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Development of Academic Patenting in European Regions – A Large Scale Analysis

Miroslav Špurek[1] ✉ — Štefan Rehák[1]

[1]Department of Public Administration and Regional Development, Faculty of National Economy, University of Economics in Bratislava, Bratislava, Slovakia

✉ *miroslav.spurek@euba.sk*

Abstract

In this article, we analyze academic patenting on an unprecedented scale - for 29 European countries. The comprehensive identification phase captures both groups of academic patents, in and outside of the ownership of universities. With stronger patent rights of universities, the share of university-owned patents is increasing faster. Nevertheless, even today, universities own only one third of their patents while the other two thirds remain in the property of individuals and companies. Universities have recently accounted for 13% of regional patent production and compared to firms their contribution to region's innovation performance remains small. The share of academic patents is higher in Eastern Europe and in regions where innovative companies are lacking, in capital regions, and in regions with a strong tradition in academic patenting. The contribution of universities to the innovation performance of the most innovative regions is relatively small, although there are large differences, and the size of the contribution can vary significantly for similar levels of patent intensity. Given the effects of university research, it has been known since the 1990s that increasing university spending on research is driving innovation on the part of companies and within the region. However, such an effect is limited to high quality research and is most effective in terms of regional policy in poor regions where innovative companies are lacking. In this paper, instead of research expenditure, university patents filed with the EPO represent university research, as other patents are assumed to be a product of companies. We have found that the latter can be predicted by the volume of academic patents.

Highlights for public administration, management and planning:

- The average share of academic patents in European regions increased from 4% in 1976-1985 to 13% in 2006-2015.
- The analysis confirms that two-thirds of academic patents in Europe are not owned by universities, but by private firms, institutes, or individuals.
- By 1995, universities owned less than 11% of academic patents. In the following years and up to 2015, universities own 33% of academic patents.
- The most innovative regions have a smaller share of academic patents.

Keywords

Academic patenting,
Universities,
Innovation,
Europe

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1 Introduction

1.1 The effects of academic research

The mere presence of the university does not guarantee a significant contribution to the performance of the innovation system. The contribution depends on the quality of research and the intensity of interaction between the universities and the other actors of the innovation system (Fritsch & Slavtchev 2007). Compared to private research and development (R&D) sector, the contribution of universities is relatively small. This is also because university research is different in nature from that carried out by firms. Since the private R&D is directed towards the commercial ends, it is easier to transform its outputs into marketable products or production technologies (Fritsch & Slavtchev 2007).

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The inventions that result from university research are rather generic in nature and often require further and costly development in order to be useful on the market. However, some university inventions can be used on the market with little or no further development (Colyvas et al. 2002). Nevertheless, it is university research that causes industry R&D and not vice versa (Jaffe 1989). The increasing research expenditures of universities had a positive and significant effect on the number of corporate patents within the state, and the region (Jaffe 1989; Acs et al. 1992; Anselin et al. 1997).

In addition, scientific publications of universities located outside of the regional innovation system had a relatively weak impact on its performance (Autant-Bernard 2001 in Fritsch and Slavtchev 2007) and most companies that introduced university-based innovations in Germany were not further than 100 km from the university knowledge source (Beise & Stahl 1999 in Fritsch and Slavtchev 2007).

The effect of universities on the innovation performance of firms is therefore geographically bounded. While size of the university and its age didn't have a significant impact on the innovation performance of regions in Germany (Fritsch & Slavtchev 2007), the expansion of the university system increased the innovation activity of local industry, especially in poorer regions of Italy (Cowan & Zinovyeva 2013). The effect was mainly due to the high-quality scientific research that new schools brought to the regions. The authors suggest that universities can substitute firms to fill the gaps in missing R&D infrastructure, especially in the initial period when the region is weakly equipped with innovation assets. Assuming that all the other assets are present, universities may push region onto a higher innovation path.

1.2 Patents and the academic patenting

It is often said that patents represent an invention rather than an innovation. The main argument is that a patent application does not necessarily lead to successful innovation and that inventors can limit their patent applications to only a subset of the discoveries. However, patents have their advantages: they consist of detailed information describing the invention and the inventor, are publicly available in a readable form, and it is reasonable to expect the patented invention will be introduced on the market. When corporate patents were replaced by more comprehensive data from innovation survey (Acs et al. 1992), the effect of academic research was even greater. Thus, patents may underestimate the effects of academic research, but remain a credible representation of innovation. The growing activity of universities in the field of patenting has allowed us to use patents as a proxy for academic research. It is widely believed that the emergence of new technologies where the distinction between basic and applied science is unclear, such as biotechnology or computer science, and the adoption of new policies have provided universities with greater incentives to commercialize their technologies (Pottelsberghe 2007). While some researchers claim that the new policies changed the ownership structure of academic patents rather than encouraged universities to seek legal protection of their inventions (Mowery & Ziedonis 2002), it was not until 2000 that policies on the European continent began to move closer to stronger patent rights for universities, perhaps except for Sweden, where universities still rarely file patent applications on their behalf (Martinez & Sterzi 2021).

Several surveys (Crespi et al. 2010; Lissoni et al. 2008) state that in large European countries, around two-thirds of patents resulting from university research are not owned by universities. However, surveys are difficult to use on a large scale - not only do they rely on country-specific data, which are often limited by time slots, but the work required to validate university inventors would also grow to a terrible extent. Dornbusch et al. (2013) proposes a comprehensive methodology for the identification of academic patents on a large scale, which is based on the idea of matching the author names from scientific publications with the inventor names from patent fillings. The basic premise is that the paper relevant to the invention was published after the filing of the patent application. A similar approach was introduced by Maraut and Martinez (2014) to find academic patents in Spain, confirming that two thirds of academic patents are owned by companies. Inspired by the latter papers, methodology below describes the identification of academic patents, yet it is applied on a much larger scale to 29 European countries.

2 Methods

The number of patent applications filed with the European Patent Office (EPO) is taken from the OECD REGPAT database. It is the inventor's address that is used to determine the origin of the patent. For a patent application to be classified as academic, it must meet one of two criteria: either it is owned or co-owned by the university, or one

of its inventors is most likely affiliated to the university. Thus, academic patents consist of two groups: (1) university-owned and (2) university-invented applications. Patents owned by the university are easy to find because the name of the university is mentioned in the application. In the case of patents invented by a university, there must be a high degree of similarity between the inventor of the patent and the university-affiliated author of the scientific article. Patents that are owned and invented by the university are designated exclusively as university-owned patents. Patents that have not been designated as academic are considered corporate patents.

2.1 University owned patents

A set of keywords from the domestic and English names of European universities is compiled to identify university-owned patents. The algorithm then scans the patent applicant's names, to find at least a partial match between the name and one of the keywords. As the main aim is to identify patents owned by European universities, applications exclusively in the ownership of universities based outside of Europe are not designated as university owned.

2.2 University invented patents

The identification of patents invented by the university consists in comparing the inventors of patents with the associated university authors who have published articles in scientific journals. The data for publications have been downloaded from Scopus database. The matching algorithm identify university invented patents in a few steps. First, a paired list of inventors and authors is created for those whose names are similar. In the next step, the number of author-inventor pairs is reduced only to those located in the same NUTS-3 region. Co-location is expected to increase the likelihood of a correct match.

The other two criteria focus on the conformity of the submitted application with the published article rather than the conformity of the inventor with the author. First, the document could not be published later than two years after the first filing of the patent application, i.e., two years after the priority date. This was implemented because the publication of the article and the registration of the invention should be timely contiguous - it is considered that pre-patent disclosure harms the application process as it could be considered prior art, and that the intensive review process of Scopus journals can take one or two years (Dornbusch et al. 2013). Finally, each patent application receives a code describing the technological area, the so-called International Patent Classification (IPC). Scopus, on the other hand, ranks journals in scientific fields, the so-called All Science Journal Classification (ASJC). The cognitive proximity between the IPC code and the ASJC code is expected to be associated with a higher probability of successfully assigning a patent application to a scientific article. However, the different nature of both classifications precludes the possibility of perfect agreement. The aim is therefore to identify the links through which science is most often transformed into technology, in order to rule out meaningless combinations of technology and science that result from the previous criteria.

3 Results

3.1 Academic patenting in Europe

Between 1964 and 2015, 1 614 455 patent applications were filed with the EPO with at least one European inventor. The first academic patent was filed in 1977. Since then, the share of academic patents has been growing (Fig. 1). Given that in 1980 only 1% of patents were granted to universities, four years later it was doubled and in 1993 it was 3%. The pace of growth accelerated in the following years.

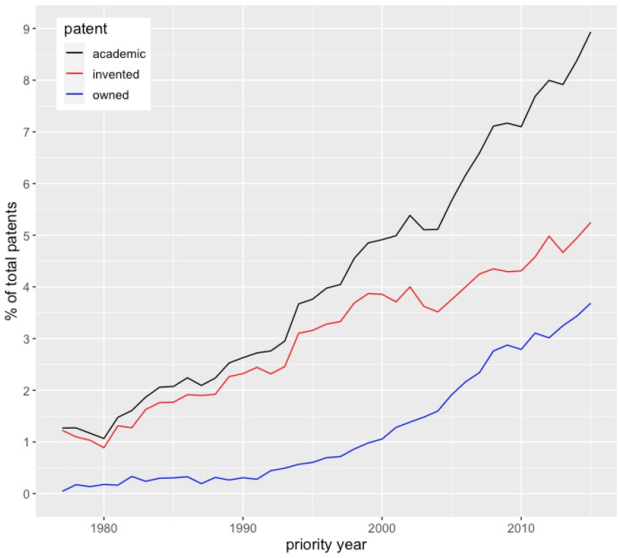

Fig. 1 Share of academic patents in Europe by priority year of patent application (1977−2015))

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In 1997, universities created 4% of total patent production, three years later it was as high as 5%. In 2006, university research generated more than 6% of patents and two years later more than 7%. The share of academic patents reaches up to 9% in 2015.

Considering the ownership structure of academic patents (blue and red curves), the share of patents owned by universities is growing. By 1995, universities owned less than 11% of academic patents (rest being owned by companies or individual scientists/innovators).In the following years and up to 2015, 33% of academic patents were owned by universities, that is three times more than in 1977−1995.

3.2 Academic patenting in regions

For regional analysis, patents were divided into four time periods based on the priority year of patent application: 1976−1985, 1986−1995, 1996−2005, 2006−2015. University patents have been found in 29 European countries, except Liechtenstein, Iceland, Serbia, the Republic of North Macedonia, Montenegro, Albania, and Cyprus. For the excluded countries, data were missing either on the side of the patents or the publications. The monitored countries consist of 294 regions (100%) at NUTS2 level. In the first period, academic patents were found in 184 regions (63%). In the second, universities have patents in 238 regions (81%) and in the third 275 regions (94%). Recently, universities have patented their inventions in 286 regions (97%). Between 1976 and 1985 (Fig. 2), in forty-two regions no university nor firm filed patent application with the EPO. Except of few, we would be speaking exclusively of regions that make eastern and southern European countries. In more than one third of regions, there were no university patents. According to median value, share of academic patents did not exceed 1.14% of total patent production in half of the European regions. On average, however, university patents account for 3.6% of regional patent production. The highest share of academic patents has been recorded in Lubelskie and Pomorskie (Poland), and in Central Portugal. Three regions of Poland (Malopolskie, Dolnoslaskie, Podkarpackie), two of Bulgaria (Northeastern, Northern Central), and Groningen (Netherlands) have been placed in the second highest interval. In the middle interval, but still above the average we may find Castilla y León (Spain), Languedoc-Roussillon and Corsica (France), West Central Scotland (United Kingdom), Province Namur (Belgium), Calabria (Italy), Central Macedonia (Greece), Southern Central Bulgaria, and few regions of Hungary and Poland including their capitals. Only few eastern European regions have been placed in the second lowest interval, others are scattered across western and northern Europe, including capital regions of Bulgaria, Germany, Sweden, Finland, and inner London (east and west). From a geographical point of view, in the first period the higher share of academic patents is concentrated exclusively in the east and south-west of Europe, while in the central and northern regions the share of academic patents remains relatively low (except Groningen).

Nine regions filed zero patent applications in the 1986−1995. Although the eastern European regions that have not filed patents before begun to be active in the patenting arena, universities remained rather idle. Still, the number of regions without university patents decreased. In half of the regions, universities accounted for more than 3.35% of patent production, although in few they exceeded average value of 5.9%. The highest share was recorded in non-capital region of Lithuania, followed by regions placed in the second highest interval - Western Greece, Warminsko-mazurskie and Podlaskie (Poland); (Fig. 3).

Middle interval regions can be seen mainly in eastern and south-western Europe – in Hungary, Poland, Czech Republic, Estonia, Bulgaria, Croatia, Slovenia, but also in Spain (Castilla y León, Galicia), France (Languedoc-Roussillon), Italy (Calabria), United Kingdom (West Central Scotland) or Netherlands (Groningen).

Those that have approached average value in the second lowest interval are rather in the western and northern parts of Europe including Berlin, Copenhagen, Helsinki, Dublin, Amsterdam, Oslo, Stockholm, Inner London, and parts of Outer London. On the other hand, Budapest, Warsaw, or Sofia are also found within the interval. Two thirds of regions were placed in the lowest interval, alongside with the capital-regions of Prague, Bratislava, Athens, Bucharest, Wien, Brussels, Bern, Madrid, Paris, Rome, Lisbon, and southern Outer London.

With minor differences, the share of academic patents is distributed similarly to the first period – the regions of central and northern Europe are mostly in the lower intervals, the higher intervals, except for Groningen, are exclusively for the eastern and southwestern regions.

Only three regions did not file patent application in 1996–2005 – Spain’s enclaves in northern Africa (Ceuta and Melilla) and North Aegean in Greece. Sixteen more regions remained without academic patents.

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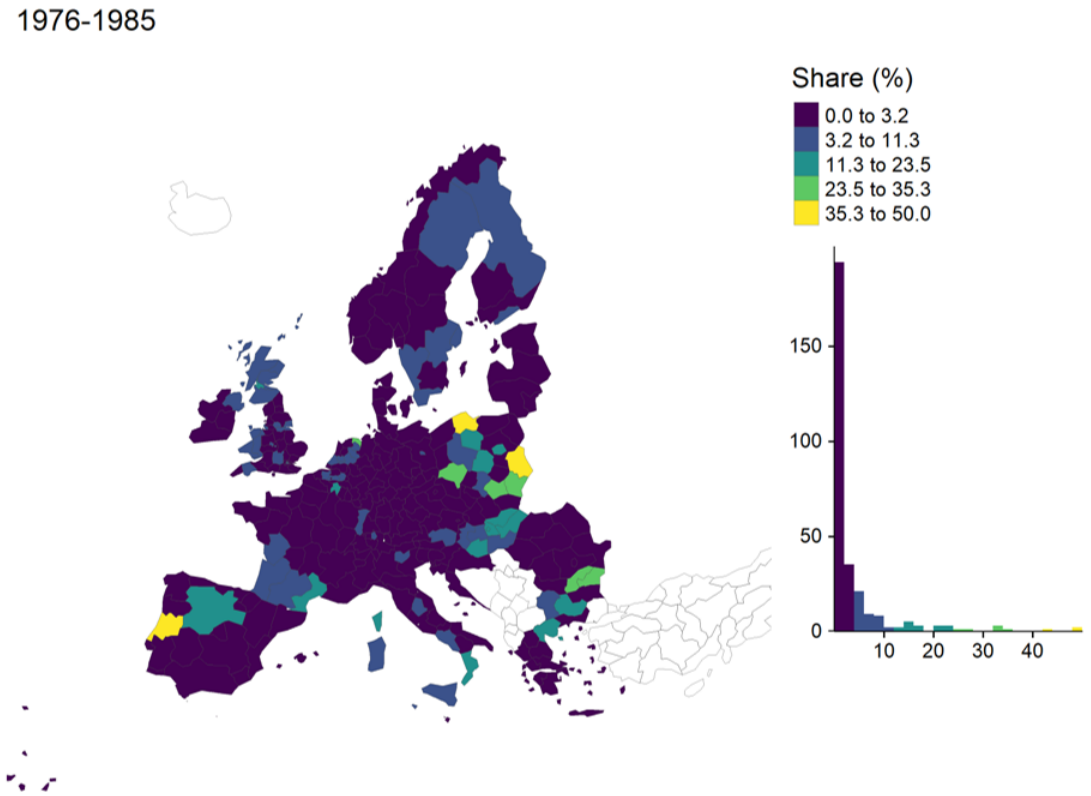

Fig. 2 Share of academic patents in the first period

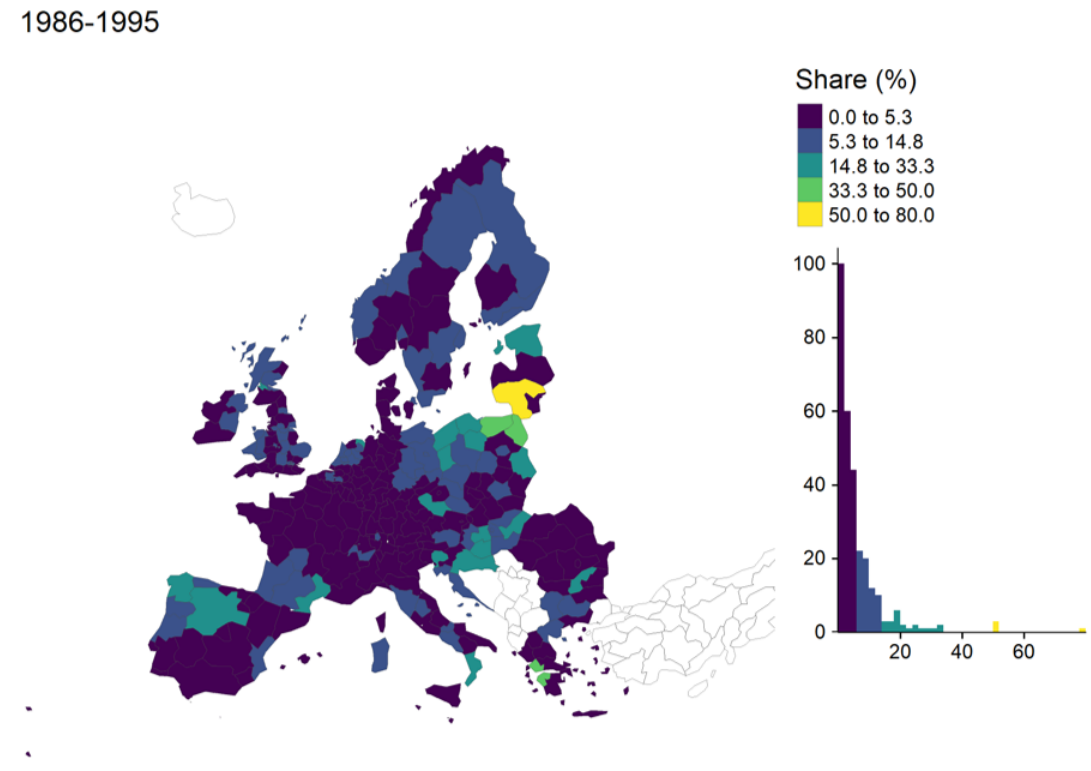

Fig. 3 Share of academic patents in the second period

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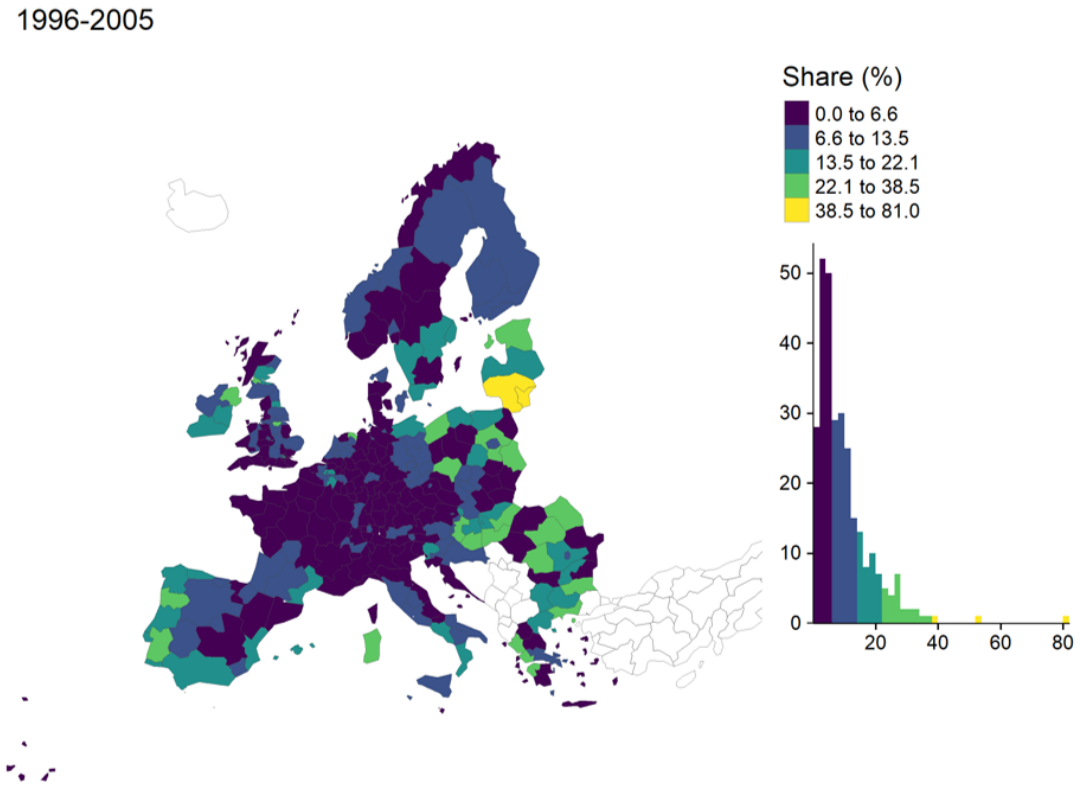

Fig. 4 Share of academic patents in the third period

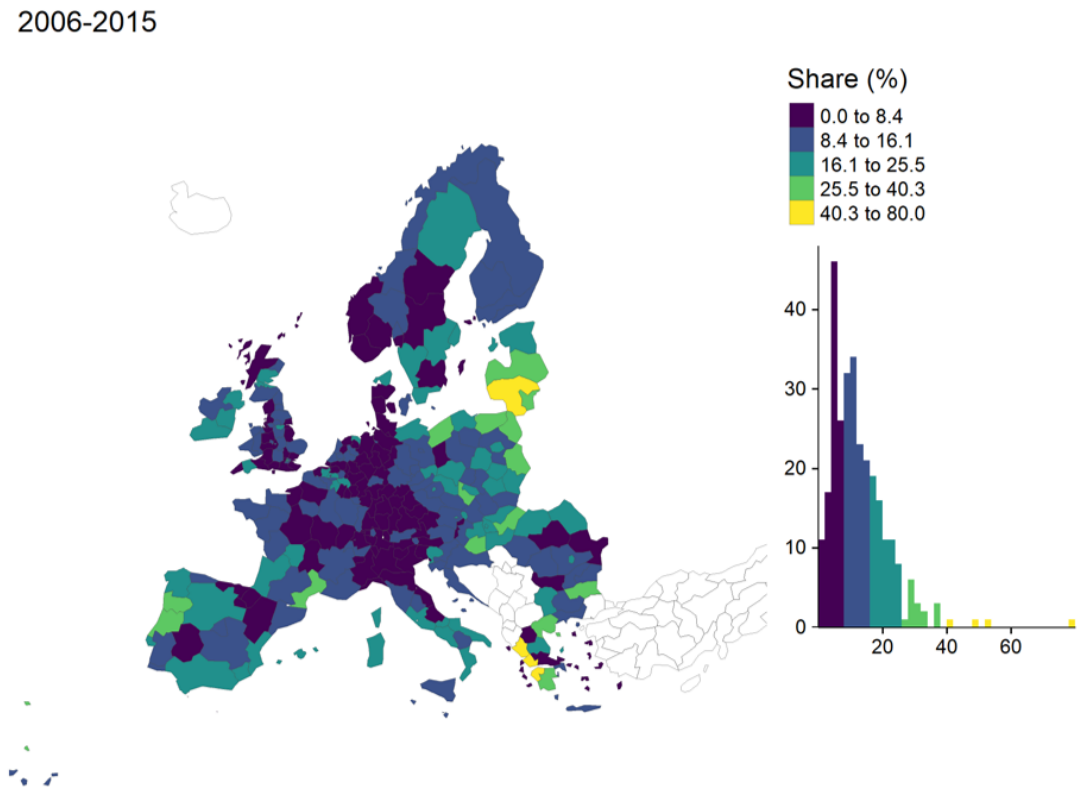

Fig. 5 Share of academic patents in the fourth period

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Although in half of the regions university patents make up at least 7.1% of patent production, majority remain below the average of 9.7%. Both Lithuania's regions are placed in the highest interval. The number of regions in the second highest interval increases, especially in eastern and southern Europe. Among those placed in the middle interval, we may find capital regions such as Inner London, Stockholm, Budapest, or Bratislava (Fig. 4).

The number of regions placed in the second lowest interval increased, including many capital regions - Wien, Brussels, Prague, Berlin, Copenhagen, Athens, Madrid, Helsinki, Rome, Amsterdam, Oslo, Warsaw, Bucharest, Outer London (West and Northwest). While the Central European regions remain located predominantly in the lowest interval of values, we observe new trends – a growing share of academic patents in the North, East and South-East of Europe.

Only Ceuta and Melilla remain without patent applications in the last period. No university patents have been filed in Aland (Finland), Southeast Romania, North and South Aegean, Ionian Islands, and Western Macedonia (Greece). As the median value of 10.8% is approaching mean of 12.7%, the right scale distribution of academic shares becomes less extreme. For the first time, most regions were placed in the second lowest interval, instead of the first (Fig. 5).

The lowest interval regions are found mainly in western Germany, Switzerland, Denmark, North of Italy, Austria, Belgium, Luxemburg, France, and Netherlands, or scattered across the United Kingdom, Spain, and Greece. However, and except for Bern, all capital regions of the aformentioned countries are placed above the lowest interval. In the second lowest interval, we may find Majority of Slovakia, Czech Republic, and some parts of Poland, Slovenia, Bulgaria, and Romania.

In the middle interval, there are Wien, Prague, Budapest, Dublin, Rome, Warsaw, Bucharest, Stockholm, Ljubljana, Bratislava, or Inner London.

In all regions of the second highest interval, share of academic patents exceed the average. Apart from Madeira, Central and North Portugal, Languedoc-Roussillon (France), they are in the eastern part of Europe – in Poland, Latvia, Lithuania (Vilnius), Hungary, Greece, Czech Republic, and Bulgaria. Three regions are in the highest interval – Epirus and Western Greece, and non-capital region of Lithuania. Above all, the gap of the lowest interval regions in the center narrowed as the share of academic patents grew in other parts of Europe – east, south-west, and north.

3.3 Innovativeness of regions and the patenting activity of universities

Looking at the figures, and especially the most recent one, we observe that the lowest share of academic patents is clustered approximately in central regions such as those in western Germany. In contrast, regions of eastern Germany fall predominantly within the higher interval. As a younger siblings of market economies, regions of eastern Germany are less innovative, at least in overall production of patents, than those of west. Similarly, the regions within the highest two intervals are often found in post socialist countries of eastern Europe. Thus, one might be interested whether there is any connection between the volume of academic patenting and the innovativeness of regions. In Fig. 6 we observe the relationship between the total number of patents per million inhabitants and the share of academic patents in regions (2006–2015). The blue curve represents "loess" best fit line. The curve has two parts – first, for regions that filed 150 patent applications and less, it is slightly growing. After this point of innovativeness, however, the curve is decreasing at rapid pace.

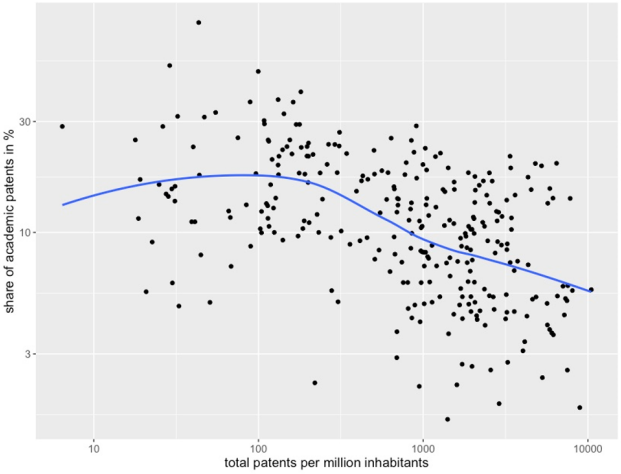

Fig. 6 The relationship between the total number of patents and the share of academic patents (2006–2015)

In the next step we analyze the relationship between the patents of universities and firms. We perform log-log linear regression (Table 1) for the number of university patents (as a predictor) and the number of firm patents (as a response). Both variables are scaled by the regional population in 2010 (number of applications per million inhabitants) and follow highly right-skewed distribution. To approach a distribution that is approximately normal, logarithms are common means of transformations.

The p value is extremely small, which indicates that the model is statistically significant. According to R-squared value, the number of academic patents explains 75% of variability in the response. A 1% increase in university patents/per million inhabitants increases the firm's patents/per million inhabitants by 1.034%. The positive relationship of the variables and the regression line is represented in Fig. 7.

Table 1 Log-Log Linear Regression model

	Dependent variable
	log10(other_per_milion + 1)
log10(academic_per_milion + 1)	1.034 ***
	(0.034)
constant	0.845 ***
	(0.066)
Observations	294
R2	0.757
Adjusted R2	0.756
Residual Std. Error	0.376 (df = 292)
F Statistic	909.470 *** (df = 1;292)

* p<0.1, ** p<0.05, *** p<0.01

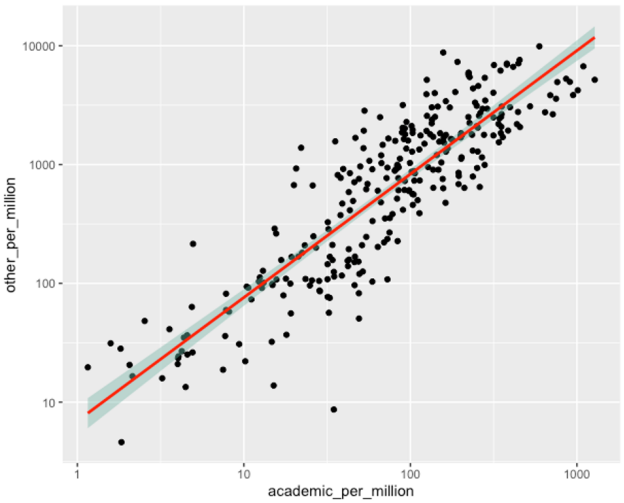

Fig. 7 The relationship between the patents of universities and firms (2006–2015)

4 Discussion

The share of academic patents has almost always exceeded last year's value. Given that in 1980 only 1% of patents were academic, in 2015 it was 9%. We witnessed an increase in academic patenting and its widespread diffusion in European regions. As a result, the share of academic patents was increasing over time - in 1976-1985 and in half of the European regions, only 1% of patents were academic, compared to 11% in 2006-2015. Similarly, the average share in regions reaches up to 13%, which is 3.5 times more than in the first period. Thus, there is convincing evidence that universities are increasingly active in the field of patenting and that they contribute to the innovation performance of regions. Although the contribution of universities to the innovation performance of regions is increasing, it remains relatively small compared to companies, as reported by Fritsch and Slavtchev (2007). Since the mid-1990s, several European countries have enacted legislation that has allowed universities to patent the results of publicly funded research. Shortly afterwards, more were added and, with a few exceptions, patent policies in Europe began to converge (Pottelsberghe 2007). The results confirm that before 1995, universities owned less than 11% of academic patents. The rest was owned by companies or individuals or other organizations. We also observe that as policies begin to converge, the proportion of patents owned by universities is growing faster than the proportion of patents invented by universities. In the years 1995-2015, a third of academic patents are university-owned. This is consistent with findings in other papers (Crespi et al. 2010; Lissoni et al. 2008; Maraut & Martinez 2014).

The number of regions in which universities have patented their inventions has grown over time. Between 1976 and 1985, more than a third of European regions did not file an academic patent, but in 2006-2015 only 3% of regions did not do so. These include the North African enclaves of Spain, south-eastern Romania and the Åland Islands in Finland, and certain regions of Greece - the northern and southern Aegean, western Macedonia, the Ionian Islands and western Greece.

Many Eastern European regions did not file a single patent application before 1986, but with the increasing rate of transformation towards market economies, the number of regions without patent applications decreased significantly between the first two periods. Although patent activity in Eastern Europe grew, in many cases it was

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on the side of companies and not universities. On the other hand, in Hungary and in some regions of Poland and Bulgaria, there is evidence that academic patenting took place even before 1989. However, it took another decade for eastern universities to increasingly patent their technologies. They still lag behind their western counterparts in patent production.

Although universities located in the central and northern regions file a higher number of patent applications, they usually have a lower share of academic patents than regions in Eastern and Southern Europe. On the other hand, in Castilla y Leon (Spain), Languedoc-Roussillon (France), Calabria (Italy), Groningen (Netherlands) and West-Central Scotland (United Kingdom), the proportion of academic patents has always been relatively high and has rarely fallen below average. In Eastern Europe, universities consistently had an above-average share of patents in Del-Denantul and Eszak-Alfold in Hungary and in Lodzkie, Lubelskie and Pomorskie in Poland. We conclude that the tradition of academic patenting is stronger in these regions than in others.

We also observe a relationship between the innovativeness of regions and academic patents. We find that in regions that file few patent applications (< 150), the share of academic patents is higher than in regions that file more patents. In fact, the contribution of universities to innovation is smaller in the most innovative regions. Nevertheless, there are large differences, and the size of the contribution can vary significantly for similar levels of patent intensity.

The positive and significant impact of increasing university research expenditures on the number of company patents in the region has already been confirmed by a few studies (Acs et al. 1992; Anselin et al. 1997). By replacing university research expenditures with the number of academic patents, we also find a positive and statistically significant relationship. The R-square value of 0.757 indicates that the innovative performance of companies can be quite accurately predicted by the number of academic patents. A 10% increase in university patenting is associated with a 10.34% increase in the corporate patenting. Thus, academic patents are not separate generic entities without any commercial use, but rather are linked to private sector research and innovation. Extremely high values of academic shares are exclusive for regions where the patent activity of companies ranges from almost non-existent to very weak. Naturally, inventions made at the university are relatively more important when companies are unable to develop their own innovation potential. This does not contradict what Cowan and Zinovyeva (2013) have suggested that, given the presence of other innovative assets, university inventions may move low-performing regions to a higher innovation path. At the other end of the spectrum, and not until recently, in most regions the share of academic patents has not exceeded or approached the average value. As a result of the growing patent activity of universities, the number of such regions has decreased and the darkest cluster of regions in the lowest interval that once engulfed Europe has now narrowed, especially to western Germany, Denmark, Switzerland, northern Italy, central-eastern France and parts of The United Kingdom or Sweden. Here, the direct contribution of universities to the innovative performance of regions is rather small. However, capital regions are rarely placed at the lowest intervals.

4.1 Conclusions

Although the contribution of universities to the innovation performance of regions is increasing, on average only 13% of patents in the region have been invented or co-invented by university. The fact that the number of patents invented by companies (scaled by regional population) can be predicted accurately by the number of academic patents suggests that academic patents are not separate generic entities without any commercial use but are linked to private sector research. As policies began to converge towards the stronger university rights in the patenting arena, the proportion of patents owned by universities grew faster than the proportion of academic patents outside of their ownership. Nevertheless, two thirds of academic patents are owned by companies or individuals. The contribution of universities to the innovation performance of regions is relatively highest when there are no or few innovative companies. In the most innovative regions share of academic patents is rather small but differences in between the regions are vast. Universities tend to hold higher proportions of patents in capital regions or when there is a strong tradition of academic patenting. Similarly, the share of academic patents is higher in regions of Eastern Europe, but also in Portugal, Spain, Ireland, southern Italy and Sweden.

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