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# Funding Structure and University Patenting: An Analysis of European Higher Education Institutions

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# Funding structure and university patenting: An analysis of European higher education institutions

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**Abstract**

Relatively poor transfer of knowledge from higher education to the market remains a concern in Europe, universities being involved in at most 10% of all patented inventions. We examine the role of university funding in patenting, addressing three key research gaps: *(i)* the limited, country-specific samples rather than pan-European data used in most patent-funding studies; *(ii)* scarce evidence on the impact of the funding *structure* on patent quality; and *(iii)* the lack of precise estimates of interactions between university patenting, funding structures, and regional systems. We fill these gaps thanks to a micro-level database of almost 2,900 higher education institutions (HEIs) in 31 European countries and 295 NUTS2 regions (2011-2019), containing detailed information on their activity as direct patent applicants and various institutional characteristics, including financial records. We show that universities with a greater share of third-party funds (research grants, contracts) apply for more patents and have better quality patents than those that rely mainly on core funding, i.e. national/regional allocations. The HEIs that do patent are richer and have more than twice the share of third-party revenues. This indicates that the very marked core-periphery pattern of university patenting in Europe is related both to the amount of university funding and to its sources. Additionally, we find that regional economic systems also influence the way in which the funding structure impacts university patenting. The positive effect of third-party funding is strongest in the wealthy European regions, less so in developed areas, and negligible in the poorest regions.

**JEL: O31, O34, I23**

**Keywords:** patents, higher education institutions, university, funding

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# 1. Introduction

Patenting has long been used to proxy for innovation and new knowledge creation, both by firms (Igna and Venturini, 2023; Lotti and Marin, 2013; Chalioti et al., 2020; Andrews et al., 2014) and by research institutions, including universities (Yang et al., 2021; Hvide and Jones, 2018; Marczewska and Weresa, 2022; Verspagen, 2006; Meyer, 2003; EPO, 2024). Patents generated in the higher education sector are important instruments for transferring knowledge and technology from academia to the market, complementing other channels such as the mobility of graduates, flows of researchers, R&D collaborations, consulting, and commercialization through spin-offs (EPO, 2024; Perkmann et al., 2013; Jaffe, 1989; Schoellman & Smirnyagin, 2021; Ertugrul et al., 2024; Janger, 2019). They are also part of the so-called "third mission" alongside traditional teaching and research (Compagnucci & Spigarelli, 2020; Guerzoni et al., 2014; Baldini et al., 2006).

Still, the share of patents originating from European higher education institutions (HEIs) is relatively low: just 10% of the patent applications filed at the EPO in 2019 originated in universities (EPO, 2024, p.11). Further, European university patenting[1] is extremely concentrated. Parteka et al. (2024) found that between 1980 and 2019, universities from just five Western European countries accounted for three-fourths of all university patent applications and patents granted, while most European HEIs (more than 70%) are not active patent applicants. EPO (2024, p.12) documents that a tiny set of European universities (5%) account for half of all patent applications. The top fifty global patenting universities include 19 in the United States and 18 in China, just 2 in Europe[2]. From the policy standpoint, understanding why so many European universities contribute so little to market-oriented innovation is important and timely, particularly in light of the current EU efforts to close the innovation gap with key global players such as the United States and China (Draghi, 2024) and the potential inflow of elite researchers to Europe as a result of institutional instability in the U.S. academic system.

The purpose of this paper is to assess the structure of university funding as a determinant of direct patenting by HEIs (i.e. patent applications that allow universities, as direct applicants, to enjoy property rights to the innovation patented). Funding sources in fact have been found to play a crucial role in shaping academic research and patenting outcomes (Geuna, 2001; Yu et al., 2022;

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[1] Throughout the paper we use the term "university patents" to refer to direct patent applications in which at least one of the applicants was classified as a higher education institution. In the related literature (e.g. EPO, 2024), a broader term, "academic patents", is used with respect to all patent applications resulting from innovation made at least partly at universities, not necessarily filed with the patent office directly by the universities themselves (direct academic patents), but possibly by other entities such as companies collaborating with universities or by individual researchers (indirect academic patents).

[2] Top 50 university PCT applicants, 2020–2022. Source: WIPO Statistics Database, March 2023 (https://www3.wipo.int/ipstats/key-search/indicator).

Guerzoni et al., 2014; Gulbrandsen and Smeby, 2005; Lawson, 2013; Hottenrott and Thorwarth, 2011; Graf and Menter, 2022; Foltz et al., 2000; Azagra-Caro et al., 2006). We distinguish in particular between *core* and *third-party* funding, given their divergent objectives as regards the expected applicability and market orientation of research output, as well as differences in degree of originality and acceptable risk of failure (Geuna, 2001; Yu et al., 2022; Guerzoni et al., 2014; Angori et al., 2023). That is, the balance between public and third-party funding can affect research outputs, helping to determine whether the funding produces publications or patent applications and affecting the latter's rate of success. Core funding typically finances the general operating budget of the higher education institution, while third-party funding is usually earmarked for specific activities, units, or researchers (Lepori, 2023), and thus potentially more supportive of patent-oriented work. This funding structure has become increasingly relevant as European universities have undergone substantial changes in research funding sources since the 1980s (Cesaroni and Piccaluga, 2002). On the one hand, HEIs responded to demands to implement their third mission by engaging more closely with industry (Guerzoni et al., 2014; Baldini et al., 2006; Rizzo and Ramaciotti, 2014), increasing joint company-university patenting (Wolszczak-Derlacz, 2025). On the other hand, HEIs faced more restrictive, performance-based public funding policies (Geuna and Nesta, 2006; Yu et al., 2022; Jain et al., 2020), compelling them to seek alternative (third-party) sources, often through newly established technology transfer offices (TTOs).

We build on the rich literature on the different levels at which university patenting is determined (Acosta et al., 2012; Yamaguchi et al., 2019). In the aggregate, it is influenced by national legislation (the Bayh-Dole Act in the U.S.: Link and Hasselt, 2019; or the so-called "professor's privilege" in some European countries: Grimm and Jaenicke, 2012; Hvide and Jones, 2018; Cesaroni and Piccaluga, 2002; Ejermo and Källström, 2016; Martínez and Sterzi, 2020; EPO, 2024) or by regional economic conditions (Bilbao-Osorio and Rodriguez-Pose, 2004; Baldini et al., 2006; Baldini, 2009; Rizzo and Ramaciotti, 2014). At the micro level, various institutional characteristics play a role, such as university type and research orientation (technical HEIs patent more – Lee, 2021), size (Baldini et al., 2006; Jain et al., 2020; Lee, 2021), employment structure (Graf and Menter, 2022; Andersen and Rossi, 2011), collaboration with firms (Wolszczak-Derlacz, 2025; Nugent et al., 2022; for a review see Rizzo and Ramaciotti, 2014), and, last but not least, their financial condition. More intensive patenting is typical of the wealthier HEIs (Coupe, 2003; Jain et al., 2020; Azagra-Caro et al., 2006; Carlsson and Fridh, 2002; Tabakovic and Wollmann, 2019) and those with a higher share of private and/or external funds (Hottenrott and Thorwarth, 2011; Lawson, 2013; Gulbrandsen and Smeby, 2005). Regarding the proportions of funding sources (public/industrial/other), the empirical evidence remains mixed, which suggests that other factors (such as the level of regional development or grant size) are significant in shaping this relationship (Bilbao-Osorio and Rodriguez-Pose, 2004; Lawson, 2013; Rizzo and Ramaciotti, 2014).

We address three main research gaps. First, most studies on the patenting-funding nexus are country-specific, with limited samples and lacking a Europe-wide perspective (e.g. Coupe, 2003 and Foltz et al., 2000 on the US; Gulbrandsen and Smeby, 2005 on Norway; Lawson, 2013 on the UK; Hottenrott and Thorwarth, 2011 and Graf and Menter, 2022 on Germany; Rizzo and Ramaciotti, 2014 on Italy). Second, empirical investigation of whether university funding structure affects patent quality as well as quantity remains scarce (Hottenrott and Thorwarth, 2011; Graf and Menter, 2022). Third, we lack precise estimates of how university patenting and funding structures interact with regional conditions, which is crucial in that the descriptive evidence in EPO (2024) shows that academic patenting is more prevalent in industrialized regions, in keeping with innovation systems theory that indicates that innovation requires university-industry interaction (Vespagen, 2006). Further, universities contribute to local innovation systems through collaborative research, workforce development, and knowledge-intensive business incubation (Schaeffer et al., 2018).

Given this background, we formulate two main research questions: (1) How does the composition of universities' funding affect their patenting and its success? (2) Is the relationship between university patenting and funding sources dependent on the characteristics of the regional innovation system? The answers derive from a large-scale analysis that considers national, regional and institutional heterogeneity within the overall European system of higher education. We use a detailed university-level dataset on about 2900 HEIs from 295 NUTS-2 regions in 31 countries, between 2011 and 2019. We combine information on universities' patent applications recorded in the PATSTAT Global database with several characteristics of HEIs, including their financial records, and with the data on regional economic conditions. To the best of our knowledge, no study has used such a large, international sample to analyse the link between university patenting, funding structure, and regional innovation systems in Europe. Generally speaking, multi-country studies on university patenting are rare (Cesaroni and Piccaluga, 2002; Geuna and Nesta, 2006; Acosta et al., 2009; Angori et al., 2023) and a good number of those available fail to use global patent data, which may lead to a home-bias effect (for instance, the recent EPO 2024 report on university patenting in Europe relies on patent applications filed at the European Patent Office only). Moreover, we analyse not only the number of university patent applications but also their impact (gauged by patent citations), thus offering new insights into universities' patenting performance in terms of quantity as well as quality. This distinction is necessary, as the literature

(Acosta et al., 2012; Hottenrott and Thorwarth, 2011; Whalley and Hicks, 2014) finds different factors (individual/university/regional level) to be significant in shaping each of the two outcomes. Identifying universities in global patent datasets such as PATSTAT is not straightforward (Parteka et al., 2024; Dornbusch et al., 2013; Geuna and Nesta, 2006; Foray and Lissoni, 2010). Our approach – analysing a broad international sample of universities and their patent applications worldwide rather than using data from just one patent office – necessarily entails a limitation: that is, we focus only on direct university patenting (i.e. patents filed by universities themselves). This accounts for only about half of all academic patenting activity (EPO, 2024; Neuhäusler and Frietsch, 2024), since many university-generated patents are filed by other entities or individual inventors (Dornbusch et al., 2013, p. 52; Verspagen, 2006, p. 621; Geuna and Nesta; 2006, p. 793). Consequently, our analysis complements the studies that rely on surveys or that link patent data with bibliometric records to identify university-affiliated researchers among patent inventors (Neuhäusler and Frietsch; 2024; EPO, 2024; Hottenrott and Thorwarth, 2011; Lissoni et al., 2009; Lissoni et al., 2013).

The rest of the paper is structured as follows. Section 2 reviews the literature on university patenting determinants, focusing on funding structure and sources and potential interactions with regional systems that may shape the effect of funding structure on patenting activity. Section 3 describes the dataset and the key stylised facts on European HEIs' direct patenting, and Section 4 presents our results . Section 5 concludes. In the appendix, we include additional materials, while a complete replication package[3] allows interested researchers to reproduce the empirical findings described in the paper.

## 2. Determinants of university patenting – review of the literature

Our paper builds on studies that take patenting as a proxy for innovation and knowledge creation (Yang et al., 2021; Hvide and Jones, 2018; Marczewska and Weresa, 2022; Verspagen, 2006; Meyer, 2003; EPO, 2024). Measuring academic patents is complicated, owing mainly to the difficulty of identifying universities in patent documents (Dornbusch et al., 2013; Parteka et al., 2024; Geuna and Nesta, 2006; Foray and Lissoni, 2010; Caviggioli et al., 2023a, 2023b; Cesaroni and Piccaluga, 2002). Much of the innovation activity is likely to be indirect; that is, applications may well be filed by a university-affiliated inventor rather than the university itself. As reported by EPO (2024), for European universities these indirect applications may exceed the number of direct academic patents. Neuhäusler and Frietsch (2024) also identified a substantial number of patents originating from academia but without universities listed among the applicants in some European

[3] The replication package to is available upon request.

countries and Canada. This problem can be even more pronounced in the countries adopting "professors' privilege" (see Ejermo and Källström, 2016 on Sweden, Lissoni et al., 2009 on Denmark or Lissoni et al., 2013 on Italy). Parteka et al. (2024) also point to a series of problems related to the proper identification of HEIs in the global patent data (encompassing patents from multiple patent offices) and develop a complex procedure for linking university applicants identified in PATSTAT with external datasets on universities' characteristics such as ETER (Lepori, et al., 2023). Despite these shortcomings, patent information has been used intensively in the analysis of innovation generated within the higher education system, gauged chiefly by number of patents applied for or granted (e.g. Lissoni et al., 2013; Rizzo and Ramaciotti, 2014; Gulbrandsen and Smeby, 2005; Cesaroni and Piccaluga, 2002). Significantly less research has been devoted to university patent quality as measured, for instance, by patent citations or other indicators (e.g. Acosta et al.; 2012; Hottenrott and Thorwarth, 2011; Graf and Menter, 2022; Guerzoni et al., 2014).

The literature on the micro-level determinants of innovation in higher education reveals a set of basic determinants of HEIs' patenting activity. But this evidence is inconclusive and indeed contradictory in some respects, as mixed results may stem from differences between patenting intensity (number of applications) and patent quality, as well as in the university samples analysed. Looking at HEI size, Baldini et al. (2006) and Jain et al. (2020) found that larger universities (in terms of budget, staff, or student body) tend to patent more. But Lee (2021) obtained the opposite result, while Acosta et al. (2012) and Azagra-Caro et al. (2006) found no significant relationship between patenting and university size. Baldini (2009) also suggests that the heavier teaching and administrative loads on faculty may be negatively related to patenting output, especially where staff evaluation puts a premium on research achievements. Interestingly, there is no consensus on the relationship between patenting and publishing (Azoulay et al., 2007; Czarnitzki et al., 2007; Baldini, 2009; Rizzo and Ramaciotti, 2014; Gulbrandsen and Smeby, 2005).

In addition, some studies suggest that the age of the department or university reflects an advantage in experience (previous patenting heightens the propensity to produce new patents: Rizzo and Ramaciotti, 2014; Lawson, 2013; Azoulay et al., 2007), so older universities can patent more: a significant age effect was found by Jain et al. (2020) but not confirmed by Lee (2021). Finally, university type matters: in particular, a technical/engineering orientation is positively related to patenting outcomes (Lee, 2021; Parteka et al., 2024), with possible further heterogeneity between fields/departments (Lawson, 2013; Jain et al., 2020). However, Acosta et al. (2012) found no significant difference in academic patent quality between high-tech and other patenting fields. The literature gives mixed results on whether medical schools have a positive effect on the patent count (Baldini et al., 2006; Baldini, 2009; Lee, 2021; Mathew et al., 2012).

The literature also finds external factors that affect academic patenting significantly. For instance, the good economic performance of highly developed regions can stimulate patenting by HEIs (Caviggioli et al., 2023b; Bilbao-Osorio and Rodriguez-Pose, 2004). This is possible even within a single country: HEIs in the northern regions of Italy display better patenting performance than those in the South, reflecting Italy's well-known uneven regional development (Baldini et al., 2006; Baldini, 2009; Rizzo and Ramaciotti, 2014). Generally, academic patents are characterised by strong regional concentration (Acosta et al., 2009; Parteka et al., 2024), and a higher level of regional industrial development bolsters academic patenting (Baldini et al., 2006). Ejermo and Källström (2016) argue that HEI patenting activity will be driven by the regional demand for innovation. Among other location-related variables, local labour market conditions are relevant, reflecting the skills and sectoral composition required for innovation (Bilbao-Osorio and Rodriguez-Pose, 2004; Anselin et al., 2000; Garcia and Araújo, 2022). But the evidence remains inconclusive: some studies in fact find that regional factors (e.g. development level, R&D expenditure) and industrial potential have little or no impact on university patenting, a more significant role being played by university-level factors (Acosta et al., 2012).

As to our main topic, namely the role of funding, many studies unsurprisingly find that the wealthier HEIs engage in more intensive patenting (Coupe, 2003; Jain et al., 2020; Azagra-Caro et al., 2006; Carlsson and Fridh, 2002; Tabakovic and Wollmann, 2019). Considering the likelihood of at least partially performance-based allocation of public funds among universities, there is an obvious bidirectional dependency here, widening the gap between the best- and the worst-performing HEIs in a sort of vicious circle (Geuna, 2001, Yu et al., 2022). And not only the level of funding but also its structure is relevant to patenting intensity and quality. The literature generally describes the relationship between public funding (which dominates universities' financial resources) and university patenting performance. Mostly positive effects have been found (Rizzo and Ramaciotti, 2014; Payne and Siow, 2003; Yu et al., 2022), with a certain lag between funding and patent application, owing to the need to complete the research infrastructure in order to obtain results (Jain et al., 2020; Lee, 2021; Lissoni et al., 2013; Acosta et al., 2009). By contrast, Krieger (2024) summarizes several studies on the German Excellence Initiative, a selective public funding program for universities between 2006 and 2017, concluding that the effect of government funding on patenting was negligible.

Some studies also find that the source of funds affects the type of academic research carried out and consequently patenting. Geuna (2001) argued that different funding sources are related to different deliverables and expectations regarding the invention, such as particular market value, secrecy and applicability. Angori et al. (2023) observe that publicly funded academic patents are more likely to be classified as basic than applied research. Yu et al. (2022) argue that researchers enjoy greater flexibility in allocating private funds to their ideas, having the opportunity to invest in riskier innovative projects, than in the case of public funds, for which the guidelines are more conservative and risk-averse. By contrast, Guerzoni et al. (2014) performed a case study on patented cancer research, finding that researchers are more likely to propose original, radical ideas when they can count on university financial support, whereas those who are entirely dependent on industrial or other private funds are less likely to develop (and potentially patent) these more original ideas.

External funding, in particular industrial funding, was found to increase the probability of patenting by faculty members in Norway (Gulbrandsen and Smeby, 2005) and the UK (Lawson, 2013), and the quality of patenting in Germany (Hottenrott and Thorwarth, 2011). Collaboration between universities and firms benefits both and has an impact on patenting (see Rizzo and Ramaciotti, 2014 for a review). Lawson (2013) studies the size and sources of research grants and shows that only large industrial grants have a positive effect on academic patenting, while small grants boost the number and citations of academic patents, regardless of funding source. However, the interregional differences in technology transfer may diminish (Lissoni et al., 2013) or even reverse the positive effect of third-party funding on patenting, as in the example of northern and southern Italy (Rizzo and Ramaciotti, 2014). Similarly, Bilbao-Osorio and Rodriguez-Pose (2004) find that private R&D funds have a stronger impact on patenting in non-peripheral than peripheral EU regions. Graf and Menter (2022) found mixed results concerning the impact of third-party funding on patent quality in German HEIs. Foltz et al. (2000) analysed federal, industrial, institutional, and other funding sources for agricultural biotechnology patents in the U.S., finding a positive effect only from federal funding. Other interesting insights on the connection between government funding and university-industry collaboration are offered by Nugent et al. (2022), who compare two Australian funding programs and show that government grants requiring industry collaboration resulted in more patent activity.

Considering the evidence set forth in the literature, in investigating the link between funding and university patenting, we will take the regional economic context into account. In the next section we describe our data, which allows detailed analysis linking the quantity and quality of universities' patenting activity with their funding sources.

# 3. Data and stylised facts

## 3.1 The dataset

We draw on a new dataset designated KC-HEI (described in detail in Parteka et al., 2024), which contains institution-level patenting indicators for HEIs in 31 European countries, identified in PATSTAT Global from 1980 onwards. Here, we are obliged to restrict the sample period to 2011-2019, given the limited availability of institution-level data from ETER (European Tertiary Education Register; Lepori et al., 2023)[4]. We merge university-level patent records, ETER variables and the data on scientific publications indexed in the Web of Science (from RISIS-OrgReg[5]) using the PATSTAT-ETER crosswalk (Płatkowski et al., 2024)[6] developed for the study of Parteka et al. (2024).

Unlike the recent EPO 2024 report on academic patenting, we extend the analysis beyond patents filed at EPO only, which could result in significant home bias, and consider European university patent applications filed with the world's top five intellectual property offices, the so-called "IP5" (namely: EPO, USPTO, CPO, JPO, KPO). Together, the IP5 account for a full 85% of global patent applications (WIPO, 2024). We focus on direct university patents, i.e. applications filed in the name of the university itself or its knowledge transfer office, identified with the use of an applicant identifier provided by PATSTAT. Patents are allocated to universities by fractional apportionment (FA) according to the applicant's share, so that patent applications resulting from university-industry collaboration are (partly) taken into account[7]. In the main analysis we use patent applications; the data on patents granted is used in the robustness checks. Additionally, we analyse forward patent citations from the OECD Patent Quality Indicators database (version: August 2023) available at the OECD STI Micro-data Lab[8] as a proxy for patent quality, capturing their technological and economic value (Squicciarini et al., 2013).

[4] We use linear interpolation of the data. Outliers – defined as values below the 1st and above the 99th percentile – are replaced with the values at those percentiles.

[5] Register of Research and Higher Education Organizations (https://www.risis2.eu/orgreg-data/).

[6] PATSTAT-ETER crosswalk is available at: https://doi.org/10.34808/h4h3-2k20.

[7] We do not capture instances in which patents result from industry-science collaboration and university researchers are among the inventors but only a company appears as the applicant.

[8] Available at: https://www.oecd.org/en/data/datasets/intellectual-property-statistics.html. We use the data by application cohort (i.e. patents with the same filing year and technological class). The OECD dataset contains a series of patent quality indicators of EPO and USPTO patents only; the quality indicators of all IP5 patents are not available. We use EPO quality indicators in the main analysis and USPTO indicators as a robustness check.

ETER is our source of data on HEIs' individual characteristics, such as foundation year, number of students ISCED 5 - 7 (total and in STEM fields[9]), academic staff (FTE)[10], HEI type (general universities versus universities of applied science[11]) and the financial variables crucial to our analysis: universities'  total budgets (revenues) and their structure[12], in particular the respective shares of core and third-party funding. Core funding consists mainly of allocations from either national or regional governments and is defined as "funding available for the operations of the whole institution, which is not earmarked to specific activities and whose internal allocation can be decided freely by the institution itself" (Lepori, 2023, p. 93). Third-party funding, instead, is "earmarked for specific activities and institutional units" and includes grants from national and international funding agencies for research (e.g., the Norwegian Research Council, EU framework programs, or COST); funds from charities and non-profit organisations for specific research and educational purposes (e.g., the Wellcome Trust of the Gates Foundation), contracts from public bodies and private companies for research and services, as well as fees or payments from companies for educational or research services (Lepori, 2013, p. 94).

Regional statistics come from Eurostat. The main characteristic is GDP per capita at NUTS2 level, but in the robustness section (see Appendix Tables A9 – A10), we use other regional variables: (1) tertiary educational attainment (ages 25-64), (2) tertiary education participation rate, (3) employment in high-technology manufacturing (% of total), (4) employment in knowledge-intensive services (% of total), (5) employment in scientific and technical activities (% of total), (6) employment in education (% of total), and (7) higher education sector intramural R&D expenditure (euros per inhabitant).

The final sample used in this paper consists of 2886 European HEIs (785 directly patenting and 2101 inactive in direct patenting[13]) in 31 countries[14] and 295 NUTS2 regions, observed in 2011-

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[9] Science, Technology, Engineering, Mathematics. We use the share of students in the following fields: 05 (Natural sciences, mathematics and statistics), 06 (Information and communication technologies) and 07 (Engineering, manufacturing and construction) – Lepori (2023, p.119)

[10] As a primary source we consider full-time equivalent academic staff (FTE), but in some countries, e.g. Italy, data are reported in headcounts (HC), in which case we consider HC.

[11] The division is based on the ETER metrics standardized university category, which classifies HEIs as: universities (institutions with the right to award doctorates), universities of applied science (which focus on professional education and typically do not have doctoral programs, such as Fachhochschule in Austria and Germany), and others (all institutions that fit neither category) (Lepori, 2013, p. 63-64). We designate ETER's university category as "general university" since we use the term university interchangeably with HEIs.

[12] Total revenues are split into current revenues (core budget, third party-funding, student fees) and unclassified revenues plus non-recurring revenues (contributions for investments, donations) – Lepori (2023), p. 87.

[13] Inactive (i.e. non-patenting) universities are identified as European HEIs present in the official register (i.e. ETER - Lepori, 2023) that are not found among applicants in PATSTAT Global (Autumn 2022) and not present in RISIS Patent and OrgReg in 2011-2019– see Parteka et al. (2024, p. 17) for details.

[14] AUT, BEL, BGR, CHE, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HRV, HUN, IRL, ISL, ITA, LTU, LUX, LVA, MLT, NLD, NOR, POL, PRT, ROU, SVK, SVN, SWE

2019. The number of institutions observed (by type and by country) is given in Table A1 in the Appendix. In some of the models estimated, the number of HEIs/countries drops due to the unavailability of some variables in ETER[15]. The Appendix also reports the summary statistics of the variables for the entire sample (Table A2), the two subsamples of patenting and non-patenting HEIs (Table A3) and mean values by country (Table A4).

## 3.2 Stylised facts – patterns of direct university patenting in Europe

### *3.2.1 Patent applications and patent quality*

Strikingly, of the 2886 European universities considered here, 73% were inactive as direct patent applicants; just a fourth, that is, appeared among applicants to the IP5 for at least one patent (Table 1). Within technically-oriented or STEM institutions the distribution is more balanced, but even so 54% made no patent applications. Excluding universities of applied science and small units (fewer than 500 students) does not change the general tendency, and two-thirds of HEIs are still inactive.

**Table 1. The share of direct patenting[1] institutions - all HEIs and specific types (2011-2019)**

| | all HEIs | | STEM[2] only | | general universities[3] only | | excluding applied science universities | | excluding small HEIs <500 students | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *number* | *%* | *number* | *%* | *number* | *%* | *number* | *%* | *number* | *%* |
| patenting [1] | 785 | 27 | 743 | 46 | 693 | 43 | 668 | 30 | 770 | 32 |
| non-patenting | 2101 | 73 | 875 | 54 | 930 | 57 | 1591 | 70 | 1621 | 68 |

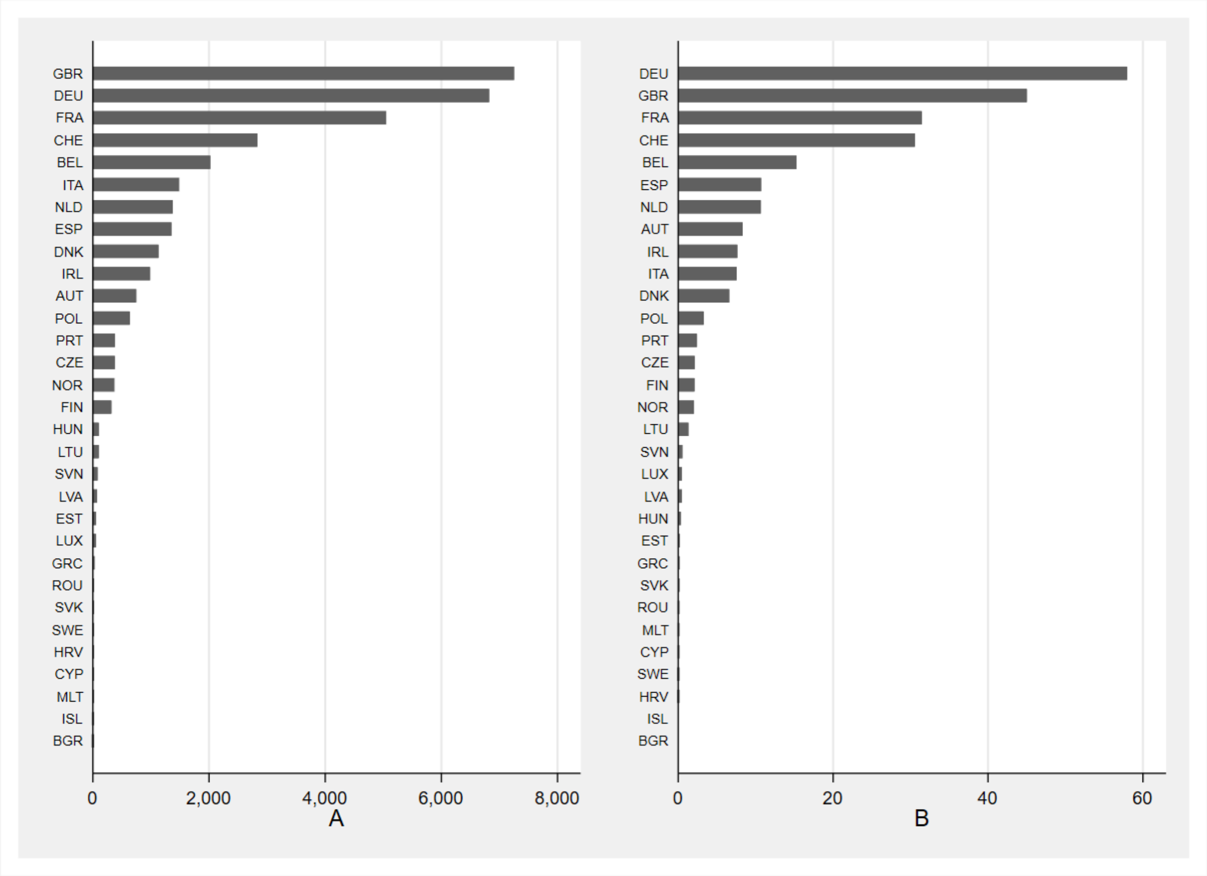
Source: Authors' own calculations based on PATSTAT Global (Autumn 2022) and ETER.
Note: [1] HEIs appearing as applicant in at least one IP5 patent application; [2] identified as HEIs with students in STEM disciplines; [3] HEI types identified using ETER (see footnote 10).

Turning to the country ranking of university direct patenting (Figure 1), we find striking differences within Europe: HEIs in the top five countries (U.K., Germany, France, Switzerland and Belgium) account for 71% of all patent applications and 73% of patent citations. Figure 2 illustrates very strong geographical concentration, showing that the most active universities are located in the economic core, and peripheral regions exhibit weak academic patenting . Figure 3 depicts the key characteristics of regional systems in Europe: the wealthier NUTS2 regions gauged by GDP per capita (in red) are mostly in Switzerland, Luxembourg, Belgium (Brussels), the southern region of Ireland, Inner London and the Czech Republic (Prague). The shares of employment in knowledge-intensive services are highest in the NUTS2 regions that comprise

[15] For instance, financial statistics (total revenues, core revenues and third-party funding) are not available for HEIs in BGR, ESP, GRC, HRV, SVN, and the data on third-party funding is missing for CZE.

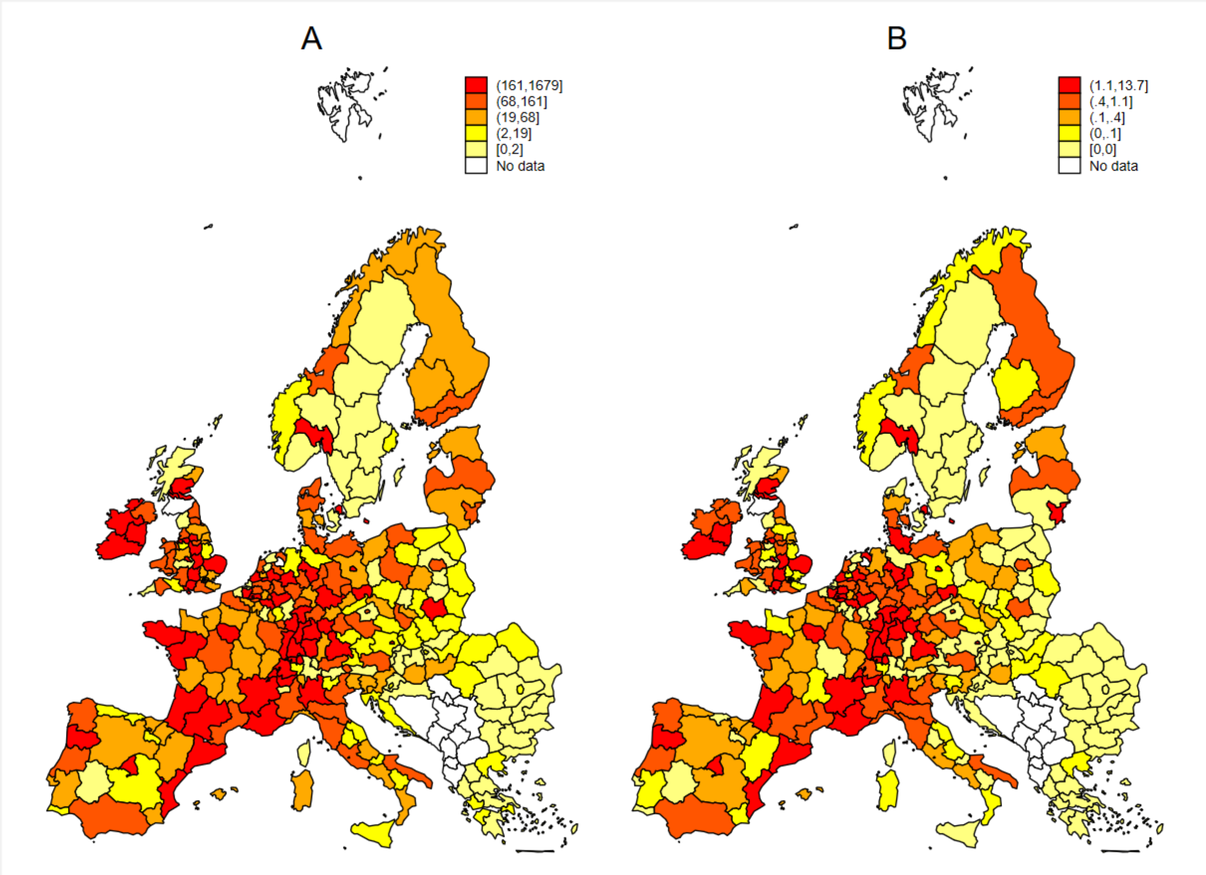
highly developed metropolitan and capital areas in Western and Northern Europe, notably Ireland, Germany, France, the United Kingdom, the Netherlands, and the Nordic countries (Figure 3B).

**Figure 1. Ranking of countries according to total number of university patent applications* - (A) and patent quality (citations)** - (B), 2011-2019**




Note: * total number of IP5 (EPO, USPTO, CPO, JPO, KPO) patent applications, FA, 2011-2019 ** Patent quality measured as the number of forward citations of EPO patents (in 5-year period) normalised by the maximum number of citations in the corresponding technological field.
Source: authors' own elaboration based on PATSTAT Global (Autumn 2022) and OECD Patent Quality Indicators database.

**Figure 2. Regional distribution of direct IP5 patents by European HEIs (A – patent applications, B – patent quality: citations), total 2011-2019**

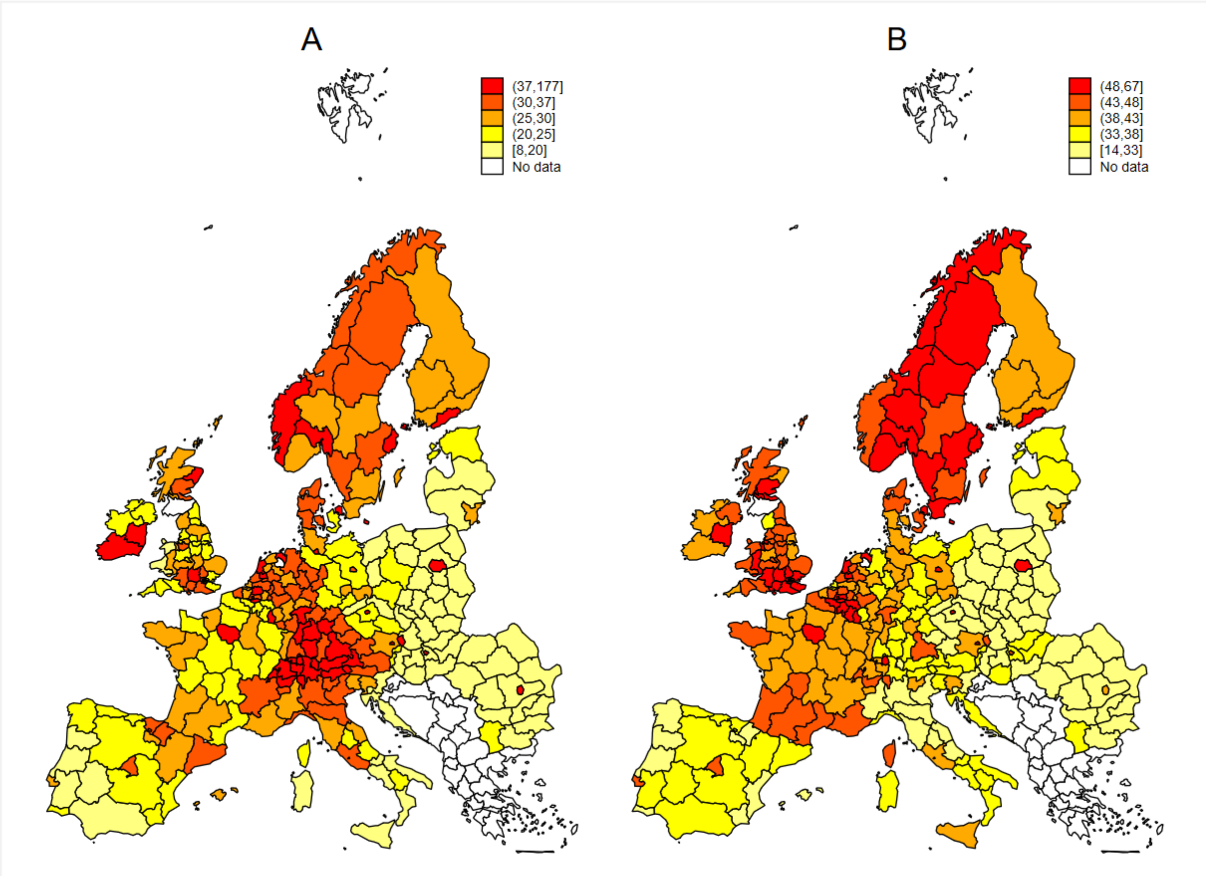



Note: Sample of 2886 HEIs in 31 European countries (2011-2019); Iceland not shown on the graph. Values for Sweden are likely to be underestimated due to professor's privilege. IP5: EPO, USPTO, CPO, JPO, KPO. Patents are allocated to HEIs using fractional apportionment (FA) by the applicant's share. Patent quality measured as the number of forward citations of EPO patents (in 5-year period) normalised by the maximum number of citations in the corresponding technological field.

Legend: Regions are divided into groups according to university patent distribution; the top class in red corresponds to the top 20% of regions with the highest cumulative number of HEI patent applications (map A) or citations (map B).

Source: authors' own elaboration using PATSTAT Global (Autumn 2022) and OECD Patent Quality Indicators database.

**Figure 3. Key features of regional systems in Europe (A – mean GDP per inhabitant in thousands of euros (PPS) in 2011 – 2019; B – employment in knowledge-intensive services, % of total employment, mean 2011-2019)**

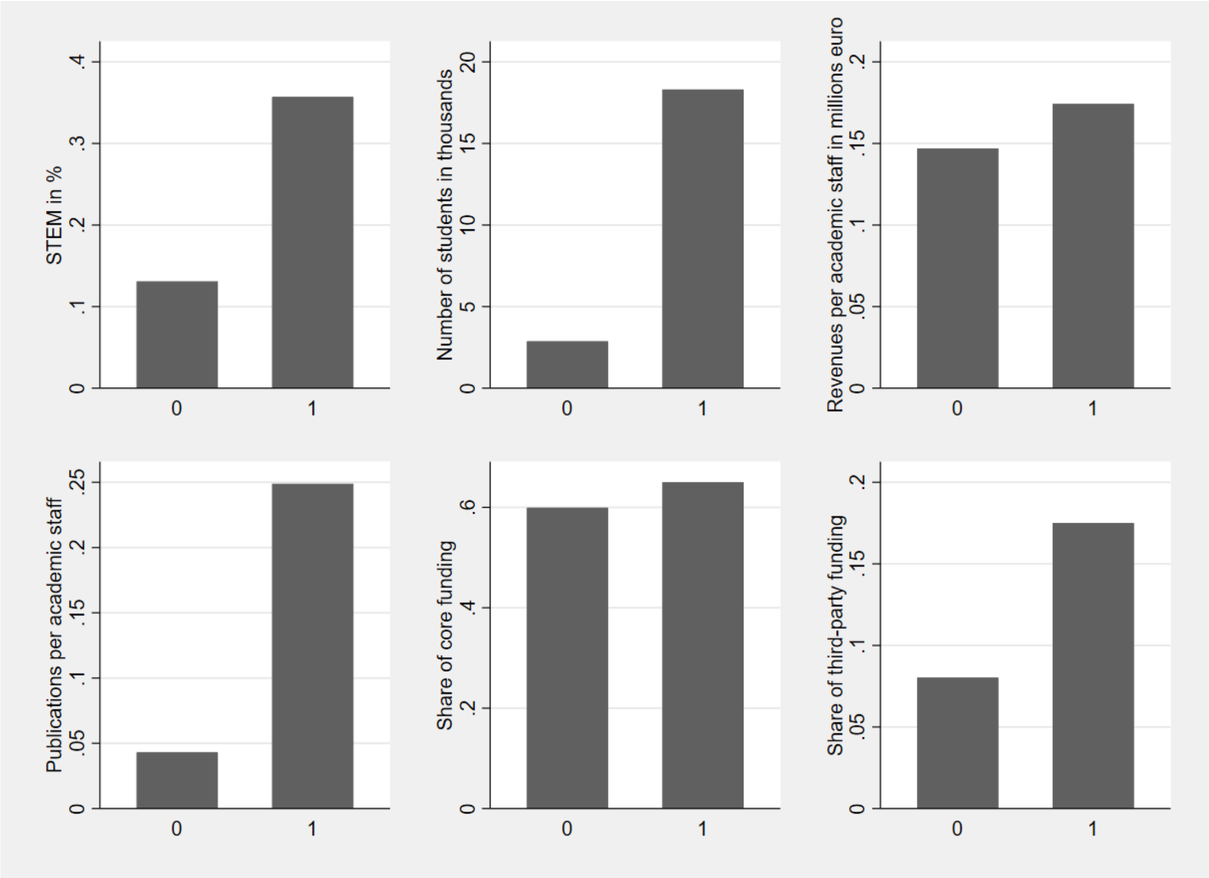



Legend: Regions are divided into groups according to regional variable distribution; the top class in red corresponds to the top 20% of regions with the highest GDP per capita in thousands of euros (PPS) (map A) or employment in knowledge-intensive services, % (map B).
Source: authors' own elaboration using regional data from Eurostat

### *3.2.2 Key features of patenting and non-patenting universities*

European HEIs are highly heterogeneous (for a complete set of summary statistics, see Tables A2-A4 in the Appendix). Figure 4 depicts the key differences between patenting and non-patenting institutions in our sample: the former have nearly three times more students in STEM disciplines, are considerably larger (student bodies 3 times as large), lighter teaching loads (i.e. lower student/teacher ratios), much better publication records (five times more scientific papers per academic staff member). As to the specific focus of our analysis, i.e. the financial records, patenting HEIs are not only richer (see Table A3 in Appendix), with 18.5% more revenues per academic staff member – Figure 4), but also have a considerably greater share of third-party revenues in the overall budget (17.5% vs. 8%).

**Figure 4. Comparison of patenting (1) and non-patenting (0) HEIs in Europe**



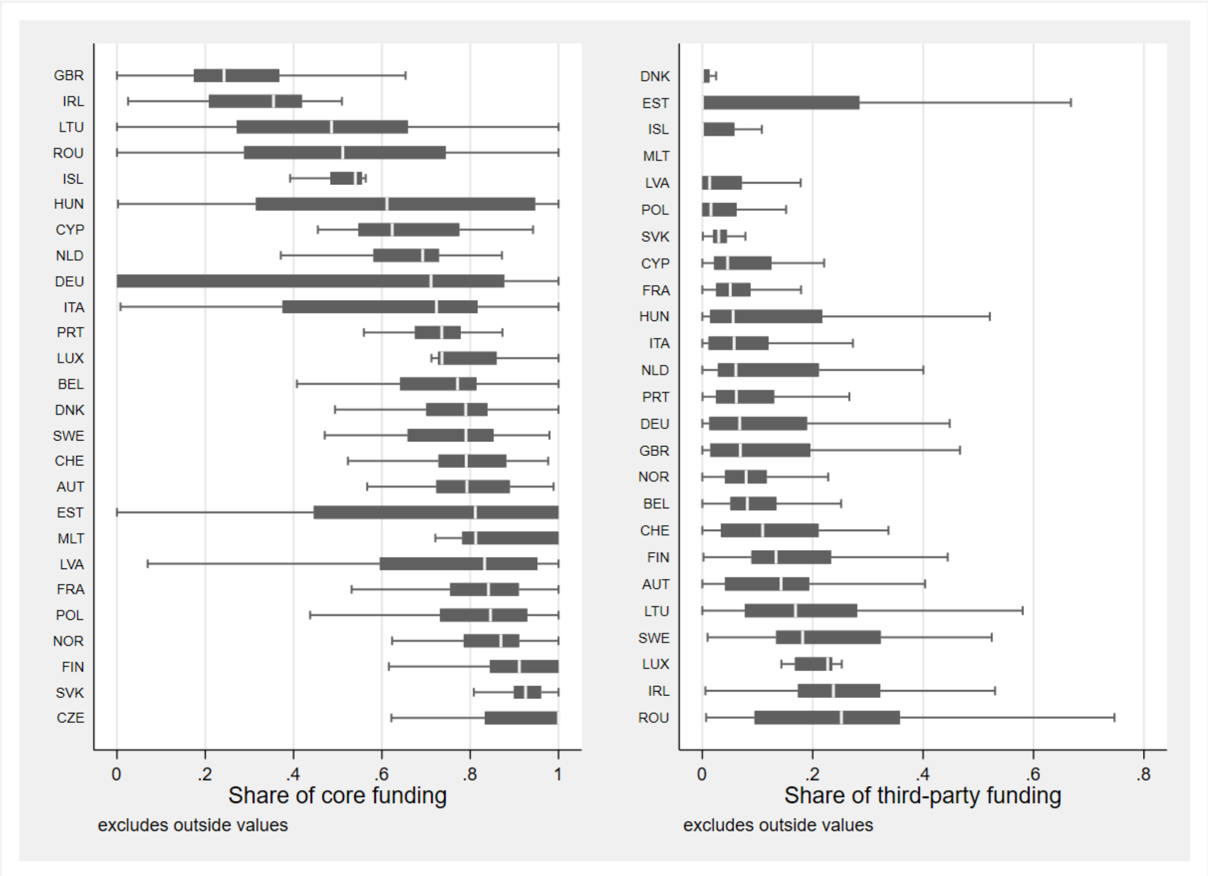

Note: Sample of 2886 HEIs fin 31 European countries (2011-2019).
Source: authors' own elaboration using PATSTAT Global (Autumn 2022), ETER and OrgReg.

### *3.2.3 Patenting and financial records*

European countries exhibit significant geographical diversity in the financing of HEIs, with strong differences in resources and their structure. The wealthiest institutions in our sample are located in Britain, the Netherlands, and Austria, with the largest total budget in proportion to staff. By comparison, Latvian HEIs operate with budgets 3 times smaller (Table A4 in Appendix). The shares of core budget and third-party funding also vary substantially both between and within countries (Figure 5). Czechia, Slovakia, and Finland show the highest share of core funding, Britain and Ireland the lowest. Significant within-country differences are found not only in larger countries like Germany, but also in Estonia and Latvia. When it comes to third-party funding, HEIs in Romania, Ireland, and Luxembourg have the highest shares, Denmark the lowest.

Do these financial features affect university patenting? At the aggregate level, we observe a correlation between the number of patent applications and the structure of the universities' funding (Figure 6). In particular, countries with larger shares of third-party funding also show more HEI patent applications. However, numerous other factors are at work here (see Section 2), so in the next section we present the outcomes of a detailed, institution-level analysis to determine how the structure of financial resources affects direct patenting by European institutions of higher education.

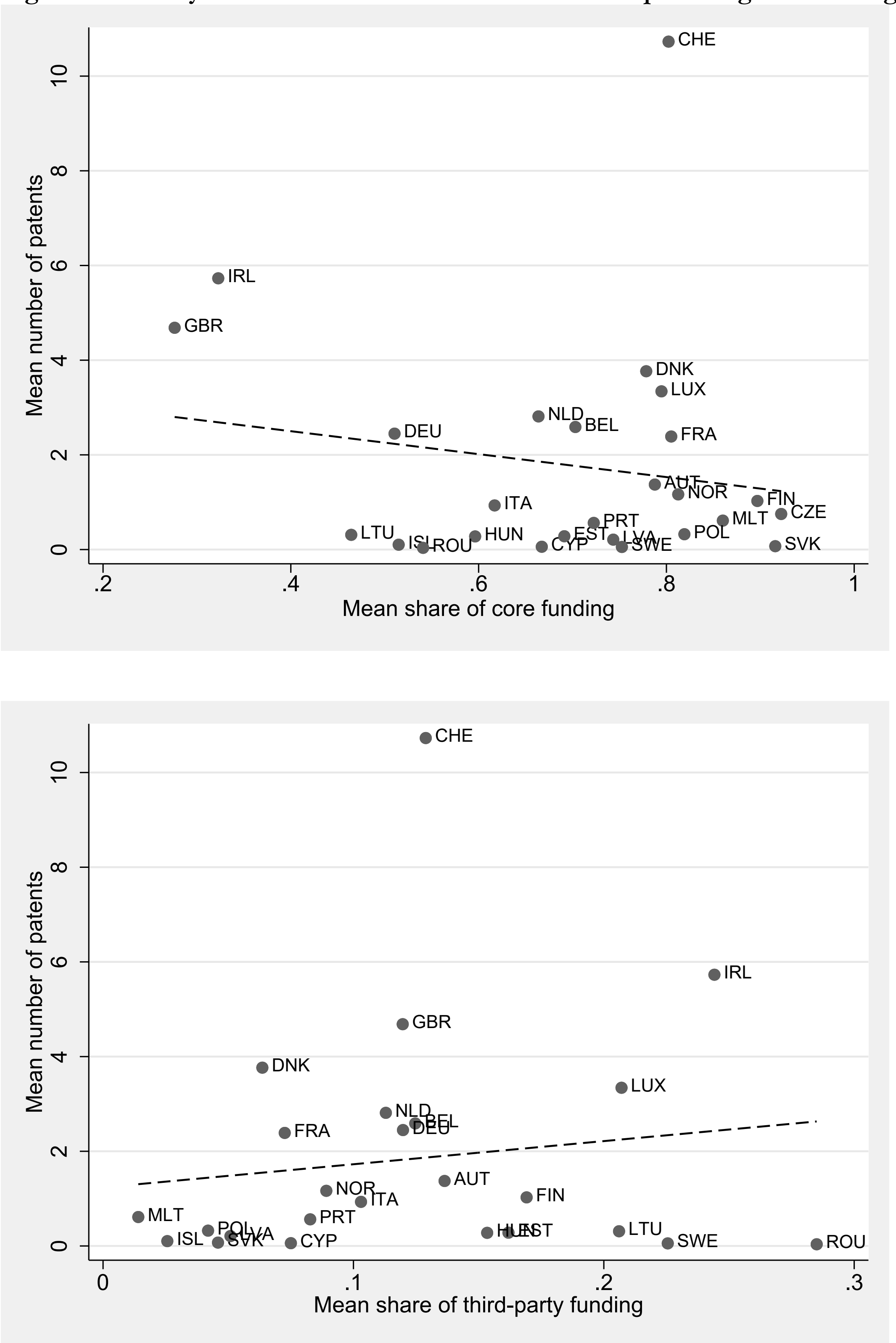
**Figure 5. Differences in HEIs' budget structures – variation between and within countries**




Note: Sample of 2886 HEIs in 31 European countries (2011-2019). Outside values, defined as observations below Q1−1.5×Interquartile Range (IQR) or above (Q3+1.5×IQR) are excluded.

Source: authors' own elaboration using ETER

**Figure 6. Country-level correlation between universities' patenting and funding structure**




Note: Mean national values calculated using a sample of 2886 HEIs in 31 European countries (2011-2019).
Source: authors' elaboration using PATSTAT Global (Autumn 2022) and ETER.

# 4. Empirical analysis

## 4.1 The basic model

Our dataset allows us to relate alternative indicators of HEIs' patenting activity (such as patent counts and patent citations) to a broad set of characteristics in terms of size, academic tradition, technical orientation, research efficiency (publication output), and regional and national conditions. Table A5 reports the correlation coefficients between the explanatory variables (they are low, so the problem of collinearity is not severe).

First, we estimate the following equation:

$$y_{irct} = \alpha + \beta_1 Age_i + \beta_2 GenUniv_i + \beta_3 STEM_{it} + \beta_4 Stud_{it} + \beta_5 Stud\_acad_{it} + \beta_6 Publ\_acad_{it} + \beta_7 Rev\_acad_{it} + \beta_8 Core\_budget_{it} + \beta_9 Third\_party_{it} + D_r + D_c + D_t + \epsilon_{irct} \quad (1)$$

where $i$ refers to the university located in region $r$ (NUTS2) and country $c$ while $t$ denotes time (year). The dependent variable, $y$, is either the number of university patent applications (IP5, FA) or an indicator of patent quality (forward citations). The set of independent variables includes the university's age ($Age_i$) calculated as 2020 minus the foundation year; institution type ($GenUniv_i$ stands for general university based on ETER nomenclature[16]), the proportion of students in STEM disciplines ($STEM_{it}$), number of students as proxy for institution size ($Stud_{it}$); student/academic staff ratio ($Stud\_acad_{it}$) as proxy for teaching load; scientific publications per academic staff member ($Publ\_acad_{it}$), reflecting research orientation. Our key variables of interest are financial: wealth, i.e. revenue per academic staff ($Rev\_acad_{it}$); and two indicators of funding structure, namely the budget shares of core funding ($Core\_budget_{it}$) and third-party funding ($Third\_party_{it}$). In all specifications, we include region ($D_r$), country ($D_c$) and time ($D_t$) effects to control for local differences, national rules (such as professors' privilege) and time trends.

The institution-level estimation results with number of university patents as dependent variable (Table 2) confirm the descriptive statistics in Figure 4: older, larger universities with a higher proportion of STEM students, lower student/teacher ratios and better publication records tend to have more patent applications. Patenting is significantly correlated with a lower share of core funding and a higher share of third-party revenues. Analogous estimations using a proxy for patent quality rather than number, i.e. forward citations of EPO patents[17], are similar (Table 3) , so we find that the institutional funding structure affects the number and the quality of patent applications filed by HEIs in a comparable manner.

[16] In ETER, "university" is defined as an HEI that has the right to award a doctorate. We call these "general universities" to distinguish them from other HEIs.

[17] In Table A11 we report the results obtained with forward citations of USPTO patents.

**Table 2. Basic estimation results – determinants of direct patent applications by HEIs**
**Dependent variable: number of patent applications to IP5 patent offices#**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.019*** | 0.019*** | 0.012*** | 0.010*** | 0.008*** | 0.013*** | 0.013*** | 0.013*** | 0.013*** |
| | [0.000] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| $GenUniv_i$ | 2.887*** | 2.443*** | 0.657*** | 0.23 | -0.037 | 1.526*** | 1.211*** | 1.044*** | 0.931*** |
| | [0.128] | [0.134] | [0.141] | [0.158] | [0.156] | [0.243] | [0.254] | [0.254] | [0.260] |
| $STEM_{it}$ | | 5.702*** | 4.820*** | 6.020*** | 4.356*** | 6.167*** | 6.526*** | 5.869*** | 6.024*** |
| | | [0.233] | [0.229] | [0.277] | [0.285] | [0.411] | [0.418] | [0.429] | [0.433] |
| $Stud_{it}$ | | | 0.222*** | 0.227*** | 0.200*** | 0.228*** | 0.241*** | 0.224*** | 0.231*** |
| | | | [0.007] | [0.008] | [0.008] | [0.010] | [0.011] | [0.011] | [0.011] |
| $Stud\_acad_{it}$ | | | | -0.055*** | -0.051*** | -0.074*** | -0.096*** | -0.059*** | -0.070*** |
| | | | | [0.004] | [0.004] | [0.008] | [0.008] | [0.008] | [0.009] |
| $Pub\_acad_{it}$ | | | | | 10.024*** | 10.467*** | 9.617*** | 8.019*** | 7.644*** |
| | | | | | [0.481] | [0.672] | [0.703] | [0.728] | [0.740] |
| $Rev\_acad_{it}$ | | | | | | 1.35 | 2.806** | 2.094 | 2.819** |
| | | | | | | [1.258] | [1.313] | [1.339] | [1.362] |
| $Core\_budget_{it}$ | | | | | | | -2.172*** | | -1.102*** |
| | | | | | | | [0.371] | | [0.399] |
| $Third\_party_{it}$ | | | | | | | | 9.827*** | 9.376*** |
| | | | | | | | | [0.821] | [0.864] |
| N | 18263 | 16976 | 16920 | 14833 | 14833 | 9639 | 9395 | 9072 | 9020 |
| R2 | 0.27 | 0.29 | 0.34 | 0.37 | 0.39 | 0.42 | 0.42 | 0.43 | 0.44 |
| Number of Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region-, country- and time-fixed effects. Standard errors in brackets, * p<0.10, ** p<0.05, *** p<0.01.
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER.

**Table 3. Basic estimation results – determinants of HEI patent quality**
**Dependent variable: forward citations of EPO patents #**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.015*** | 0.014*** | 0.009*** | 0.008*** | 0.007*** | 0.011*** | 0.011*** | 0.011*** | 0.011*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| $GenUniv_i$ | 1.985*** | 1.604*** | 0.430*** | 0.122 | -0.065 | 1.349*** | 1.137*** | 0.925*** | 0.887*** |
| | [0.139] | [0.147] | [0.158] | [0.181] | [0.180] | [0.284] | [0.297] | [0.298] | [0.306] |
| $STEM_{it}$ | | 5.416*** | 4.859*** | 6.083*** | 4.916*** | 6.861*** | 7.094*** | 6.695*** | 6.771*** |
| | | [0.257] | [0.257] | [0.317] | [0.328] | [0.479] | [0.489] | [0.503] | [0.509] |
| $Stud_{it}$ | | | 0.145*** | 0.149*** | 0.130*** | 0.145*** | 0.154*** | 0.142*** | 0.145*** |
| | | | [0.008] | [0.009] | [0.009] | [0.012] | [0.012] | [0.012] | [0.013] |
| $Stud\_acad_{it}$ | | | | -0.040*** | -0.037*** | -0.053*** | -0.067*** | -0.040*** | -0.045*** |
| | | | | [0.005] | [0.005] | [0.009] | [0.010] | [0.009] | [0.010] |
| $Pub\_acad_{it}$ | | | | | 7.028*** | 7.232*** | 6.791*** | 5.229*** | 5.064*** |
| | | | | | [0.555] | [0.783] | [0.822] | [0.854] | [0.870] |
| $Rev\_acad_{it}$ | | | | | | 0.038 | 0.923 | 0.593 | 0.956 |
| | | | | | | [1.466] | [1.535] | [1.572] | [1.601] |
| $Core\_budget_{it}$ | | | | | | | -1.390*** | | -0.475 |
| | | | | | | | [0.434] | | [0.468] |
| $Third\_party_{it}$ | | | | | | | | 8.168*** | 8.018*** |
| | | | | | | | | [0.964] | [1.016] |
| N | 18263 | 16976 | 16920 | 14833 | 14833 | 9639 | 9395 | 9072 | 9020 |
| r2 | 0.18 | 0.2 | 0.22 | 0.24 | 0.24 | 0.27 | 0.27 | 0.28 | 0.28 |
| Number of Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region-, country- and time-fixed effects. Standard errors in brackets, * p<0.10, ** p<0.05, *** p<0.01 # sum of forward citations in 5-year period of EPO patent applications.
Source: Authors' calculations using PATSTAT Global (autumn 2022), ETER, OrgReg, OECD/STI Micro-data.

## 4.2 Extended model – the role of regional systems

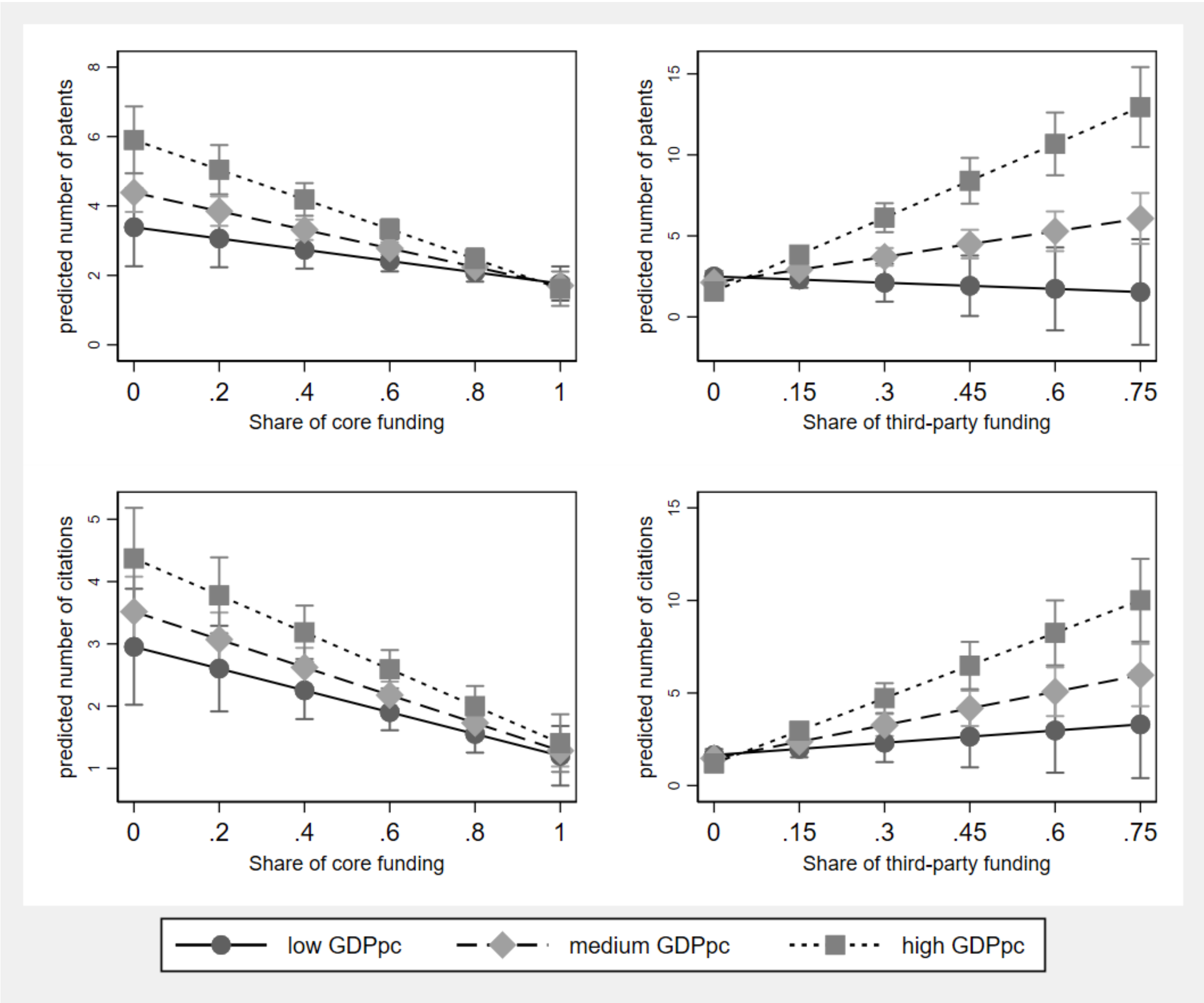
Following the literature (Lissoni et al., 2013; Rizzo and Ramaciotti, 2014; Bilbao-Osorio and Rodriguez-Pose, 2004) and the observed correlation between regional economic conditions and university patenting (Figures 2 and 3), we further investigate how university location and the regional economy influence the relationship between financing structure and patenting, re-estimating the models but now with NUTS2-level per capita GDP in lieu of the regional dummies and also considering its interaction with the funding structure variables:

$$y_{irct} = \alpha + \beta_1 Age_i + \beta_2 GenUniv_i + \beta_3 STEM_{it} + \beta_4 Stud_{it} + \beta_5 Stud\_acad_{it} + \beta_6 Publ\_acad_{it} + \beta_7 Rev\_acad_{it} + \beta_8 Core\_budget_{it} + \beta_9 GDPpc_{rt} + \beta_{10} Core\_budget_{it} \times GDPpc_{rt} + D_c + D_t + \epsilon_{irct} \quad (2)$$

$$y_{irct} = \alpha + \beta_1 Age_i + \beta_2 GenUniv_i + \beta_3 STEM_{it} + \beta_4 Stud_{it} + \beta_5 Stud\_acad_{it} + \beta_6 Publ\_acad_{it} + \beta_7 Rev\_acad_{it} + \beta_8 Third\_part_{it} + \beta_9 GDPpc_{rt} + \beta_{10} Third\_party_{it} \times GDPpc_{rt} + D_c + D_t + \epsilon_{irct} \quad (3)$$

Figure 7 illustrates this interaction effect through marginal plots (Appendix Table A6 details the estimation results): the horizontal axis represents the proportion of core or third-party funding, the vertical axis the predicted patent volume (upper panel) or forward citation count (lower panel). The three curves correspond to HEIs located in regions with low, medium, and high GDP per capita.[18].

**Figure 7. Regional systems' influence on university funding structure – patenting relationships: marginal plots from models (2) and (3)**




Note. Full estimation results are reported in Table A6 in the Appendix.
Source: Authors' calculations using PATSTAT Global (Autumn 2022), ETER, OrgReg, OECD/STI Micro-data and Eurostat data.

[18] The determination of low, medium and high GDP per capita is according to the distribution of European regions: low indicates the tenth percentile, medium the median, high the ninetieth percentile.

A larger core budget share corresponds to fewer patents and forward citations, and the decline is greater among universities in the wealthier regions (steeper slope for the high GDP line). The two outcomes (number of applications and patent quality) converge as core budget revenue increases. The relationship between third-party funding and patenting also differs by region, but the effect is the opposite of that for core funding: as the share of external funding increases, universities in medium- and high-income regions make more direct patent applications and receive more forward citations. For universities in low-income regions, however, increased third-party funding does not significantly affect either patent quantity or quality .

These results underscore the importance of university location in the relationship between funding sources and patenting. Increasing the core funding – which is typically stable, internal funding – may decrease both the quantity and the quality of patenting activity, especially in wealthier regions. Conversely, boosting third-party (external) funding appears to stimulate patent applications and patent citations in medium- and high-income regions but has little effect in low-income regions.

### 4.3 Extensions and robustness

To validate our results, we ran a number of robustness checks (see Appendix). First, we estimated models with lagged financial variables to account for potential delayed effects on patent/citation outcomes. Tables A7 and A8 confirm our main findings – core budget remains negatively correlated with patents/citations while third-party funding maintains its positive association. We then replaced regional GDP per capita with other NUTS2-level regional variables, such as: tertiary education attainment, employment in high-technology manufacturing, knowledge-intensive services, scientific activities, education sector participation, and higher education R&D expenditure per inhabitant. All these variables show statistically significant positive correlations with university patent applications/patent citations (Tables A9 and A10). Next, we tested our model using forward citations relating to USPTO rather than EPO (Table A11), again confirming our basic specifications.

To address potential biases produced by professors’ privilege in Sweden and Italy, we added country dummies for them. Our findings confirm the lower counts of patents and forward citations there (Tables A12 and A13), presumably because professors' privilege facilitates indirect patenting, academics applying for patents independently rather than through their institutions. Martinez and Sterzi (2000) find decreased technological importance and lower value of university-owned patents in countries that abolished professors' privilege.

We further validated our model by running regressions for patents granted only (rather than all applications), as shown in Table A14. This did not affect our conclusions regarding the impact of institutional characteristics on HEI patenting. Moreover, the estimations run on distinct subsamples – general universities, STEM universities, samples excluding universities of applied sciences, and samples excluding small institutions – did not significantly alter our benchmark results (Tables A15-A22).

## 5. Conclusions and policy implications

Cross-country empirical studies on university patenting remain scarce. We present novel empirical evidence based on a large micro-level dataset of nearly 2,900 universities in 31 European countries and 295 NUTS2 regions (2011-2019). Our research contributes to the literature on the determinants of market-oriented innovation in higher education (Baldini et al., 2006; Baldini, 2009; Geuna & Rossi, 2011; Gulbrandsen & Smeby, 2005; Acosta et al., 2012) by specifying the relationship between universities' funding structure and the quantity and quality of their patenting, conditional on regional economic effects.

Our baseline results, consistent with previous research (Gulbrandsen and Smeby, 2005; Lawson, 2013; Hottenrott and Thorwarth, 2011), indicate the significance of the relationship for third-party funding, i.e. its positive relationship with direct university patenting. Third-party funds, which as a rule are earmarked for specific activities and institutional units, generate stronger effects on university patenting. Consequently, our findings support the view that alternative funding sources more effectively stimulate applied, innovative, and commercially relevant research (Geuna, 2001; Angori et al., 2023; Yu et al., 2022), and hence more patent applications. The absence of a positive impact of core funding on patenting may reflect its general-purpose nature, allowing universities to distribute funds across various institutional needs apart from patent-generating research. This finding is consistent with the observation of a negligible effect of government funding on university patenting Krieger (2024).

We have shown that on a European-wide basis the interaction between regional system and universities' funding structure produces distinct patenting patterns. The positive impact of third-party funding on patenting is strongest in highly developed regions, diminishes in the less developed, and turns insignificant in the poorest. This supports the thesis that regional mechanisms as such, over and above university-level factors, are important drivers of universities' research performance (Lissoni et al., 2013; Bilbao-Osorio & Rodriguez-Pose, 2004; Baldini et al., 2006; Baldini, 2009; Caviggioli et al., 2023b; Rizzo & Ramaciotti, 2014; Ejermo & Källström, 2016; Anselin et al., 2000; Garcia & Araújo, 2022). In particular, our findings are in keeping with studies of smaller samples, such as Bilbao-Osorio and Rodriguez-Pose (2004), whose analysis of NUTS2 regions in nine European countries showed that regional socio-economic factors influence the capacity to transform R&D into innovation, or Rizzo and Ramaciotti (2014), who document location-specific effects on patenting in the Italian university system.

Our findings on the significant influence of regional conditions on the relationship between patenting and university funding carry important policy implications. First of all, there must be support for regional industrial development and innovation networks, insofar as universities operate as part of local systems and are closely dependent on them. The strong core-periphery pattern in European university patenting, combined with the reciprocal stimulation of local economic performance and university patenting, should heighten our awareness of the risk of exacerbating regional disparities (Maraut et al., 2008; Bilbao-Osorio & Rodriguez-Pose, 2004). Consequently, the public action for stimulating HEIs' patenting needs to be region-specific, in that tailor-made policies can respond to the different realities of the target areas and thus help to avoid a vicious circle in which the periphery is left behind. In the wealthiest regions, in fact, a higher share of core funding may actually undercut the quantity and quality of patents. In those regions, consequently, policy should encourage universities to diversify and increase their external research funding to enhance innovation outputs. At the same time, different support mechanisms are needed for universities in low-income regions, given that more third-party funding alone does not significantly improve their patenting performance: other channels, such as improving the skill composition of the labour force and promoting entrepreneurship in innovative industries, may serve their needs better.

Finally, it should be borne in mind that patenting is only one of the outputs of university research (Lee, 2021; Gulbrandsen & Smeby, 2005; Yu et al., 2022; Whalley & Hicks, 2014; Hottenrott & Thorwarth, 2011; Payne & Siow, 2003; Jain et al., 2020). Accordingly, we do not advocate any dramatic shift from core to alternative funding. Diversified funding can make resource allocation fairer and prevent self-reinforcing mechanisms that widen the gaps between successful and struggling institutions (Geuna, 2001). Core funding remains essential for universities in the less developed regions; it enables them to serve as the pillars of local innovation networks (EPO, 2024), which benefits the local economy and ultimately enhances university research output.

This paper demonstrates, lastly, that large-scale, micro-level empirical studies on university patenting are feasible. There remain a number of voids in research that future studies could address, such as distinguishing between different types of patents (e.g. AI patents and those in other technological fields); evaluating the effectiveness of various models of university-industry collaboration under diverse funding structures and their impact on the commercialization of academic inventions; and analysing the role of knowledge transfer offices. Additionally, we need in-depth analysis of the higher education system in the United States, to examine the causal relationship between different funding sources and the quantity and quality of university patenting, in order to compare it with the European context.

## References


Acosta, M., Coronado, D., & Martínez, M. Á. (2012). Spatial differences in the quality of university patenting: Do regions matter? *Research Policy*, *41*(4), 692–703. https://doi.org/10.1016/j.respol.2012.01.002

Acosta, M., Coronado, D., León, M. D., & Martínez, M. Á. (2009). Production of university technological knowledge in European regions: Evidence from patent data. *Regional Studies*, *43*(9), 1167–1181. https://doi.org/10.1080/00343400802154573

Andersen, B., & Rossi, F. (2011). UK universities look beyond the patent policy discourse in their intellectual property strategies. *Science and Public Policy*, *38*(4), 254–268. https://doi.org/10.3152/016502611X12849792159236

Andrews, D., C. Criscuolo and C. Menon (2014), "Do Resources Flow to Patenting Firms?: Cross-Country Evidence from Firm Level Data", *OECD Economics Department Working Papers*, No. 1127, OECD Publishing, Paris, https://doi.org/10.1787/5jz2lpmk0gs6-en.

Angori, G., Marzocchi, C., Ramaciotti, L., & Rizzo, U. (2023). A patent-based analysis of the evolution of basic, mission-oriented, and applied research in European universities. *The Journal of Technology Transfer*. https://doi.org/10.1007/s10961-023-10001-5

Anselin, L., Varga, A., & Acs, Z. J. (2000). Geographic and sectoral characteristics of academic knowledge externalities. *Papers in Regional Science*, *79*(4), 435–443. https://doi.org/10.1007/PL00011486/METRICS

Azagra-Caro, J. M., Yegros-Yegros, A., & Archontakis, F. (2006). What do university patent routes indicate at regional level? *Scientometrics*, *66*(1), 219–230. https://doi.org/10.1007/s11192-006-0015-2

Azoulay, P., Ding, W., & Stuart, T. (2007). The determinants of faculty patenting behavior: Demographics or opportunities? *Journal of Economic Behavior and Organization*, *63*(4), 599–623. https://doi.org/10.1016/j.jebo.2006.05.015

Baldini, N. (2009). Implementing Bayh-Dole-like laws: Faculty problems and their impact on university patenting activity. *Research Policy*, *38*(8), 1217–1224. https://doi.org/10.1016/j.respol.2009.06.013

Baldini, N., Grimaldi, R., & Sobrero, M. (2006). Institutional changes and the commercialization of academic knowledge: A study of Italian universities' patenting activities between 1965 and 2002. *Research Policy*, *35*(4), 518–532. https://doi.org/10.1016/j.respol.2006.01.004

Bilbao-Osorio, B., & Rodríguez-Pose, A. (2004). From R&D to Innovation and Economic Growth in the EU. *Growth and Change*, *35*(4), 434–455. https://doi.org/10.1111/J.1468-2257.2004.00256.X

Carlsson, B., & Fridh, A. C. (2002). Technology transfer in United States universities. *Journal of Evolutionary Economics*, *12*(1–2), 199–232. https://doi.org/10.1007/s00191-002-0105-0

Caviggioli, F., Colombelli, A., De Marco, A., Scellato, G., & Ughetto, E. (2023a). Co-evolution patterns of university patenting and technological specialization in European regions. *The Journal of Technology Transfer*, *48*(1), 216–239. https://doi.org/10.1007/s10961-021-09910-0

Caviggioli. F., Colombelli. A., De Marco. A., Scellato. G., & Ughetto. E. (2023b). The Impact of University Patenting on the Technological Specialization of European Regions: A Technology-Level Analysis. *Technological Forecasting and Social Change. 188*. https://doi.org/10.2139/ssrn.4040647

Cesaroni, F., & Piccaluga, A. (2002). Patenting Activity of European Universities . Relevant ? Growing ? Useful ? In Conference "Rethinking Science Policy: Analytical Frameworks for Evidence-Based Policy" (pp. 1–22). SPRU, University of Sussex, Brighton.

Chalioti, E., Drivas, K., Kalyvitis, S., & Katsimi, M. (2020). Innovation, patents and trade: A firm-level analysis. *Canadian Journal of Economics*, *53*(3), 949–981. https://doi.org/10.1111/caje.12451

Compagnucci, L., & Spigarelli, F. (2020). The third mission of the university: A systematic literature review on potentials and constraints. *Technological Forecasting and Social Change, 161*, 120284.

Coupé, T. (2003). Science Is Golden: Academic R&D and University Patents. *The Journal of Technology Transfer*, *28*(1), 31–46. https://doi.org/10.1023/A:1021626702728

Czarnitzki, D., Glänzel, W., & Hussinger, K. (2007). Patent and publication activities of German professors: An empirical assessment of their co-activity. *Research Evaluation*, *16*(4), 311–319. https://doi.org/10.3152/095820207X254439

Draghi (2024). The future of European competitiveness – A competitiveness strategy for Europe. European Commission. https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en [date of access: Jan 16, 2025]

Dornbusch, F., Schmoch, U., Schulze, N., & Bethke, N. (2013). Identification of university-based patents: A new large-scale approach. *Research Evaluation*, *22*(1), 52-63.

Ejermo, O., & Källström, J. (2016). What is the causal effect of R&D on patenting activity in a "professor's privilege" country? Evidence from Sweden. *Small Business Economics*, *47*(3), 677–694. https://doi.org/10.1007/s11187-016-9752-7

EPO (2024). The role of European universities in patenting and innovation. European Patent Office. https://link.epo.org/web/publications/studies/en-the-role-of-european-universities-in-patenting-and-innovation.pdf [date of access: Jan 28, 2025]

Ertugrul, M., Krishnan, K., & Yu, Q. (2024). Knowledge spillover and entrepreneurship: Evidence from BITNET. *Research Policy, 53*(9), 105091.

Foltz, J., Barham, B., & Kim, K. (2000). Universities and agricultural biotechnology patent production. *Agribusiness*, *16*(1), 82–95. https://doi.org/10.1002/(SICI)1520-6297(200024)16:1<82::AID-AGR7>3.0.CO;2-V

Foray, D., & Lissoni, F. (2010). University Research and Public–Private Interaction. *Handbook of the Economics of Innovation*, *1*(1 C), 275–314. https://doi.org/10.1016/S0169-7218(10)01006-3

Garcia, R., & Araújo, V. (2022). Determinants of university and industrial patents in Brazilian regions: a Spatial Panel Approach. *Blucher Engineering Proceedings, 9*(1), 555–569. https://doi.org/10.5151/vi-enei-892

Geuna, A. (2001). The changing rationale for European university research funding: Are there negative unintended consequences? *Journal of Economic Issues*, *35*(3), 607–632. https://doi.org/10.1080/00213624.2001.11506393

Geuna, A., & Nesta, L. J. J. (2006). University patenting and its effects on academic research: The emerging European evidence. *Research Policy*, *35*(6), 790–807. https://doi.org/10.1016/j.respol.2006.04.005

Geuna, A., & Rossi, F. (2011). Changes to university IPR regulations in Europe and the impact on academic patenting. *Research Policy*, *40*(8), 1068–1076. https://doi.org/10.1016/j.respol.2011.05.008

Graf, H., & Menter, M. (2022). Public research and the quality of inventions: the role and impact of entrepreneurial universities and regional network embeddedness. *Small Business Economics*, *58*(2), 1187–1204. https://doi.org/10.1007/s11187-021-00465-w

Grimm, H. M., & Jaenicke, J. (2012). What drives patenting and commerzialisation activity at East German universities? The role of new public policy, institutional environment and individual prior knowledge. *The Journal of Technology Transfer, 37,* 454-477.

Guerzoni, M., Taylor Aldridge, T., Audretsch, D. B., & Desai, S. (2014). A new industry creation and originality: Insight from the funding sources of university patents. *Research Policy*, *43*(10), 1697–1706. https://doi.org/10.1016/j.respol.2014.07.009

Gulbrandsen, M., & Smeby, J. C. (2005). Industry funding and university professors' research performance. *Research Policy*, *34*(6), 932–950. https://doi.org/10.1016/j.respol.2005.05.004

Hottenrott, H., & Thorwarth, S. (2011). Industry Funding of University Research and Scientific Productivity. *Kyklos*, *64*(4), 534–555. https://doi.org/10.1111/j.1467-6435.2011.00519.x

Hvide, H. K., & Jones, B. F. (2018). University innovation and the professor's privilege. *American Economic Review*, *108*(7), 1860–1898. https://doi.org/10.1257/aer.20160284

Igna, I., & Venturini, F. (2023). The determinants of AI innovation across European firms. *Research Policy*, *52*(2), 104661. https://doi.org/https://doi.org/10.1016/j.respol.2022.104661

Jaffe, A. B. (1989). Real effects of academic research. *The American Economic Review*, 957-970.

Jain, A., Sharma, R., & Ilavarasan, P. V. (2020). Public funds and outputs in higher academic technical institutions: insights from India. *Technology Analysis and Strategic Management*, *32*(9), 1007–1019. https://doi.org/10.1080/09537325.2020.1737324

Janger, J. (2019). Universities' Role in Regional Innovation Reconsidered: Looking at the Bottom of the Iceberg. In *Under Pressure. Higher Education Institutions Coping with Multiple Challenges*, ed. by Pedro N. Teixeira, Amélia Veiga, Maria J. Rosa, & António Magalhães, 11:235–49. Higher Education Research in the 21st Century Series. Leiden: Brill Sense, 2019. https://brill.com/view/book/edcoll/9789004398481/BP000014.xml.

Krieger, B. (2024). Heterogeneous university funding programs and regional firm innovation: An empirical analysis of the German Excellence Initiative. *Research Policy*, *53*(5), 104995. https://doi.org/10.1016/j.respol.2024.104995

Lawson, C. (2013). Academic patenting: The importance of industry support. *Journal of Technology Transfer*, *38*(4), 509–535. https://doi.org/10.1007/s10961-012-9266-7

Lee, Y. H. (2021). Determinants of research productivity in Korean Universities: the role of research funding. *Journal of Technology Transfer*, *46*(5), 1462–1486. https://doi.org/10.1007/s10961-020-09817-2

Lepori, B. (2023). European Tertiary Education Register (ETER) Handbook for Data Collection. Zenodo. https://doi.org/10.5281/zenodo.10065818

Lepori, B., Lambrechts, A. A., Wagner-Schuster, D., & Zahradnik, G. (2023). The European Tertiary Education Register, the reference dataset on European higher education institutions. *Scientific data*, *10*(1), 438.

Link, A. N., & van Hasselt, M. (2019). On the transfer of technology from universities: The impact of the Bayh–Dole Act of 1980 on the institutionalization of university research. *European Economic Review, 119,* 472-481.

Lissoni, F., Lotz, P., Schovsbo, J., & Treccani, A. (2009). Academic patenting and the professor's privilege: Evidence on Denmark from the KEINS database. *Science and Public Policy*, *36*(8), 595–607. https://doi.org/10.3152/030234209X475443

Lissoni, F., Pezzoni, M., Poti', B., & Romagnosi, S. (2013). University Autonomy, the Professor Privilege and Academic Patenting: Italy, 1996-2007. *Industry and Innovation*, *20*(5), 399–421. https://doi.org/10.1080/13662716.2013.824192

Lotti, F., & Marin, G. (2013). *Matching of PATSTAT applications to AIDA firms: discussion of the methodology and results* (No. 166). *Questioni di Economia e Finanza.*

Maraut, S., Dernis, H., Webb, C., Spiezia, V., & Guellec, D. (2008). *The OECD REGPAT database: a presentation (No. 2008/02). OECD Science, Technology and Industry Working Papers.* Paris. https://doi.org/10.1787/241437144144

Marczewska, M., & Weresa, M. A. (2022). Creativity and Innovation in Polish Universities: The Knowledge Triangle Approach. *Communications in Computer and Information Science*, *1593 CCIS*, 145–159. https://doi.org/10.1007/978-3-031-07920-7_12

Martínez, C., & Sterzi, V. (2020). The impact of the abolishment of the professor's privilege on European university-owned patents. *Industry and Innovation*, 28(3), 247–282. https://doi.org/10.1080/13662716.2019.1709421

Mathew, M., Arunagiri, S., & Nag, D. (2012). A comparison of North American Universities with and without Medical Schools and their technology transfer initiatives. *2012 Proceedings of Portland International Center for Management of Engineering and Technology: Technology Management for Emerging Technologies, PICMET'12*, 1684–1691.

Meyer, M. (2003). Academic patents as an indicator of useful research? A new approach to measure academic inventiveness. *Research Evaluation, 12(*1), 17-27.

Neuhäusler, P., & Frietsch, R. (2024, November 12). Academic patenting in the EU-27, Switzerland and Canada: changing patterns and differences across countries. The 28th International Conference on Science, Technology and Innovation Indicators, 2024 (STI2024), Berlin, Germany. https://doi.org/10.5281/zenodo.14101139

Nugent, A., Chan, H. F., & Dulleck, U. (2022). Government funding of university-industry collaboration: exploring the impact of targeted funding on university patent activity. Scientometrics (Vol. 127). https://doi.org/10.1007/s11192-021-04153-0

Parteka, A., Płatkowski, P., Szymczak, S., & Wolszczak-Derlacz, J. (2024). A dataset on knowledge creation and patenting by European Higher Education Institutions (KC-HEI). GUT FME Working Paper Series A. No. 2/2024 (73). https://www.econstor.eu/handle/10419/300341

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'este, P., ... & Sobrero, M. (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy*, *42*(2), 423-442.

Payne, A. A., & Siow, A. (2003). Does Federal Research Funding Increase University Research Output? Retrieved from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=6d14d708f9eac5949d466aee0cf836a68aa350d9

Parteka P., Płatkowski P., Szymczak S., Wolszczak-Derlacz J. (2024). *A dataset on knowledge creation and patenting by European Higher Education Institutions (KC-HEI).* GUT FME Working Papers Series A, No 2/2024(73). Gdansk (Poland): Gdansk University of Technology, Faculty of Management and Economics.

Płatkowski P., Szymczak S, Parteka A., Wolszczak-Derlacz J. (2024). PATSTAT-ETER crosswalk. https://doi.org/10.34808/h4h3-2k20

Rizzo, U., & Ramaciotti, L. (2014). The determinants of academic patenting by Italian universities. *Technology Analysis and Strategic Management*, *26*(4), 469–483. https://doi.org/10.1080/09537325.2014.882502

Schaeffer, P. R., Fischer, B., & Queiroz, S. (2018). Beyond education: The role of research universities in innovation ecosystems. *Foresight and STI Governance*, *12*(2), 50–61. https://doi.org/10.17323/2500-2597.2018.2.50.61

Schoellman, T., & Smirnyagin, V. (2021). *The Growing Importance of Universities for Patenting and Innovation.* Available at SSRN: https://ssrn.com/abstract=3911375 or http://dx.doi.org/10.2139/ssrn.391137 5

Squicciarini, M., Dernis, H., & Criscuolo, C. (2013). *Measuring Patent Quality: Indicators of Technological and Economic Value* (OECD Science, Technology and Industry Working Papers No. 2013/03). Paris. https://doi.org/10.1787/5k4522wkw1r8-en

Tabakovic, H., & Wollmann, T. G. (2019). The impact of money on science: Evidence from unexpected NCAA football outcomes. *Journal of Public Economics*, *178*, 104066. https://doi.org/10.1016/j.jpubeco.2019.104066

Verspagen, B. (2006). University Research, Intellectual Property Rights and European Innovation Systems. *Journal of Economic Surveys, 20*(4), 607–632.

Whalley, A., & Hicks, J. (2014). Spending Wisely? How Resources Affect Knowledge Production In Universities. *Economic Inquiry*, *52*(1), 35–55. https://doi.org/10.1111/ECIN.12011

WIPO (2024). WIPO Statistics Database, November 2024 https://www.wipo.int/en/ipfactsandfigures/patents [date of access: Jan 14, 2025]

Wolszczak-Derlacz, J. (2025). The determinants of European universities patenting and co-patenting with companies. *The Journal of Technology Transfer, 50,* 620-636. https://doi.org/10.1007/s10961-024-10112-7

Yamaguchi, Y., Fujimoto, J., Yamazaki, A., & Koshiyama, T. (2019). Analysis of the factors influencing patent creation and patent-based technology transfer in universities. In *2019 Portland International Conference on Management of Engineering and Technology (PICMET)* (Vol. 0).

Yang J., Hamdan-Livramento, I., Feuvre, B.L., Wunsch-Vincent, S., & Zhou, H. (2021). Measuring Global Patenting of Universities and Public Research Institutes. In A. Arundel, S. Athreye, & S. Wunsch-Vincent (Eds.), *Harnessing Public Research for Innovation in the 21st Century: An International Assessment of Knowledge Transfer Policies* (pp. 80–138). chapter, Cambridge: Cambridge University Press.

Yu, N., Dong, Y., & de Jong, M. (2022). A helping hand from the government? How public research funding affects academic output in less-prestigious universities in China. *Research Policy*, *51*(10), 104591. https://doi.org/10.1016/j.respol.2022.104591

**Appendix:** see below

**Replication package:** as supplementary materials, we provide Stata do-files enabling other researchers to replicate our results (available upon request - see footnote 3).

# Appendix to the paper:
# "Funding structure and university patenting: An analysis of European higher education institutions"

**Table A1. Patenting and non-patenting universities - across countries and by HEI type**

| | All HEIS | | STEM | | General universities | |
|---|---|---|---|---|---|---|
| country | number | % of patenting | number | % of patent-ing | number | % of patent-ing |
| AUT | 71 | 31.0 | 39 | 51.3 | 56 | 39.3 |
| BEL | 159 | 10.1 | 47 | 21.3 | 55 | 29.1 |
| BGR | 51 | 3.9 | 34 | 5.9 | 18 | 5.6 |
| CHE | 38 | 52.6 | 18 | 94.4 | 20 | 90.0 |
| CYP | 31 | 6.5 | 21 | 9.5 | 27 | 7.4 |
| CZE | 77 | 23.4 | 32 | 53.1 | 30 | 60.0 |
| DEU | 400 | 37.3 | 232 | 62.9 | 293 | 49.8 |
| DNK | 43 | 14.0 | 29 | 20.7 | 42 | 14.3 |
| ESP | 79 | 78.5 | 76 | 81.6 | 73 | 79.5 |
| EST | 29 | 10.3 | 12 | 16.7 | 27 | 11.1 |
| FIN | 47 | 34.0 | 38 | 42.1 | 47 | 34.0 |
| FRA | 392 | 37.0 | 202 | 66.3 | 101 | 80.2 |
| GBR | 257 | 40.1 | 157 | 63.1 | 124 | 78.2 |
| GRC | 57 | 22.8 | 45 | 28.9 | 43 | 30.2 |
| HRV | 42 | 7.1 | 27 | 11.1 | 40 | 7.5 |
| HUN | 49 | 12.2 | 26 | 23.1 | 45 | 13.3 |
| IRL | 26 | 65.4 | 22 | 68.2 | 18 | 72.2 |
| ISL | 7 | 14.3 | 6 | 16.7 | 7 | 14.3 |
| ITA | 217 | 28.1 | 80 | 73.8 | 86 | 68.6 |
| LTU | 41 | 14.6 | 28 | 21.4 | 40 | 15.0 |
| LUX | 3 | 33.3 | 1 | 100.0 | 2 | 50.0 |
| LVA | 48 | 8.3 | 25 | 16.0 | 24 | 16.7 |
| MLT | 4 | 25.0 | 2 | 50.0 | 1 | 100.0 |
| NLD | 61 | 19.7 | 38 | 31.6 | 60 | 20.0 |
| NOR | 54 | 20.4 | 34 | 32.4 | 38 | 28.9 |
| POL | 284 | 14.8 | 216 | 19.4 | 87 | 48.3 |
| PRT | 114 | 16.7 | 64 | 29.7 | 109 | 17.4 |
| ROU | 86 | 11.6 | 9 | 33.3 | 12 | 33.3 |
| SVK | 31 | 19.4 | 18 | 33.3 | 25 | 24.0 |
| SVN | 51 | 5.9 | 12 | 25.0 | 46 | 6.5 |
| SWE | 37 | 13.5 | 28 | 17.9 | 27 | 18.5 |
| **Total** | **2886** | | **1618** | | **1623** | |
| **Mean** | | **27.2** | | **45.9** | | **42.7** |

Source: Authors' own calculations

**Table A2 Summary statistics – all sample (2886 HEIs, 2011-2019)**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Number of patent applications | 18922 | 1.78 | 7.64 | 0.00 | 192.83 |
| Number of citations (*100) | 18922 | 1.31 | 7.88 | 0.00 | 306.81 |
| Age (years) | 18268 | 72.51 | 114.43 | 0.00 | 932.00 |
| Share of students in STEM | 17331 | 0.19 | 0.26 | 0.00 | 1.00 |
| Students in thousands | 17618 | 6.57 | 10.11 | 0.04 | 50.16 |
| Students per academic staff | 15055 | 19.29 | 15.44 | 2.37 | 95.57 |
| Publication per academic staff | 15117 | 0.10 | 0.16 | 0.00 | 0.90 |
| Revenues per academic staff in millions euro | 9857 | 0.16 | 0.09 | 0.02 | 0.54 |
| Share of core funding | 10012 | 0.62 | 0.32 | 0.00 | 1.00 |
| Share of third-party funding | 9654 | 0.11 | 0.14 | 0.00 | 0.75 |

Source: Authors' own calculations

**Table A3. Summary statistics - patenting and non-patenting universities (2011-2019)**

**Patenting (n=785)**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Age (years) | 4067 | 155.55 | 191.11 | 0.00 | 932.00 |
| Share of students in STEM | 4214 | 0.36 | 0.25 | 0.00 | 1.00 |
| Students in thousands | 4225 | 18.31 | 12.74 | 0.04 | 50.16 |
| Students per academic staff | 4094 | 15.28 | 8.91 | 2.37 | 95.57 |
| Publication per academic staff | 4112 | 0.25 | 0.20 | 0.00 | 0.90 |
| Revenues per academic staff in millions euro | 3601 | 0.17 | 0.07 | 0.02 | 0.54 |
| Share of core funding | 3597 | 0.65 | 0.24 | 0.00 | 1.00 |
| Share of third-party funding | 3453 | 0.18 | 0.13 | 0.00 | 0.75 |

**Non-Patenting (n=2101)**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Age (years) | 14201 | 48.73 | 62.02 | 0.00 | 730.00 |
| Share of students in STEM | 13117 | 0.13 | 0.24 | 0.00 | 1.00 |
| Students in thousands | 13393 | 2.87 | 5.10 | 0.04 | 50.16 |
| Students per academic staff | 10961 | 20.79 | 17.01 | 2.37 | 95.57 |
| Publication per academic staff | 11005 | 0.04 | 0.10 | 0.00 | 0.90 |
| Revenues per academic staff in millions euro | 6256 | 0.15 | 0.09 | 0.02 | 0.54 |
| Share of core funding | 6415 | 0.60 | 0.36 | 0.00 | 1.00 |
| Share of third-party funding | 6201 | 0.08 | 0.13 | 0.00 | 0.75 |

Source: Authors' own calculations

**Table A4. Summary statistics (mean values of universities' characteristics) at the country level**

| country | Number of patent applications | Age in years | STEM in % | Students total in thousands | Students per academic staff | Publications per academic staff | Revenues per academic staff millions of PPS euro | Core budget (% of total funds) | Third-party funding (% of total funds) |
|---|---|---|---|---|---|---|---|---|---|
| AUT | 1.37 | 75 | 0.14 | 4.45 | 11.56 | 0.07 | 0.20 | 0.79 | 0.14 |
| BEL | 2.59 | 78 | 0.10 | 6.44 | 20.94 | 0.24 | 0.12 | 0.70 | 0.12 |
| BGR | 0.01 | 54 | 0.24 | 4.64 | 16.46 | 0.02 | n.a. | n.a. | n.a. |
| CHE | 10.73 | 74 | 0.13 | 5.72 | 8.10 | 0.09 | 0.16 | 0.80 | 0.13 |
| CYP | 0.06 | 28 | 0.17 | 1.48 | 21.96 | 0.08 | 0.14 | 0.67 | 0.08 |
| CZE | 0.75 | 53 | 0.12 | 4.36 | 26.71 | 0.10 | 0.14 | 0.92 | |
| DEU | 2.45 | 88 | 0.18 | 6.67 | 19.76 | 0.06 | 0.15 | 0.51 | 0.12 |
| DNK | 3.77 | 50 | 0.24 | 7.42 | 12.77 | 0.16 | 0.15 | 0.78 | 0.06 |
| ESP | 2.71 | 127 | 0.23 | 18.88 | 20.78 | 0.18 | n.a. | n.a. | n.a. |
| EST | 0.28 | 58 | 0.19 | 2.07 | 12.92 | 0.14 | 0.18 | 0.69 | 0.16 |
| FIN | 1.03 | 44 | 0.28 | 6.32 | 16.79 | 0.12 | 0.12 | 0.90 | 0.17 |
| FRA | 2.39 | 74 | 0.50 | 7.75 | 20.31 | 0.27 | 0.18 | 0.81 | 0.07 |
| GBR | 4.68 | 116 | 0.13 | 9.18 | 16.61 | 0.19 | 0.23 | 0.28 | 0.12 |
| GRC | 0.08 | 46 | 0.29 | 11.09 | 38.65 | 0.11 | n.a. | n.a. | n.a. |
| HRV | 0.04 | 20 | 0.23 | 2.90 | 19.46 | 0.04 | n.a. | n.a. | n.a. |
| HUN | 0.28 | 86 | 0.10 | 4.21 | 18.14 | 0.03 | 0.17 | 0.60 | 0.15 |
| IRL | 5.73 | 95 | 0.24 | 8.81 | 16.52 | 0.16 | 0.17 | 0.32 | 0.24 |
| ISL | 0.10 | 32 | 0.16 | 2.26 | 19.00 | 0.25 | 0.17 | 0.51 | 0.03 |
| ITA | 0.93 | 130 | 0.08 | 7.50 | 13.82 | 0.08 | 0.17 | 0.62 | 0.10 |
| LTU | 0.31 | 37 | 0.19 | 2.88 | 20.46 | 0.04 | 0.08 | 0.46 | 0.21 |
| LUX | 3.34 | 12 | 0.21 | 4.90 | 4.56 | 0.18 | 0.15 | 0.79 | 0.21 |
| LVA | 0.21 | 30 | 0.16 | 1.45 | 24.99 | 0.04 | 0.07 | 0.74 | 0.05 |
| MLT | 0.61 | 71 | 0.20 | 3.37 | 10.60 | 0.03 | 0.07 | 0.86 | 0.01 |
| NLD | 2.81 | 76 | 0.13 | 12.68 | 16.63 | 0.15 | 0.21 | 0.66 | 0.11 |
| NOR | 1.16 | 45 | 0.13 | 5.54 | 17.59 | 0.13 | 0.17 | 0.81 | 0.09 |
| POL | 0.32 | 39 | 0.14 | 4.39 | 25.90 | 0.02 | 0.09 | 0.82 | 0.04 |
| PRT | 0.56 | 47 | 0.12 | 2.58 | 12.91 | 0.07 | 0.11 | 0.72 | 0.08 |
| ROU | 0.04 | 37 | 0.32 | 5.19 | 24.48 | 0.09 | 0.10 | 0.54 | 0.29 |
| SVK | 0.07 | 33 | 0.08 | 4.06 | 12.35 | 0.11 | 0.09 | 0.92 | 0.05 |
| SVN | 0.30 | 15 | 0.16 | 2.22 | 11.05 | 0.15 | n.a. | n.a. | n.a. |
| SWE | 0.05 | 66 | 0.18 | 9.82 | 20.35 | 0.23 | 0.18 | 0.75 | 0.23 |

Source: Authors' own calculations

**Table A5. Partial correlations between university-level variables**

| | Number of patent applications | Number of citations (*100) | Age (years) | Share of students inn STEM | Students in thousands | Students per academic staff | Publication per academic staff | Revenues per academic staff in millions | Share of core funding | Share of third-party funding |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of patent applications | 1.000 | | | | | | | | | |
| Number of citations (*100) | 0.757 | 1.000 | | | | | | | | |
| Age (years) | 0.318 | 0.232 | 1.000 | | | | | | | |
| Share of students in STEM | 0.193 | 0.160 | 0.057 | 1.000 | | | | | | |
| Students in thousands | 0.404 | 0.278 | 0.436 | 0.185 | 1.000 | | | | | |
| Students per academic staff | -0.131 | -0.101 | -0.161 | -0.043 | 0.061 | 1.000 | | | | |
| Publication per academic staff | 0.343 | 0.237 | 0.252 | 0.367 | 0.405 | -0.061 | 1.000 | | | |
| Revenues per academic staff in millions | 0.085 | 0.043 | 0.067 | 0.032 | 0.102 | 0.238 | 0.259 | 1.000 | | |
| Share of core funding | -0.041 | -0.020 | 0.024 | 0.108 | 0.069 | -0.267 | -0.051 | -0.157 | 1.000 | |
| Share of third-party funding | 0.299 | 0.230 | 0.190 | 0.197 | 0.203 | -0.216 | 0.346 | 0.032 | -0.217 | 1.000 |

Source: Authors' own calculations

**Table A6. Estimation results, interaction between GDP per capita and financial variables**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Patents | | Citations | |
| $Age_i$ | 0.012*** | 0.012*** | 0.010*** | 0.010*** |
| | [0.002] | [0.002] | [0.002] | [0.003] |
| $GenUniv_i$ | -0.2 | -0.142 | -0.068 | -0.068 |
| | [0.193] | [0.183] | [0.209] | [0.200] |
| $STEM_{it}$ | 7.188*** | 6.222*** | 7.105*** | 6.412*** |
| | [0.862] | [0.858] | [1.038] | [1.058] |
| $Stud_{it}$ | 0.231*** | 0.213*** | 0.165*** | 0.151*** |
| | [0.019] | [0.019] | [0.021] | [0.021] |
| $Stud\_acad_{it}$ | -0.103*** | -0.059*** | -0.081*** | -0.044*** |
| | [0.007] | [0.006] | [0.007] | [0.007] |
| $Pub\_acad_{it}$ | 9.844*** | 8.122*** | 7.878*** | 6.256*** |
| | [0.766] | [0.817] | [0.904] | [0.917] |
| $Rev\_acad_{it}$ | 2.462* | 3.108** | 0.832 | 1.029 |
| | [1.378] | [1.212] | [1.068] | [0.976] |
| $GDPpc_{rt}$ | 0.081*** | -0.030*** | 0.046** | -0.014** |
| | [0.030] | [0.007] | [0.023] | [0.006] |
| $Core\_budget_{it}$ | -0.195 | | -1.099 | |
| | [1.462] | | [1.180] | |
| $Core\_budget_{it} \times GDPpc_{rt}$ | -0.085** | | -0.039 | |
| | [0.043] | | [0.034] | |
| $Third\_party_{it}$ | | -10.086** | | -2.9 |
| | | [4.289] | | [3.618] |
| $Third\_party_{it} \times GDPpc_{rt}$ | | 0.527*** | | 0.306*** |
| | | [0.119] | | [0.098] |
| N | 7957 | 7658 | 7957 | 7658 |
| r2 | 0.32 | 0.36 | 0.19 | 0.2 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A7. Estimation results, depending variable: the number of patent applications to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment (using applicant share) and CPC fractional count, financial variables lagged**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *$Age_i$* | 0.013*** | 0.013*** | 0.013*** | 0.013*** |
| | [0.001] | [0.001] | [0.001] | [0.001] |
| *GenUniv* | 1.799*** | 1.463*** | 1.253*** | 1.139*** |
| | [0.284] | [0.299] | [0.297] | [0.306] |
| *$STEM_{it}$* | 7.684*** | 8.023*** | 7.377*** | 7.490*** |
| | [0.495] | [0.502] | [0.516] | [0.520] |
| *$Stud_{it}$* | 0.249*** | 0.261*** | 0.243*** | 0.249*** |
| | [0.012] | [0.012] | [0.012] | [0.013] |
| *$Stud\_acad_{it}$* | -0.072*** | -0.093*** | -0.056*** | -0.065*** |
| | [0.009] | [0.009] | [0.009] | [0.010] |
| *$Pub\_acad_{it}$* | 11.279*** | 10.575*** | 8.604*** | 8.328*** |
| | [0.780] | [0.813] | [0.848] | [0.860] |
| *$Rev\_acad_{it-1}$* | -0.347 | 1.17 | 0.721 | 1.36 |
| | [1.471] | [1.540] | [1.570] | [1.593] |
| *$Core\_budget_{it-1}$* | | -2.006*** | | -0.883* |
| | | [0.432] | | [0.462] |
| *$Third\_party_{it-1}$* | | | 10.633*** | 10.278*** |
| | | | [0.957] | [1.005] |
| N | 7871 | 7670 | 7432 | 7391 |
| r2 | 0.46 | 0.46 | 0.47 | 0.47 |
| Num Countries | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A8. Estimation results, depending variable sum of Forward citations in 5-years period of patent applications (by applicant) to EPO; normalised using max for cohort; multiplied by PA_EPO_fa, re-scaled by 100, financial variables lagged**

| | (1) | (2) | (3) | (94 |
|---|---|---|---|---|
| $Age_i$ | 0.011*** | 0.010*** | 0.010*** | 0.010*** |
| | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv | 1.543*** | 1.336*** | 1.059*** | 1.048*** |
| | [0.332] | [0.350] | [0.349] | [0.360] |
| $STEM_{it}$ | 8.109*** | 8.318*** | 7.900*** | 7.936*** |
| | [0.578] | [0.589] | [0.606] | [0.612] |
| $Stud_{it}$ | 0.159*** | 0.167*** | 0.154*** | 0.155*** |
| | [0.014] | [0.014] | [0.014] | [0.015] |
| $Stud\_acad_{it}$ | -0.050*** | -0.064*** | -0.037*** | -0.039*** |
| | [0.010] | [0.011] | [0.011] | [0.012] |
| $Pub\_acad_{it}$ | 7.445*** | 7.152*** | 5.151*** | 5.087*** |
| | [0.911] | [0.953] | [0.996] | [1.012] |
| $Rev\_acad_{it-1}$ | -1.71 | -0.822 | -0.869 | -0.577 |
| | [1.718] | [1.804] | [1.845] | [1.873] |
| $Core\_budget_{it-1}$ | | -1.180** | | -0.163 |
| | | [0.506] | | [0.544] |
| $Third\_party_{it-1}$ | | | 9.145*** | 9.180*** |
| | | | [1.125] | [1.182] |
| N | 7871 | 7670 | 7432 | 7391 |
| r2 | 0.29 | 0.29 | 0.3 | 0.3 |
| Num Countries | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A9. Estimation results, depending variable: the number of patent applications to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment (using applicant share) and CPC fractional count, additional regional variables**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.012*** | 0.010*** | 0.003** | 0.012*** | 0.011*** | 0.011*** | 0.011*** | 0.007*** |
| | [0.002] | [0.002] | [0.001] | [0.002] | [0.002] | [0.002] | [0.002] | [0.002] |
| $GenUniv_i$ | -0.340* | 0.031 | 2.221*** | 0.490** | 0.029 | 0.111 | 0.074 | -0.304** |
| | [0.193] | [0.205] | [0.685] | [0.226] | [0.199] | [0.204] | [0.196] | [0.154] |
| $STEM_{it}$ | 6.672*** | 6.195*** | 8.425*** | 5.815*** | 6.312*** | 6.258*** | 5.807*** | 4.256*** |
| | [0.897] | [0.812] | [1.926] | [0.857] | [0.822] | [0.815] | [0.796] | [0.558] |
| $Stud_{it}$ | 0.221*** | 0.252*** | 0.225*** | 0.237*** | 0.246*** | 0.248*** | 0.242*** | 0.219*** |
| | [0.019] | [0.018] | [0.022] | [0.018] | [0.017] | [0.017] | [0.018] | [0.020] |
| $Stud\_acad_{it}$ | -0.076*** | -0.080*** | -0.117*** | -0.089*** | -0.081*** | -0.078*** | -0.091*** | -0.054*** |
| | [0.007] | [0.007] | [0.018] | [0.008] | [0.007] | [0.007] | [0.007] | [0.007] |
| $Pub\_acad_{it}$ | 8.015*** | 5.589*** | 2.084** | 5.583*** | 5.444*** | 5.660*** | 5.180*** | 5.676*** |
| | [0.797] | [0.676] | [0.979] | [0.700] | [0.663] | [0.682] | [0.674] | [0.969] |
| $Rev\_acad_{it}$ | 2.4 | 4.242*** | 1.441 | 7.413*** | 4.054*** | 3.805*** | 6.557*** | 0.881 |
| | [1.461] | [1.305] | [1.728] | [1.362] | [1.285] | [1.332] | [1.240] | [1.234] |
| $Core\_budget_{it}$ | -2.244*** | -1.890*** | -2.889*** | -2.250*** | -1.575*** | -1.639*** | -1.815*** | -1.027*** |
| | [0.310] | [0.290] | [0.770] | [0.310] | [0.283] | [0.296] | [0.278] | [0.232] |
| $Third\_party_{it}$ | 9.253*** | 10.491*** | 10.194*** | 10.378*** | 10.831*** | 10.715*** | 10.967*** | 9.892*** |
| | [1.010] | [1.079] | [1.811] | [1.135] | [1.096] | [1.089] | [1.090] | [1.216] |
| $Regional_{rt}$ | 0.047*** | 0.145*** | 0.281*** | 0.580*** | 0.189*** | 0.449*** | 0.726*** | 0.004*** |
| | [0.015] | [0.024] | [0.077] | [0.196] | [0.027] | [0.078] | [0.172] | [0.001] |
| N | 7620 | 7640 | 2735 | 6772 | 7729 | 7631 | 7640 | 4909 |
| r2 | 0.33 | 0.33 | 0.32 | 0.34 | 0.33 | 0.33 | 0.33 | 0.33 |

Notes: All specifications include country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Different regional variables ($Regional_{rt}$) in different specifications: (1) GDP per capita, (2) educational attainment for ages 25 to 64, tertiary education, total (NUTS 2), (3) Participation rate in Tertiary education (NUTS 2), (4) Employment in high-technology manufacturing, % of tot. employment, total (NUTS 2, (5) Employment in knowledge-intensive services, % of tot. employment, total (NUTS 2), (6) Employment in scientific and technical activities, % of tot. employment (NUTS2), (7) Employment in education, % of tot. employment, total (NUTS 2), (8) Higher education sector intramural expenditure in R&D, euro per inhabitant

**Table A10. Estimation results, depending variable sum of Forward citations in 5-years period of patent applications (by applicant) to EPO; normalised using max for cohort; multiplied by PA_EPO_fa, re-scaled by 100, additional regional variables**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.010*** | 0.009*** | 0.002 | 0.011*** | 0.010*** | 0.010*** | 0.010*** | 0.008** |
| | [0.003] | [0.002] | [0.002] | [0.003] | [0.002] | [0.002] | [0.003] | [0.003] |
| $GenUniv_i$ | -0.224 | 0.262 | 3.207*** | 0.673** | 0.239 | 0.326 | 0.268 | -0.362* |
| | [0.212] | [0.246] | [0.962] | [0.279] | [0.238] | [0.246] | [0.238] | [0.186] |
| $STEM_{it}$ | 6.762*** | 7.224*** | 11.243*** | 7.202*** | 7.373*** | 7.299*** | 6.956*** | 3.916*** |
| | [1.093] | [1.110] | [2.732] | [1.179] | [1.122] | [1.113] | [1.088] | [0.618] |
| $Stud_{it}$ | 0.158*** | 0.177*** | 0.118*** | 0.168*** | 0.172*** | 0.174*** | 0.168*** | 0.171*** |
| | [0.022] | [0.020] | [0.024] | [0.022] | [0.020] | [0.020] | [0.020] | [0.028] |
| $Stud\_acad_{it}$ | -0.058*** | -0.059*** | -0.070*** | -0.069*** | -0.057*** | -0.057*** | -0.068*** | -0.040*** |
| | [0.007] | [0.007] | [0.017] | [0.009] | [0.007] | [0.007] | [0.008] | [0.008] |
| $Pub\_acad_{it}$ | 6.072*** | 4.077*** | 1.321 | 4.241*** | 4.045*** | 4.147*** | 3.648*** | 5.062*** |
| | [0.924] | [0.793] | [1.217] | [0.864] | [0.786] | [0.793] | [0.797] | [1.165] |
| $Rev\_acad_{it}$ | 0.863 | 1.538 | -2.588 | 4.004*** | 1.055 | 1.068 | 3.461*** | 0.267 |
| | [1.117] | [1.068] | [2.143] | [1.092] | [1.075] | [1.090] | [1.007] | [1.207] |
| $Core\_budget_{it}$ | -1.663*** | -1.353*** | -1.513** | -1.667*** | -1.006*** | -1.126*** | -1.157*** | -0.821*** |
| | [0.317] | [0.303] | [0.694] | [0.340] | [0.285] | [0.298] | [0.304] | [0.297] |
| $Third\_party_{it}$ | 8.117*** | 9.053*** | 9.712*** | 9.515*** | 9.335*** | 9.240*** | 9.579*** | 9.094*** |
| | [1.160] | [1.221] | [1.834] | [1.336] | [1.224] | [1.224] | [1.235] | [1.424] |
| $Regional_{rt}$ | 0.030*** | 0.118*** | 0.447*** | 0.21 | 0.183*** | 0.386*** | 0.881*** | 0.003** |
| | [0.011] | [0.022] | [0.114] | [0.235] | [0.028] | [0.068] | [0.173] | [0.001] |
| N | 7620 | 7640 | 2735 | 6772 | 7729 | 7631 | 7640 | 4909 |
| r2 | 0.2 | 0.19 | 0.2 | 0.19 | 0.2 | 0.2 | 0.19 | 0.18 |

Notes: All specifications include country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01

Different regional variables ($Regional_{rt}$) in different specifications: (1) GDP per capita, (2) educational attainment for ages 25 to 64, tertiary education, total (NUTS 2), (3) Participation rate in Tertiary education (NUTS 2), (4) Employment in high-technology manufacturing, % of tot. employment, total (NUTS 2, (5) Employment in knowledge-intensive services, % of tot. employment, total (NUTS 2), (6) Employment in scientific and technical activities, % of tot. employment (NUTS2), (7) Employment in education, % of tot. employment, total (NUTS 2), (8) Higher education sector intramural expenditure in R&D, euro per inhabitant

## Table A11. Estimation results, depending variable forward citation to USPTO

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Age$_{i}$ | 0.008*** | 0.008*** | 0.007*** | 0.007*** | 0.006*** | 0.009*** | 0.008*** | 0.009*** | 0.009*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv$_{i}$ | 0.370*** | 0.293*** | -0.085 | -0.191* | -0.261** | 0.064 | -0.057 | -0.101 | -0.153 |
| | [0.085] | [0.091] | [0.099] | [0.114] | [0.114] | [0.183] | [0.192] | [0.194] | [0.199] |
| STEM$_{it}$ | | 0.974*** | 0.788*** | 0.980*** | 0.547*** | 0.611** | 0.700** | 0.515 | 0.572* |
| | | [0.159] | [0.161] | [0.200] | [0.208] | [0.310] | [0.316] | [0.327] | [0.331] |
| Stud$_{it}$ | | | 0.047*** | 0.048*** | 0.041*** | 0.048*** | 0.053*** | 0.047*** | 0.050*** |
| | | | [0.005] | [0.005] | [0.006] | [0.008] | [0.008] | [0.008] | [0.008] |
| Stud_acad$_{it}$ | | | | -0.004 | -0.003 | 0.005 | -0.001 | 0.011* | 0.007 |
| | | | | [0.003] | [0.003] | [0.006] | [0.006] | [0.006] | [0.007] |
| Pub_acad$_{it}$ | | | | | 2.613*** | 3.127*** | 2.856*** | 2.402*** | 2.262*** |
| | | | | | [0.352] | [0.506] | [0.532] | [0.556] | [0.566] |
| Rev_acad$_{it}$ | | | | | | -0.181 | 0.237 | -0.048 | 0.217 |
| | | | | | | [0.948] | [0.993] | [1.023] | [1.041] |
| Core_budget$_{it}$ | | | | | | | -0.780*** | | -0.458 |
| | | | | | | | [0.281] | | [0.305] |
| Third_party$_{it}$ | | | | | | | | 2.935*** | 2.725*** |
| | | | | | | | | [0.627] | [0.661] |
| N | 18263 | 16976 | 16920 | 14833 | 14833 | 9639 | 9395 | 9072 | 9020 |
| r2 | 0.09 | 0.1 | 0.1 | 0.11 | 0.11 | 0.13 | 0.13 | 0.13 | 0.14 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A12. Estimation results, depending variable: the number of patent applications to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment (using applicant share) and CPC fractional count, additional variable professor privilege**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $ProfPriv_{ct}$ | -1.884*** | -1.430*** | -1.786*** | -2.240*** | -2.381*** | -4.568*** | -4.302*** | -4.678*** | -4.505*** |
| | [0.179] | [0.186] | [0.180] | [0.194] | [0.192] | [0.321] | [0.328] | [0.331] | [0.337] |
| $Age_{i}$ | 0.021*** | 0.021*** | 0.013*** | 0.012*** | 0.011*** | 0.012*** | 0.011*** | 0.011*** | 0.011*** |
| | [0.000] | [0.000] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv | 2.034*** | 1.769*** | 0.348*** | -0.208 | -0.480*** | 0.390* | -0.018 | -0.238 | -0.417* |
| | [0.110] | [0.118] | [0.122] | [0.142] | [0.141] | [0.227] | [0.234] | [0.239] | [0.242] |
| $STEM_{it}$ | | 5.001*** | 3.766*** | 5.034*** | 3.415*** | 5.088*** | 5.875*** | 4.781*** | 5.262*** |
| | | [0.220] | [0.217] | [0.276] | [0.285] | [0.413] | [0.420] | [0.427] | [0.434] |
| $Stud_{it}$ | | | 0.219*** | 0.235*** | 0.199*** | 0.246*** | 0.263*** | 0.251*** | 0.262*** |
| | | | [0.006] | [0.007] | [0.007] | [0.010] | [0.010] | [0.010] | [0.010] |
| $Stud\_acad_{it}$ | | | | -0.073*** | -0.068*** | -0.108*** | -0.139*** | -0.092*** | -0.112*** |
| | | | | [0.004] | [0.004] | [0.008] | [0.008] | [0.008] | [0.009] |
| $Pub\_acad_{it}$ | | | | | 9.113*** | 8.108*** | 6.929*** | 5.705*** | 5.181*** |
| | | | | | [0.463] | [0.655] | [0.670] | [0.693] | [0.697] |
| $Rev\_acad_{iit}$ | | | | | | 6.046*** | 6.033*** | 6.815*** | 6.628*** |
| | | | | | | [1.151] | [1.186] | [1.217] | [1.225] |
| $Core\_budget_{it}$ | | | | | | | -3.412*** | | -2.139*** |
| | | | | | | | [0.306] | | [0.332] |
| $Third\_party_{it}$ | | | | | | | | 11.498*** | 10.478*** |
| | | | | | | | | [0.761] | [0.811] |
| N | 18268 | 16980 | 16924 | 14839 | 14839 | 9645 | 9401 | 9077 | 9025 |
| r2 | 0.13 | 0.15 | 0.2 | 0.22 | 0.24 | 0.26 | 0.27 | 0.28 | 0.29 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A13. Estimation results, depending variable sum of Forward citations in 5-years period of patent applications (by applicant) to EPO; normalised using max for cohort; multiplied by PA_EPO_fa, re-scaled by 100, additional variable professor privilege**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $ProfPriv_{ct}$ | -1.580*** | -1.176*** | -1.408*** | -1.754*** | -1.845*** | -3.568*** | -3.399*** | -3.690*** | -3.608*** |
| | [0.191] | [0.199] | [0.197] | [0.214] | [0.213] | [0.361] | [0.370] | [0.375] | [0.382] |
| $Age_i$ | 0.016*** | 0.015*** | 0.011*** | 0.009*** | 0.009*** | 0.009*** | 0.009*** | 0.009*** | 0.009*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv | 1.523*** | 1.296*** | 0.368*** | -0.101 | -0.279* | 0.481* | 0.178 | -0.065 | -0.166 |
| | [0.117] | [0.127] | [0.134] | [0.156] | [0.156] | [0.255] | [0.264] | [0.270] | [0.274] |
| $STEM_{it}$ | | 4.432*** | 3.634*** | 4.997*** | 3.936*** | 5.708*** | 6.278*** | 5.485*** | 5.776*** |
| | | [0.236] | [0.238] | [0.305] | [0.317] | [0.464] | [0.474] | [0.484] | [0.493] |
| $Stud_{it}$ | | | 0.143*** | 0.152*** | 0.129*** | 0.159*** | 0.171*** | 0.162*** | 0.169*** |
| | | | [0.007] | [0.008] | [0.008] | [0.011] | [0.011] | [0.012] | [0.012] |
| $Stud\_acad_{it}$ | | | | -0.056*** | -0.053*** | -0.086*** | -0.109*** | -0.072*** | -0.084*** |
| | | | | [0.005] | [0.005] | [0.009] | [0.009] | [0.009] | [0.010] |
| $Pub\_acad_{it}$ | | | | | 5.968*** | 5.094*** | 4.319*** | 3.070*** | 2.760*** |
| | | | | | [0.515] | [0.736] | [0.757] | [0.784] | [0.790] |
| $Rev\_acad_{iit}$ | | | | | | 3.389*** | 3.292** | 3.842*** | 3.749*** |
| | | | | | | [1.294] | [1.340] | [1.377] | [1.390] |
| $Core\_budget_{it}$ | | | | | | | -2.460*** | | -1.273*** |
| | | | | | | | [0.346] | | [0.376] |
| $Third\_party_{it}$ | | | | | | | | 9.888*** | 9.370*** |
| | | | | | | | | [0.861] | [0.920] |
| N | 18268 | 16980 | 16924 | 14839 | 14839 | 9645 | 9401 | 9077 | 9025 |
| r2 | 0.07 | 0.08 | 0.11 | 0.12 | 0.13 | 0.14 | 0.14 | 0.15 | 0.16 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A14. Estimation results, depending variable: the number of granted patents to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment and CPC fractional count**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.008*** | 0.008*** | 0.005*** | 0.004*** | 0.004*** | 0.006*** | 0.006*** | 0.006*** | 0.006*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| $GenUniv_i$ | 1.269*** | 1.072*** | 0.331*** | 0.148** | 0.048 | 0.657*** | 0.525*** | 0.439*** | 0.396*** |
| | [0.058] | [0.061] | [0.065] | [0.073] | [0.072] | [0.113] | [0.118] | [0.118] | [0.121] |
| $STEM_{it}$ | | 2.562*** | 2.200*** | 2.755*** | 2.137*** | 2.992*** | 3.155*** | 2.843*** | 2.907*** |
| | | [0.106] | [0.105] | [0.128] | [0.132] | [0.191] | [0.194] | [0.199] | [0.201] |
| $Stud_{it}$ | | | 0.092*** | 0.094*** | 0.084*** | 0.097*** | 0.102*** | 0.094*** | 0.097*** |
| | | | [0.003] | [0.003] | [0.003] | [0.005] | [0.005] | [0.005] | [0.005] |
| $Stud\_acad_{it}$ | | | | -0.023*** | -0.022*** | -0.034*** | -0.043*** | -0.026*** | -0.031*** |
| | | | | [0.002] | [0.002] | [0.004] | [0.004] | [0.004] | [0.004] |
| $Pub\_acad_{it}$ | | | | | 3.723*** | 3.827*** | 3.434*** | 2.627*** | 2.481*** |
| | | | | | [0.223] | [0.312] | [0.327] | [0.338] | [0.344] |
| $Rev\_acad_{it}$ | | | | | | 0.766 | 1.423** | 1.061* | 1.390** |
| | | | | | | [0.584] | [0.610] | [0.622] | [0.633] |
| $Core\_budget_{it}$ | | | | | | | -0.958*** | | -0.436** |
| | | | | | | | [0.173] | | [0.185] |
| $Third\_party_{it}$ | | | | | | | | 4.704*** | 4.537*** |
| | | | | | | | | [0.382] | [0.402] |
| N | 18263 | 16976 | 16920 | 14833 | 14833 | 9639 | 9395 | 9072 | 9020 |
| r2 | 0.25 | 0.28 | 0.32 | 0.35 | 0.36 | 0.38 | 0.39 | 0.4 | 0.4 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A15. Estimation results, depending variable: the number of patent applications to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment and CPC fractional count, only general universities**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.025*** | 0.024*** | 0.016*** | 0.013*** | 0.012*** | 0.014*** | 0.014*** | 0.014*** | 0.014*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| $STEM_{it}$ | | 10.242*** | 8.290*** | 8.489*** | 7.178*** | 8.739*** | 9.662*** | 8.609*** | 9.385*** |
| | | [0.367] | [0.372] | [0.414] | [0.412] | [0.525] | [0.545] | [0.554] | [0.573] |
| $Stud_{it}$ | | | 0.205*** | 0.211*** | 0.170*** | 0.188*** | 0.204*** | 0.182*** | 0.196*** |
| | | | [0.009] | [0.010] | [0.010] | [0.012] | [0.013] | [0.013] | [0.013] |
| $Stud\_acad_{it}$ | | | | -0.103*** | -0.084*** | -0.109*** | -0.135*** | -0.087*** | -0.106*** |
| | | | | [0.008] | [0.008] | [0.011] | [0.012] | [0.012] | [0.013] |
| $Pub\_acad_{it}$ | | | | | 12.648*** | 12.724*** | 11.502*** | 10.141*** | 9.300*** |
| | | | | | [0.669] | [0.858] | [0.890] | [0.937] | [0.949] |
| $Rev\_acad_{it-}$ | | | | | | 2.606 | 3.046* | 2.278 | 2.904 |
| | | | | | | [1.708] | [1.780] | [1.863] | [1.872] |
| $Core\_budget_{it}$ | | | | | | | -3.558*** | | -2.860*** |
| | | | | | | | [0.503] | | [0.539] |
| $Third\_party_{it}$ | | | | | | | | 10.440*** | 9.548*** |
| | | | | | | | | [1.042] | [1.073] |
| N | 10703 | 10577 | 10546 | 9650 | 9650 | 7439 | 7225 | 6925 | 6890 |
| r2 | 0.34 | 0.39 | 0.41 | 0.44 | 0.46 | 0.48 | 0.48 | 0.49 | 0.5 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A16. Estimation results, depending variable sum of Forward citations in 5-years period of patent applications (by applicant) to EPO; normalised using max for cohort; multiplied by PA_EPO_fa, re-scaled by 100, only general universities**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.019*** | 0.018*** | 0.013*** | 0.011*** | 0.011*** | 0.012*** | 0.012*** | 0.012*** | 0.012*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| $STEM_{it}$ | | 9.322*** | 8.133*** | 8.562*** | 7.598*** | 9.143*** | 9.765*** | 9.223*** | 9.701*** |
| | | [0.416] | [0.428] | [0.484] | [0.487] | [0.623] | [0.650] | [0.661] | [0.687] |
| $Stud_{it}$ | | | 0.126*** | 0.131*** | 0.101*** | 0.106*** | 0.117*** | 0.099*** | 0.108*** |
| | | | [0.011] | [0.012] | [0.012] | [0.014] | [0.015] | [0.015] | [0.016] |
| $Stud\_acad_{it}$ | | | | -0.079*** | -0.065*** | -0.079*** | -0.096*** | -0.060*** | -0.071*** |
| | | | | [0.009] | [0.009] | [0.013] | [0.014] | [0.015] | [0.016] |
| $Pub\_acad_{it}$ | | | | | 9.298*** | 9.553*** | 8.794*** | 7.464*** | 6.961*** |
| | | | | | [0.791] | [1.019] | [1.060] | [1.119] | [1.137] |
| $Rev\_acad_{it-}$ | | | | | | -0.263 | -0.116 | -0.71 | -0.312 |
| | | | | | | [2.026] | [2.120] | [2.226] | [2.244] |
| $Core\_budget_{it}$ | | | | | | | -2.313*** | | -1.737*** |
| | | | | | | | [0.600] | | [0.645] |
| $Third\_party_{it}$ | | | | | | | | 8.579*** | 8.048*** |
| | | | | | | | | [1.244] | [1.286] |
| N | 10703 | 10577 | 10546 | 9650 | 9650 | 7439 | 7225 | 6925 | 6890 |
| r2 | 0.24 | 0.28 | 0.29 | 0.3 | 0.31 | 0.33 | 0.33 | 0.34 | 0.34 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A17. Estimation results, depending variable: the number of patent applications to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment and CPC fractional count, only STEM**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.023*** | 0.023*** | 0.015*** | 0.013*** | 0.011*** | 0.013*** | 0.012*** | 0.012*** | 0.012*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| $GenUniv_i$ | 3.586*** | 3.586*** | 1.474*** | 0.396 | 0.645** | 1.781*** | 1.773*** | 1.278*** | 1.364*** |
| | [0.217] | [0.217] | [0.247] | [0.285] | [0.277] | [0.403] | [0.410] | [0.414] | [0.416] |
| $Stud_{it}$ | | | 0.228*** | 0.236*** | 0.200*** | 0.232*** | 0.249*** | 0.212*** | 0.223*** |
| | | | [0.009] | [0.010] | [0.010] | [0.013] | [0.014] | [0.014] | [0.014] |
| $Stud\_acad_{it}$ | | | | -0.075*** | -0.051*** | -0.087*** | -0.124*** | -0.046*** | -0.068*** |
| | | | | [0.006] | [0.006] | [0.011] | [0.012] | [0.012] | [0.013] |
| $Pub\_acad_{it}$ | | | | | 14.943*** | 15.575*** | 14.312*** | 10.646*** | 10.140*** |
| | | | | | [0.622] | [0.835] | [0.866] | [0.923] | [0.931] |
| $Rev\_acad_{it-}$ | | | | | | -0.41 | 0.508 | -1.635 | -1.309 |
| | | | | | | [1.911] | [1.976] | [2.016] | [2.036] |
| $Core\_budget_{it}$ | | | | | | | -4.825*** | | -2.721*** |
| | | | | | | | [0.626] | | [0.666] |
| $Third\_party_{it}$ | | | | | | | | 18.815*** | 17.728*** |
| | | | | | | | | [1.268] | [1.327] |
| N | 12013 | 12013 | 11096 | 9766 | 9766 | 6902 | 6731 | 6535 | 6496 |
| r2 | 0.34 | 0.34 | 0.38 | 0.41 | 0.44 | 0.44 | 0.45 | 0.46 | 0.47 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A18. Estimation results, depending variable sum of Forward citations in 5-years period of patent applications (by applicant) to EPO; normalised using max for cohort; multiplied by PA_EPO_fa, re-scaled by 100, only STEM**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.017*** | 0.017*** | 0.013*** | 0.011*** | 0.009*** | 0.011*** | 0.010*** | 0.010*** | 0.010*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| $GenUniv_i$ | 2.290*** | 2.290*** | 0.918*** | 0.146 | 0.335 | 1.278*** | 1.248** | 0.818* | 0.867* |
| | [0.241] | [0.241] | [0.280] | [0.329] | [0.325] | [0.476] | [0.487] | [0.494] | [0.498] |
| $Stud_{it}$ | | | 0.147*** | 0.159*** | 0.131*** | 0.150*** | 0.161*** | 0.134*** | 0.138*** |
| | | | [0.011] | [0.012] | [0.012] | [0.016] | [0.016] | [0.016] | [0.017] |
| $Stud\_acad_{it}$ | | | | -0.059*** | -0.041*** | -0.066*** | -0.091*** | -0.031** | -0.041*** |
| | | | | [0.007] | [0.007] | [0.013] | [0.014] | [0.014] | [0.015] |
| $Pub\_acad_{it}$ | | | | | 11.381*** | 12.406*** | 11.705*** | 8.238*** | 8.014*** |
| | | | | | [0.730] | [0.986] | [1.028] | [1.102] | [1.114] |
| $Rev\_acad_{it-}$ | | | | | | -2.645 | -2.138 | -3.881 | -3.725 |
| | | | | | | [2.257] | [2.346] | [2.407] | [2.436] |
| $Core\_budget_{it}$ | | | | | | | -3.027*** | | -1.067 |
| | | | | | | | [0.743] | | [0.797] |
| $Third\_party_{it}$ | | | | | | | | 16.025*** | 15.724*** |
| | | | | | | | | [1.513] | [1.588] |
| N | 12013 | 12013 | 11096 | 9766 | 9766 | 6902 | 6731 | 6535 | 6496 |
| r2 | 0.25 | 0.25 | 0.26 | 0.27 | 0.29 | 0.29 | 0.3 | 0.31 | 0.31 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A19. Estimation results, depending variable: the number of patent applications to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment and CPC fractional count, excluding small HEIs with number of students lower than 500**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Age$_i$ | 0.022*** | 0.022*** | 0.014*** | 0.012*** | 0.011*** | 0.014*** | 0.014*** | 0.013*** | 0.013*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv | 3.038*** | 2.601*** | 0.833*** | 0.299 | 0.052 | 1.458*** | 1.108*** | 0.766** | 0.612** |
| | [0.165] | [0.173] | [0.181] | [0.198] | [0.195] | [0.289] | [0.300] | [0.301] | [0.308] |
| STEM$_{it}$ | | 6.875*** | 6.030*** | 7.023*** | 5.104*** | 6.803*** | 7.105*** | 6.184*** | 6.370*** |
| | | [0.292] | [0.288] | [0.329] | [0.339] | [0.461] | [0.465] | [0.479] | [0.483] |
| Stud$_{it}$ | | | 0.217*** | 0.220*** | 0.192*** | 0.224*** | 0.239*** | 0.216*** | 0.226*** |
| | | | [0.008] | [0.009] | [0.009] | [0.011] | [0.012] | [0.012] | [0.012] |
| Stud_acad$_{it}$ | | | | -0.052*** | -0.048*** | -0.079*** | -0.106*** | -0.057*** | -0.073*** |
| | | | | [0.005] | [0.005] | [0.009] | [0.010] | [0.009] | [0.010] |
| Pub_acad$_{it}$ | | | | | 10.960*** | 10.745*** | 9.451*** | 7.051*** | 6.541*** |
| | | | | | [0.572] | [0.765] | [0.796] | [0.833] | [0.846] |
| Rev_acad$_{it}$ | | | | | | 3.504** | 4.758*** | 3.422** | 4.406*** |
| | | | | | | [1.563] | [1.610] | [1.636] | [1.659] |
| Core_budget$_{it}$ | | | | | | | -3.016*** | | -1.654*** |
| | | | | | | | [0.461] | | [0.495] |
| Third_party$_{it-}$ | | | | | | | | 13.731*** | 12.962*** |
| | | | | | | | | [1.056] | [1.107] |
| N | 14352 | 13259 | 13203 | 12084 | 12084 | 8445 | 8293 | 8014 | 7970 |
| r2 | 0.29 | 0.32 | 0.36 | 0.39 | 0.41 | 0.43 | 0.43 | 0.45 | 0.45 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * $p<0.10$, ** $p<0.05$, *** $p<0.01$
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A20. Estimation results, depending variable sum of Forward citations in 5-years period of patent applications (by applicant) to EPO; normalised using max for cohort; multiplied by PA_EPO_fa, re-scaled by 100, excluding small HEIs with number of students lower than 500**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.017*** | 0.017*** | 0.012*** | 0.011*** | 0.010*** | 0.012*** | 0.012*** | 0.012*** | 0.012*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv | 2.104*** | 1.721*** | 0.568*** | 0.204 | 0.029 | 1.313*** | 1.084*** | 0.722** | 0.664* |
| | [0.181] | [0.192] | [0.205] | [0.228] | [0.227] | [0.338] | [0.353] | [0.356] | [0.364] |
| $STEM_{it}$ | | 6.576*** | 6.059*** | 7.100*** | 5.746*** | 7.525*** | 7.706*** | 7.121*** | 7.213*** |
| | | [0.324] | [0.326] | [0.379] | [0.395] | [0.540] | [0.548] | [0.566] | [0.572] |
| $Stud_{it}$ | | | 0.141*** | 0.142*** | 0.122*** | 0.142*** | 0.152*** | 0.135*** | 0.139*** |
| | | | [0.009] | [0.010] | [0.010] | [0.013] | [0.014] | [0.014] | [0.014] |
| $Stud\_acad_{it}$ | | | | -0.037*** | -0.033*** | -0.053*** | -0.071*** | -0.035*** | -0.043*** |
| | | | | [0.006] | [0.006] | [0.010] | [0.011] | [0.011] | [0.012] |
| $Pub\_acad_{it}$ | | | | | 7.731*** | 7.555*** | 6.829*** | 4.573*** | 4.336*** |
| | | | | | [0.665] | [0.896] | [0.936] | [0.985] | [1.001] |
| $Rev\_acad_{it}$ | | | | | | 0.733 | 1.397 | 0.588 | 1.102 |
| | | | | | | [1.832] | [1.893] | [1.933] | [1.964] |
| $Core\_budget_{it}$ | | | | | | | -1.931*** | | -0.752 |
| | | | | | | | [0.543] | | [0.586] |
| $Third\_party_{it-}$ | | | | | | | | 11.211*** | 10.916*** |
| | | | | | | | | [1.247] | [1.310] |
| N | 14352 | 13259 | 13203 | 12084 | 12084 | 8445 | 8293 | 8014 | 7970 |
| r2 | 0.2 | 0.22 | 0.24 | 0.25 | 0.26 | 0.28 | 0.28 | 0.29 | 0.29 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A21. Estimation results, depending variable: the number of patent applications to 5 patent offices: EPO, USPTO, CPO, JPO, KPO; fractional apportionment and CPC fractional count, excluding universities of applied science**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.016*** | 0.015*** | 0.009*** | 0.009*** | 0.008*** | 0.011*** | 0.011*** | 0.011*** | 0.010*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv | 4.483*** | 4.026*** | 2.020*** | 1.384*** | 0.935*** | 2.784*** | 2.692*** | 1.588*** | 1.710*** |
| | [0.191] | [0.204] | [0.224] | [0.248] | [0.250] | [0.390] | [0.404] | [0.416] | [0.422] |
| $STEM_{it}$ | | 8.437*** | 7.673*** | 9.433*** | 7.515*** | 10.635*** | 10.569*** | 9.363*** | 9.336*** |
| | | [0.366] | [0.364] | [0.422] | [0.458] | [0.649] | [0.658] | [0.689] | [0.691] |
| $Stud_{it}$ | | | 0.201*** | 0.205*** | 0.193*** | 0.236*** | 0.242*** | 0.229*** | 0.222*** |
| | | | [0.010] | [0.011] | [0.011] | [0.015] | [0.015] | [0.016] | [0.016] |
| $Stud\_acad_{it}$ | | | | -0.042*** | -0.044*** | -0.119*** | -0.137*** | -0.100*** | -0.095*** |
| | | | | [0.007] | [0.007] | [0.014] | [0.014] | [0.014] | [0.016] |
| $Pub\_acad_{it}$ | | | | | 7.730*** | 6.123*** | 5.514*** | 2.900*** | 2.932*** |
| | | | | | [0.749] | [1.048] | [1.079] | [1.121] | [1.128] |
| $Rev\_acad_{it}$ | | | | | | 2.98 | 3.322 | 1.743 | 1.691 |
| | | | | | | [2.016] | [2.069] | [2.110] | [2.148] |
| $Core\_budget_{it}$ | | | | | | | -2.104*** | | 1.766** |
| | | | | | | | [0.753] | | [0.864] |
| $Third\_party_{it-}$ | | | | | | | | 16.385*** | 18.117*** |
| | | | | | | | | [1.477] | [1.654] |
| N | 10904 | 9842 | 9796 | 9158 | 9158 | 6132 | 6036 | 5816 | 5773 |
| r2 | 0.38 | 0.41 | 0.44 | 0.45 | 0.46 | 0.48 | 0.48 | 0.49 | 0.49 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

**Table A22. Estimation results, depending variable sum of Forward citations in 5-years period of patent applications (by applicant) to EPO; normalised using max for cohort; multiplied by PA_EPO_fa, re-scaled by 100, excluding universities of applied science**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $Age_i$ | 0.012*** | 0.011*** | 0.007*** | 0.008*** | 0.007*** | 0.009*** | 0.009*** | 0.009*** | 0.009*** |
| | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] | [0.001] |
| GenUniv | 3.271*** | 2.899*** | 1.663*** | 1.343*** | 1.098*** | 2.987*** | 2.984*** | 2.078*** | 2.232*** |
| | [0.218] | [0.234] | [0.262] | [0.293] | [0.297] | [0.468] | [0.487] | [0.504] | [0.512] |
| $STEM_{it}$ | | 8.190*** | 7.768*** | 9.569*** | 8.524*** | 11.939*** | 11.924*** | 11.159*** | 11.150*** |
| | | [0.421] | [0.425] | [0.497] | [0.543] | [0.779] | [0.792] | [0.834] | [0.838] |
| $Stud_{it}$ | | | 0.123*** | 0.120*** | 0.113*** | 0.135*** | 0.137*** | 0.131*** | 0.120*** |
| | | | [0.012] | [0.013] | [0.013] | [0.018] | [0.018] | [0.019] | [0.019] |
| $Stud\_acad_{it}$ | | | | -0.022*** | -0.023*** | -0.069*** | -0.079*** | -0.054*** | -0.044** |
| | | | | [0.008] | [0.008] | [0.016] | [0.017] | [0.017] | [0.019] |
| $Pub\_acad_{it}$ | | | | | 4.210*** | 2.580** | 2.466* | 0.201 | 0.349 |
| | | | | | [0.887] | [1.258] | [1.299] | [1.357] | [1.368] |
| $Rev\_acad_{it}$ | | | | | | -0.558 | -0.651 | -1.482 | -1.902 |
| | | | | | | [2.418] | [2.491] | [2.555] | [2.604] |
| $Core\_budget_{it}$ | | | | | | | -0.722 | | 2.429** |
| | | | | | | | [0.907] | | [1.047] |
| $Third\_party_{it-}$ | | | | | | | | 12.231*** | 14.356*** |
| | | | | | | | | [1.788] | [2.005] |
| N | 10904 | 9842 | 9796 | 9158 | 9158 | 6132 | 6036 | 5816 | 5773 |
| r2 | 0.26 | 0.28 | 0.29 | 0.3 | 0.3 | 0.32 | 0.32 | 0.32 | 0.32 |
| Num Countries | 31 | 31 | 31 | 31 | 26 | 26 | 25 | 25 | 25 |

Notes: All specifications include region, country and time-fixed effects. * p<0.10, ** p<0.05, *** p<0.01
Source: authors' calculations using PATSTAT Global (Autumn 2022), OrgReg and ETER

## ABOUT RETHINK-GSC

The project ‚Rethinking Global Supply Chains: Measurement, Impact and Policy' (RETHINK-GSC) captures the impact of knowledge flows and service inputs in Global Supply Chains (GSCs). Researchers from 11 institutes are applying their broad expertise in a multidisciplinary approach, developing new methodologies and using innovative techniques to analyse, measure and quantify the increasing importance of intangibles in global supply chains and to provide new insights into current and expected changes in global production processes.

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