	19
Female	36	1.76	0.86	9

The share of patents with at least one female academic inventor is 18%. This finding is in stark contrast with Naldi et al. (2004) who find that females contributed to 5.6% of EPO patent applications filed in 1998.[21] There are, however, large differences across industries and countries. Females contribute

[21] Naldi et al. (2004) identify females by the first name. Contribution is defined as fractional count.

most in pharmaceuticals (16.1%) and chemicals (11.7%). Their shares in these two disciplines are found lowest in Germany (10.2% in pharmaceuticals and 7.5% in chemicals) and Great Britain (15.2% and 11.5%, respectively) and highest in Spain (27.4% and 21.5%, respectively). Given this evidence and pharmaceutical-chemical specialization of patenting among Belgian academic inventors, the high contribution of woman is no longer surprising.

6 Conclusions

The aim of this article was to document inventive performance at the French speaking universities located in the Walloon-Brussels region in Belgium. To adequately measure the extent of university inventions the definition of university-invented patents has beed adapted. Academic inventors are identified among the inventors listed on European Patent Office applications using matching and filtering methods.

Filtering method applied here is based on both external information on residence addresses of inventors and correspondence addresses on the patents applied by public institutions where the scholars are currently employed. This allows assessing the importance of private address information in the validation stage. The results show that 10% of validated matches would have been excluded if information on residence address was not provided and information on addresses as provided in university owned patents was used.

The outcome of the matching and filtering is 272 academic inventors, among 2,364 academics and FNRS researchers, who are listed as inventors on the EPO patent applications filed in the period 1994-2007. The main trends in this data can be summarized as follows:

- Academics and FNRS researchers are listed on 6.5% of the EPO patent applications filed by the residents of the Walloon-Brussels region. This share is comparable to the rates found in France, Sweden and in the United States and is higher then that found in Italy and in the Netherlands (Lissoni et al., 2012).

- Universities own 33.3% of university-invented patents. This rate is among the highest in Europe - among the countries for which similar statistics are available - since only the Netherlands and United Kingdom have university ownership higher than 20%. Notwithstanding methodological limitations, between periods 1994-2000 and 2001-2007 the share university owned patents has increased from 26% to 54%.

- 9-12% of academics and FNRS researchers working in science filed at least one patent application. Among them 23% are women. Great majority of academic inventors (78%) conduct research in life sciences and chemistry and so their patents fall into pharmaceutical, chemistry and biotechnology industries.

Relatively high performance in terms of the number of university-invented patents and high share of inventors among academics can be attributed to the relative specialization of universities in biomedical research, on one hand, and to regional business R&D specialization and relative technological advantage in chemicals, pharmaceuticals and biotech sectors on the other. At the same time, scientific specialization of universities in life sciences, early establishment of technology transfer offices and adoption of the institutional IPR regime by local government contributed to higher number of patent filings by universities.

Filing a patent application, however, does not tell us much about its value for commercial application. Academic inventions tend to be far from market place and it takes time to commercialize them. As the value distribution of the patents is skewed (Sapsalis et al., 2006) it remains important to investigate the actual commercial potential of patents invented by universities in the French-speaking Community of Belgium.

The possible extension of this study would be to empirically test the importance of national regulatory environment (i.e. IPR regimes and scope of autonomy at universities) relative to regional factors and university characteristics in determining the volume and value of academic patenting. It will help to identified inefficiency channels and existing opportunities for academic patenting. I believe that such a study would facilitate on-going debate on the ability of European universities to turn science into business.

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