Workshop: Methodology in Science of Science: Between Theory and Empirical Applications

Analysis of bibliometric indicators and empirical efficiency analyses of higher education institutions

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Motivation

- Academic research - a key factor of human capital creation
- The debate about universities in Europe: their role (teaching versus research), funding, governance and efficiency

"*In the global knowledge economy, people's skills, learning, talents, and attributes - their human capital - have become key to both their ability to earn a living and to wider economic growth. Education system can do much to help people to realize their potential, but when they fail it can lead to lifelong social and economic problems*" (OECD, 2007 p.21)

"*...Europe simply must have a first-class university system - with universities recognized internationally as the best in the various field involved" (European Commission*, 2003 p.22)

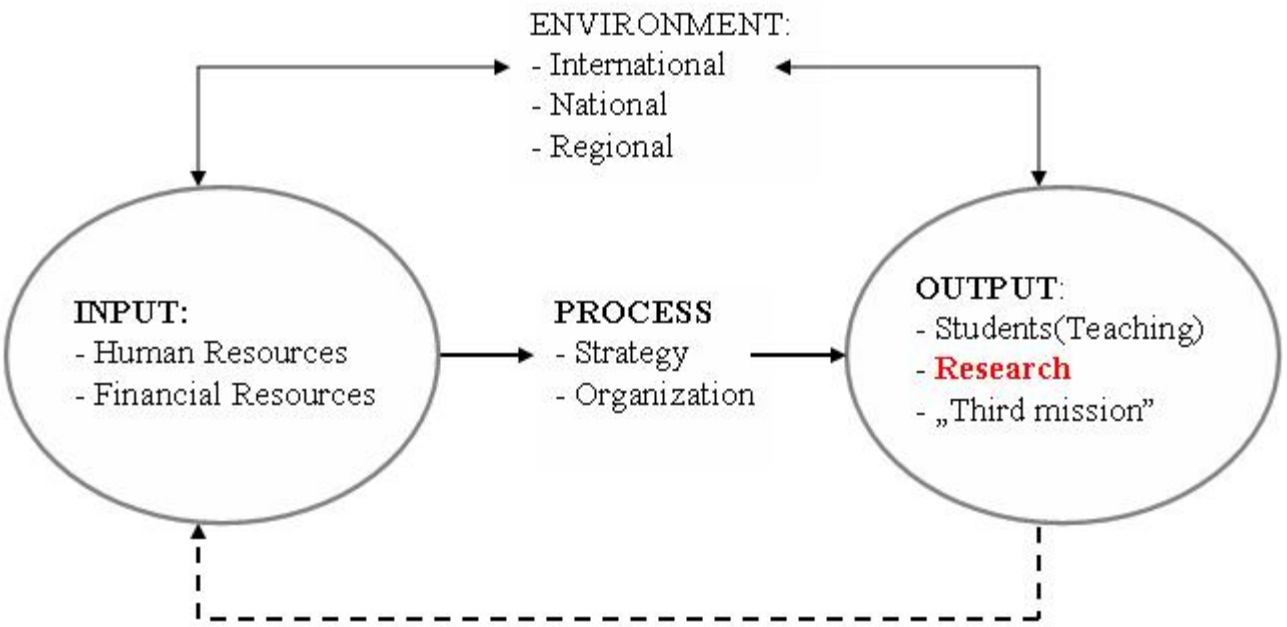
Literature review

- HEIs: mainly country-specific studies (Australia: Abbott and Doucouliagos, 2003; Worthington and Lee, 2008; UK: Flegg et al., 2004; Johnes 2006; Italy: Abramo et al., 2008; Agasisti and Salerno, 2007; Bonaccorsi et al., 2006; Tommaso and Bianco, 2006; Austria: Leitner et al., 2007;Germany: Fandel, 2007; Kempkes and Pohl, 2006);

- Cross-country studie: Bonaccorsi et.al., 2007; Agasisti and Johnes, 2009; Agasisti and Haelermans, 2015; Daraio et al., 2015a, 2015b; Bolli et al. 2016; Wolszczak-Derlacz, 2017.

- Methodology: One, two step estimations, Second step: mainly tobit model used: Kirjavainen and Loikkanen, 1998; Kempkes and Pohl, 2008. Bootstrapping procedure: Oliviera and Santos, 2005; Alexander et al., 2010, conditional efficiency: Daraio and Simar, 2005, 2007, ; Bădin et al., 2012, 2014

University production function



How to measure results of university's production?

Research output

How to measure research output:

- expert peer-review process
- evaluation of research orientation e.g PhD to total number of students
- comparision of research grants
- bibliometric indicators – publications, citations

Bibliometric indicators

Advantages:

- comparable across universities
- easy to implement
- low cost
- quick update

Disadvantages

- quality versus quantity
- differences across disciplines
- self citation

Teaching output

How to measure teaching output:

- number of graduates
- number degrees, bachelor master
- number of doctoral degrees awarder
- ratio of drop outs to continuing study

Third mission

How to measure institutional role of interacting directly with society to transfer knowledge and create tangible benefits outside the academic world:

- number of patents
- numbers of start-ups, spin-offs companies
- technology transfer contracts
- number of partnerships with industry/NGOs
- public events

History

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Research paper

An evaluation and explanation of (in)efficiency in higher education institutions in Europe and the U.S. with the application of two-stage semi-parametric DEA

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European-US comparison

ABSTRACT

In this study the technical efficiency of number of public European and American HEIs is assessed over a decade. Efficiency scores are determined using nonparametric DEA with different input-output sets and considering different frontiers: global frontier (all HEIs pooled together), regional frontier (Europe and the U.S. having their own frontiers) and country-specific ones. The external factors affecting the degree of HEI inefficiency are also investigated, e.g. institutional settings (size and department composition), location and funding structure. Specifically, the results indicate a positive association between both regional GDP per capita and number of departments and an institution's efficiency (for both the European and U.S. samples). On average, older European HEIs are more efficient, but this is not confirmed for American ones. Finally, government funding seems to have a negative effect on the efficiency of universities in Europe, which again is not confirmed for the U.S. However, some country heterogeneity at the European level is found through intensive sensitivity analysis.

Data used at the level of individual universities:

- **Number of students**
- **Number of graduates**
- **Number of academic staff**
- **Total revenues**
- **Core revenues**
- **Third-party revenues**
- **Tuition fees**
- **Number of publications indexed in WoS**

Sources:

- **National statistical offices (AUT, GER, CHE)**
- **Ministry websites (FIN, SWE)**
- **Other country-specific sources:**
  - PL: *Higher Education – Basic Data* (MNiSW)
  - Spanish Rectors Conference (CRUE)
  - Association of Netherlands Universities (VSNU)
  - ITA: National Agency for the Evaluation of Universities (ANVUR)
  - UK: Higher Education Statistics Agency
  - USA: The Integrated Postsecondary Education Data System (IPEDS)
- **University financial reports/statements**
- **University websites**
- **Web of Science - publications**

Table A3. Detailed description of variables used in first and second step analysis together with their sources

Variable	Country	Definition	Source
Academic staff	Austria	Professors, assistants and other academic staff, full-time equivalent Persons with several employment relationships are counted only once.	Federal Ministry of Science Research and Economy www.bmwf.gv.at/unidata
	Finland	Professors, associate professors, senior assistants, assistants, lecturers, teachers and research personnel, full time equivalent	Finnish Ministry of Education and Culture 2000 – 2009: https://kotaplus.csc.fi/online/Haku.do Since 2010: http://vipunen.csc.fi/.
	Germany	Professors, lecturers, scientific assistants, scientific and artistic employees, teaching personnel, full time employment	Federal Statistical Office (Destatis) www.destatis.de Publication: Reihe (Series) 4.4 "Personal an Hochschulen" (personnel at institutions of higher education).
	Italy	Professors (1st and 2nd category) researchers, registered at the end of the year, who in December received at least 95% of the salary typical for the post at the full-time employment level	National Agency for the Evaluation of Universities (ANVUR)
	Netherlands	The personnel files contain only data of persons appearing in the personnel records of the Dutch universities. That is, the data excludes staff hired through third parties. Without hospitals faculty staff who transferred from the university as an employer to the university medical center as an employer. FTE, as recorder on the 31st Dec, including student assistants	Association of Universities in the Netherlands (VSNU) http://www.vsnu.nl/en_GB
	Poland	Professors, docents, adjuncts, assistants, senior lecturers, lecturers and specialist librarians, full time employment	Ministry of Science and Higher Education.
	Spain	Academic staff excluded graduate students employed for teaching assistance or research.	Spanish Rectors Conference (CRUE), www.crue.org
	Sweden	The number of teaching and research staff in FTE. The figures include professors, senior lecturers, lecturers, post-doctoral research appointments, visiting lecturers, part-time lecturers and other research and teaching staff.	Swedish Higher Education Authority http://www.uk-ambetet.se/
	Switzerland	Professors, adjuncts and lectures, full time equivalent, referring to the last day of each year. The counting method is function-based for the FTEs but is based on single attribution for HC. An individual is counted once within each institution but, if he/she works for two or more institution, he/she is counted twice or more times, once for each institution. When the person is active in more than one field, he/she is counted only in the field with the higher percentage of activity.	Swiss Federal Statistic Office: https://www.bfs.admin.ch/bfs/en/home/statistics/education-science.html
	UK	Academic contract staff defined as professionals holding a contract for planning, directing and undertaking academic teaching and research within HE providers. Examples of such contracts include those for vice-chancellors, medical practitioners, dentists, veterinarians and other health care professionals who undertake lecturing or research activities. Full and part-time expressed in full-persons equivalents (FPE), excluding atypical staff: whose contracts involve working arrangements that are not permanent, involve complex employment relationships and/or involve work away from the supervision of the normal work provider.	Higher Education Statistics Agency http://www.heidi.ac.uk/
	US	All full-time faculty (Instruction/Research/Public Service). Persons identified by the institution as such and typically those whose initial assignments are made for the purpose of conducting instruction, research or public service as a principal activity (or activities). They may hold academic rank titles of professor, associate professor, assistant professor, instructor, lecturer or the equivalent of any of those academic ranks. Graduate, instruction, and research assistants are not included in this category.	Integrated Postsecondary Education Data System (IPEDS) http://nces.ed.gov/ipeds/ run by the National Center for Education Statistics

Methodology: Data envelopment analysis (DEA)

- no functional form
- multiply inputs and multiply outputs
- relative efficiency of each HEI (vis-a-vis the best performence)
- output orientated model: maximising output while using no more than observed amount of inputs
- inputs/output set

TWO-STAGE BOOTSTRAP DEA ANALYSIS

based on Simar and Wilson (2007) procedure:

1st step: DEA scores:

$$\hat{\lambda}_{VRS}(x,y) = \sup\{\lambda | \lambda y \leq \sum_{i=1}^{n} \gamma_i y_i; x \geq \sum_{i=1}^{n} \gamma_i x_i \quad \text{for} \quad (\gamma_1, \ldots \gamma_n)$$

$$\text{such that:} \sum_{i=1}^{n} \gamma_i = 1 \text{ and } \gamma_i \geq 0, i = 1, \ldots, n\}.$$

2nd step: determinants of efficiency

$$\hat{\lambda}_i = a + z_i\beta + \varepsilon_i$$

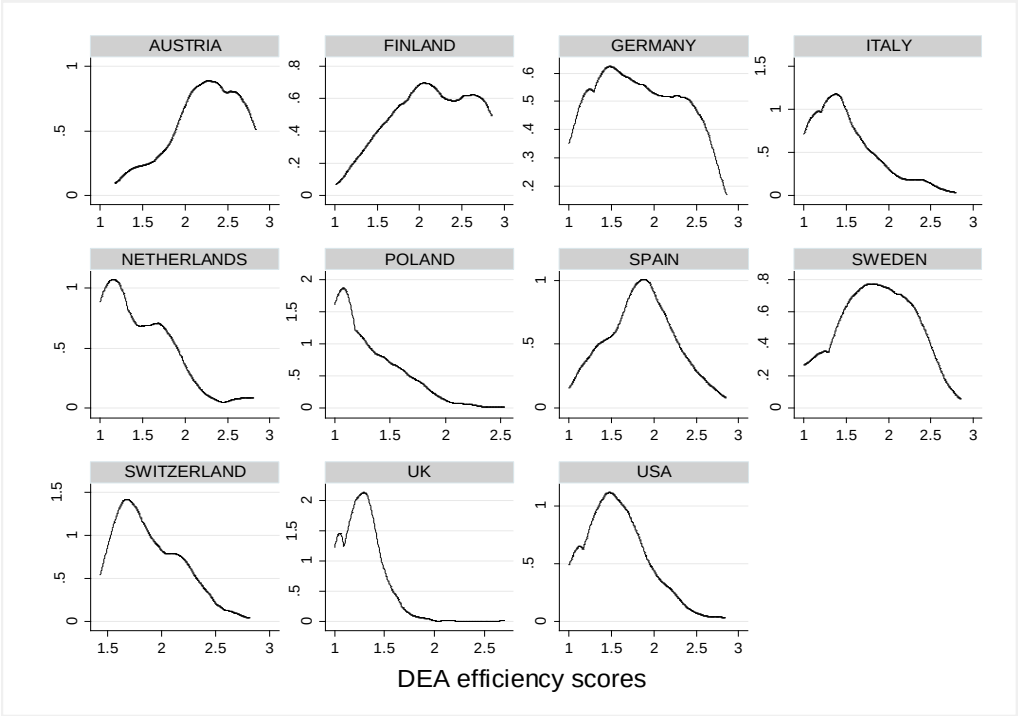
where:

$\hat{\lambda}_i$- DEA scores

z_i- environmental variables

ε_i- noise, $\varepsilon_i \geq 1 - a - z_i\beta$

The distribution of efficiency scores by country (all years pooled), common frontier.



Step 2: Parametric estimates

$$DEA_{i,t} = \alpha + \beta_1 GDP_{n,t} + \beta_2 DEP_{i,t} + \beta_3 FOUND_i + +\beta_4 REV\_GOV_{i,t} / REV\_FEE_{i,t} + \beta X_{ij,t} + u_{ijt}$$

where: *i* refers to a single HEI, and *t* denotes the time period

GDP - GDP per capita of the region *n* (NUTS2) where the institution is located
DEP - the number of different departments
FOUND - year of foundation
REV_GOV - share of government funding in total revenues
REV_FEE - the share of tuition fees
X – control variables

The determinants of inefficiency scores for the **European** sample – DEA 3-input/2-output model with common frontier

	(1) Bias-adjusted coefficients	95% bootstrap confidence intervals		(2) Bias-adjusted coefficients	95% bootstrap confidence intervals		(3) Bias-adjusted coefficients	95% bootstrap confidence intervals	
		low	high		low	high		low	high
GDP	-0.309***	-0.429	-0.198	-0.323***	-0.454	-0.205	-0.227***	-0.321	-0.133
DEP	-0.029***	-0.036	-0.022	-0.025***	-0.033	-0.016	-0.005*	-0.013	0.002
FOUND	0.080***	0.066	0.100	0.085***	0.067	0.107	0.030***	0.015	0.043
REV_GOV				0.376**	0.088	0.686			
REV_FEE							-1.193***	-1.63	-0.794
Obs.	4174			3355			1725		

Notes: * indicates that the value zero does not fall within the 90% confidence interval, ** indicates that the value zero does not fall within the 95% confidence interval, *** indicates that the value zero does not fall within the 99% confidence interval. Confidence intervals obtained from 1000 bootstrapping interactions.
Constants are not reported. Dummies for medical departments and technical institutions as well as year and country individual effects included in all models.
Source: own calculations

The determinants of inefficiency scores for the **U.S**. sample – DEA 3-input/2-output model with common frontier

	(1) Bias-adjusted coefficients	95% bootstrap confidence intervals		(2) Bias-adjusted coefficients	95% bootstrap confidence intervals		(3) Bias-adjusted coefficients	95% bootstrap confidence intervals	
		low	high		low	high		low	high
GDP	-0.815***	-0.985	-0.643	-0.858***	-1.028	-0.684	-0.843***	-1.018	-0.667
DEP	-0.036***	-0.044	-0.029	-0.035***	-0.042	-0.028	-0.032***	-0.040	-0.025
FOUND	-0.021	-0.071	0.033	-0.019	-0.071	0.036	-0.007	-0.058	0.045
REV_GOV				0.156	-0.066	0.378			
REV_FEE							0.281*	0.017	0.583
Obs.	1976			1669			1670		

Notes: * indicates that the value zero does not fall within the 90% confidence interval, ** indicates that the value zero does not fall within the 95% confidence interval, *** indicates that the value zero does not fall within the 99% confidence interval. Confidence intervals obtained from 1000 bootstrapping interactions.
Constants are not reported. Dummies for medical departments and technical institutions as well as year effects included in all models.
Source: own calculations

Conclusions – from the paper

high level of technical inefficiency of HEIs, substantial variability in the efficiency scores both between and within countries

inefficiency is determined by:

- a shift to government funding as a revenue source decreases a university's technical efficiency in Europe (relationship is statistically insignificant for the U.S)
- the proportion of funding from students' fee (positive for Europe)
- size: larger units have higher efficiency: European and US
- location: units located within wealthier regions are more efficient: European and US

policy implication:

- increasing competitive funding for HEI
- European versus US systems
- feasibility of creating a comprehensive cross-country database at the level of individual institutions → **see next slide**

DATA

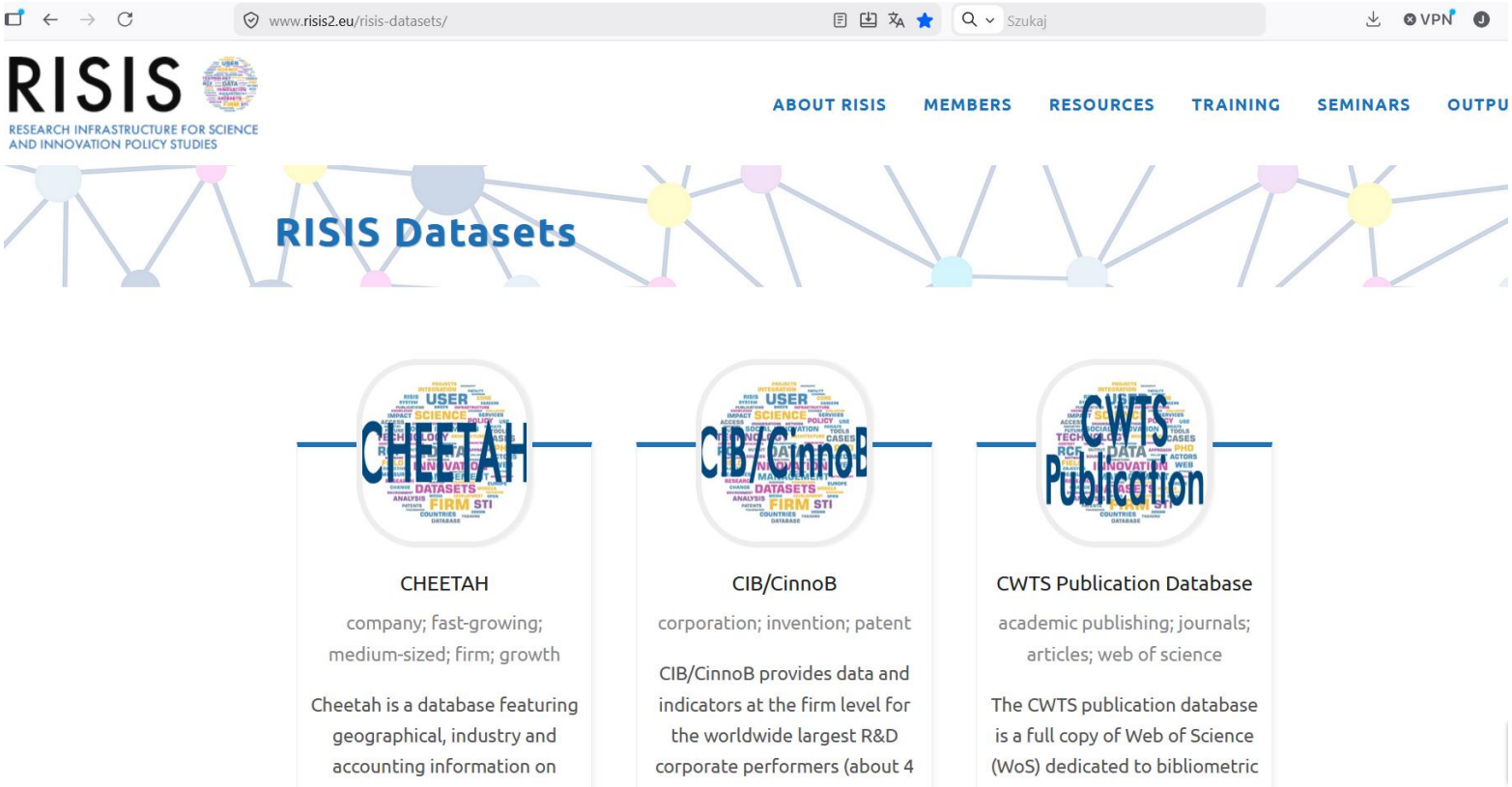
European Commission initiatives to create a unified database with statistics for individual universities

- Advances Quantitative Methods for the Evaluation of the Performance of Public Sector Research (Aquameth) – **access only for consortium members**
- EUMIDA European University Data Collection – **access only for consortium members**
- **Research Infrastructure for Science and Innovation (RISIS)**
- **The European Tertiary Education Register (ETER):** Open data access
- **The European Higher Education Sector Observatory (EHESO)**

RISIS

(now 15 different datasets):

https://www.risis2.eu/risis-datasets/



RISIS

Datasets on the universities:

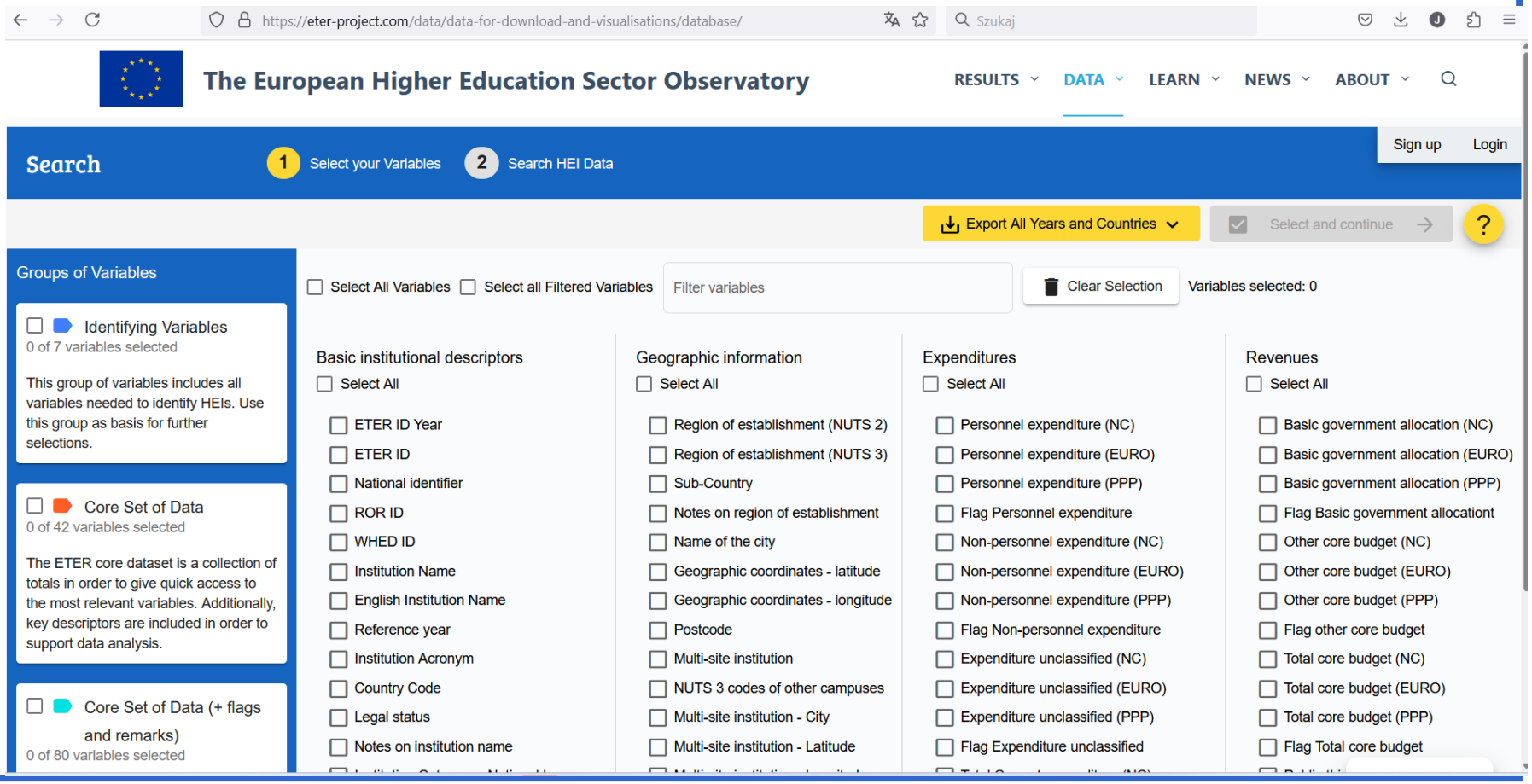
- CWTS Publication Database
- EUPRO: R&D projects, participants and resulting networks of the EU FP,
- MORE – research mobility
- RISIS-ETER
- RISIS Patent

Open access or *research project*

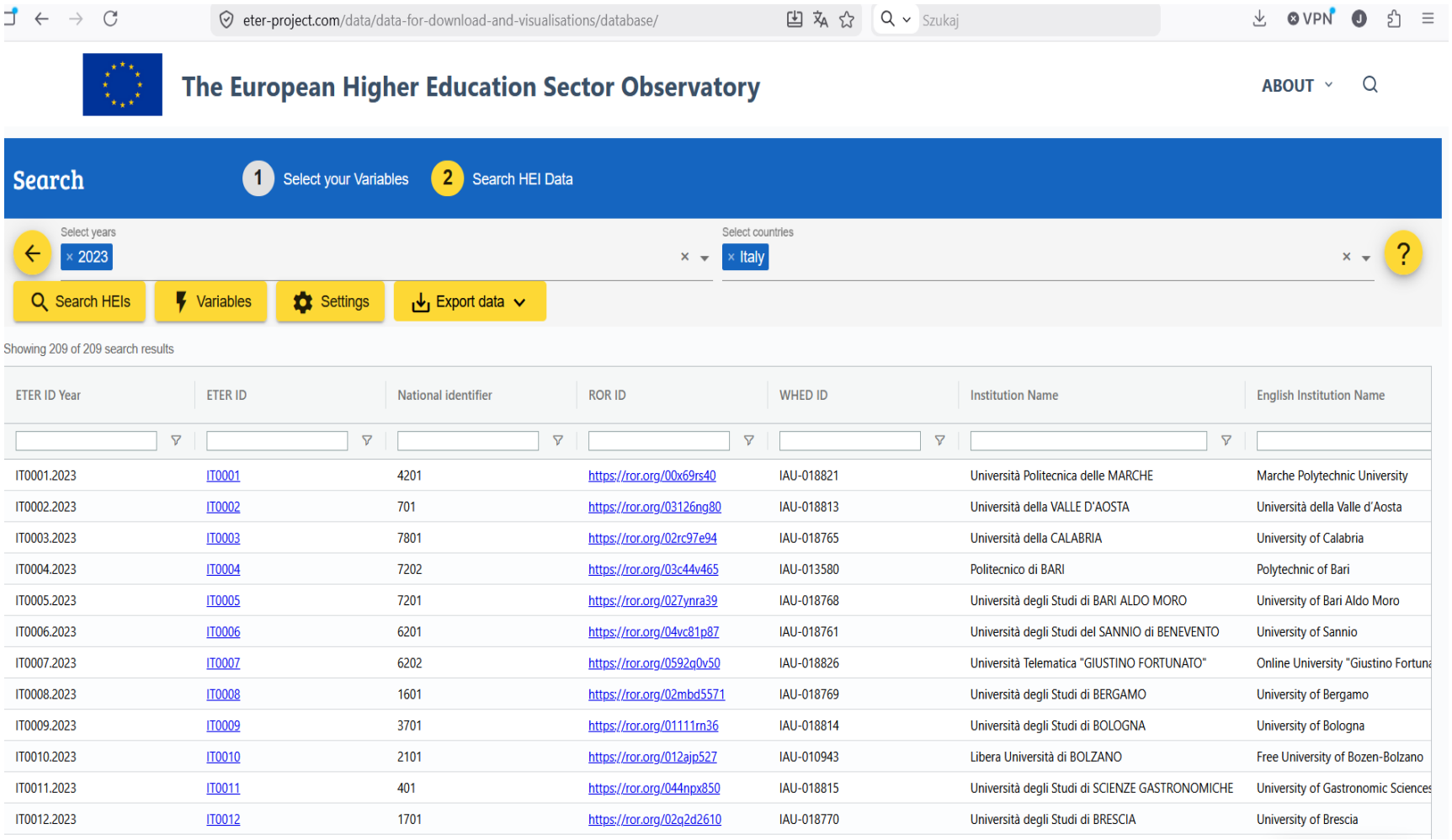
Advantage: linking data at the level of individual universities: _id

European Higher Education Sector Observatory (EHESO)

https://eter-project.com/data/data-for-download-and-visualisations/database/

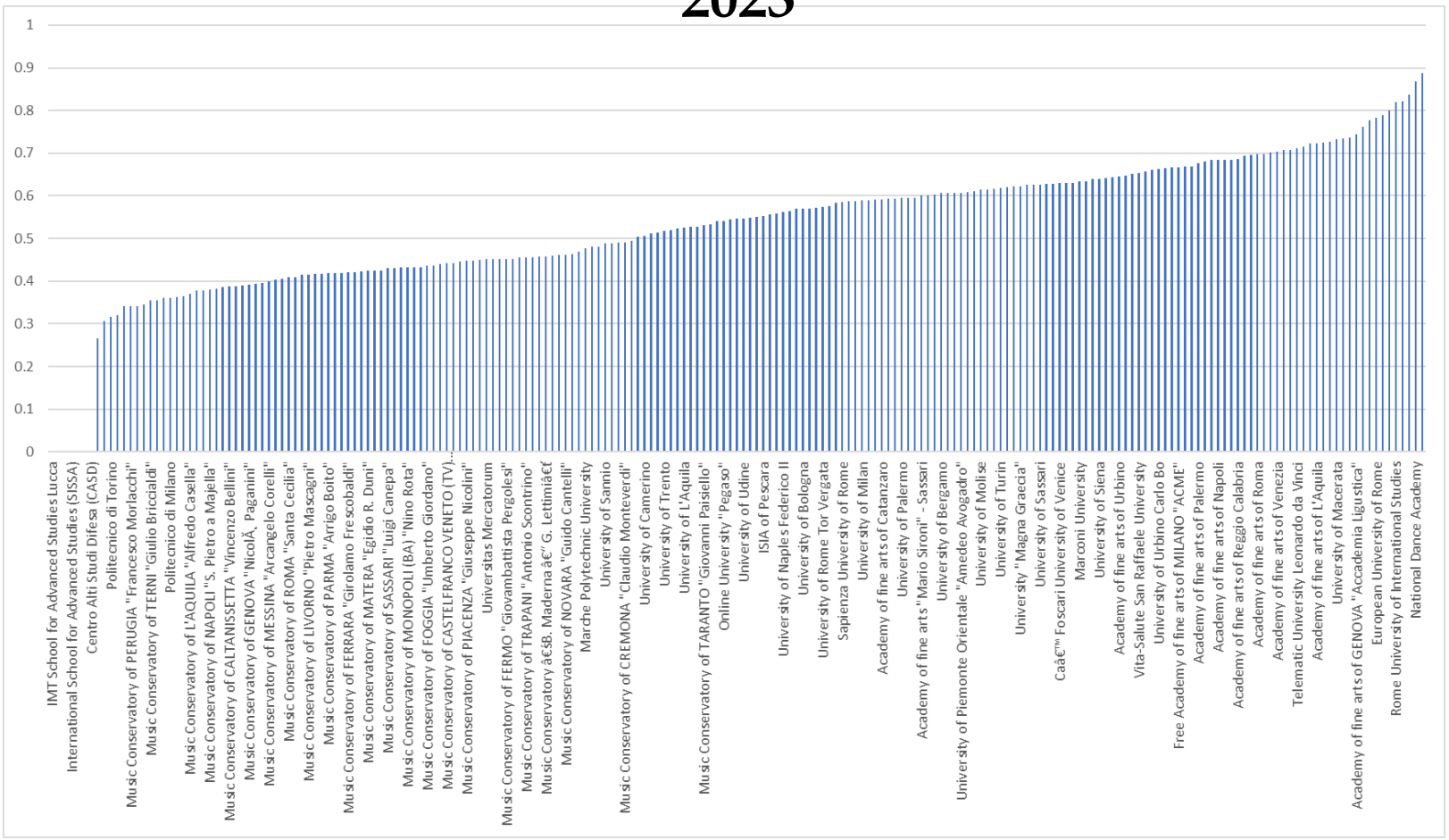


Currently data for 2011-2023, 4163 universities from 41 countries, 80 variables



ETER ID Year	ETER ID	National identifier	ROR ID	WHED ID	Institution Name	English Institution Name
IT0001.2023	IT0001	4201	https://ror.org/00x69rs40	IAU-018821	Università Politecnica delle MARCHE	Marche Polytechnic University
IT0002.2023	IT0002	701	https://ror.org/03126ng80	IAU-018813	Università della VALLE D'AOSTA	Università della Valle d'Aosta
IT0003.2023	IT0003	7801	https://ror.org/02rc97e94	IAU-018765	Università della CALABRIA	University of Calabria
IT0004.2023	IT0004	7202	https://ror.org/03c44v465	IAU-013580	Politecnico di BARI	Polytechnic of Bari
IT0005.2023	IT0005	7201	https://ror.org/027ynra39	IAU-018768	Università degli Studi di BARI ALDO MORO	University of Bari Aldo Moro
IT0006.2023	IT0006	6201	https://ror.org/04vc81p87	IAU-018761	Università degli Studi del SANNIO di BENEVENTO	University of Sannio
IT0007.2023	IT0007	6202	https://ror.org/0592q0v50	IAU-018826	Università Telematica "GIUSTINO FORTUNATO"	Online University "Giustino Fortuna
IT0008.2023	IT0008	1601	https://ror.org/02mbd5571	IAU-018769	Università degli Studi di BERGAMO	University of Bergamo
IT0009.2023	IT0009	3701	https://ror.org/01111rn36	IAU-018814	Università degli Studi di BOLOGNA	University of Bologna
IT0010.2023	IT0010	2101	https://ror.org/012ajp527	IAU-010943	Libera Università di BOLZANO	Free University of Bozen-Bolzano
IT0011.2023	IT0011	401	https://ror.org/044npx850	IAU-018815	Università degli Studi di SCIENZE GASTRONOMICHE	University of Gastronomic Sciences
IT0012.2023	IT0012	1701	https://ror.org/02q2d2610	IAU-018770	Università degli Studi di BRESCIA	University of Brescia

Share of women students (ISCED 5-7), Italian universities, 2023



Source: own elaboration based on data from EHESO

Share of women full professors, Italian universities

Name of the university	Share of women full professors
University for Foreigners Perugia	0.54
Università della Valle d'Aosta	0.50
University for Foreigners of Siena	0.45
Free University Maria SS.Assunta (LUMSA)	0.41
Suor Orsola Benincasa University	0.40
Rome University of International Studies	0.40
University of Bergamo	0.32
University of Milano-Bicocca	0.31
University of Messina	0.30
"Orientale" University of Naples	0.30
University of Rome "Foro Italico"	0.30
Roma Tre University	0.30
University of Milano	0.28
University of Turin	0.28
University of Modena and Reggio Emilia	0.27
University of Bari Aldo Moro	0.27
University of Cagliari	0.26
University of Verona	0.26
University of Pavia	0.26
Sapienza University of Rome	0.26

Source: own elaboration based on data from EHESO

What ca be analyzed based on EHESO data

- Country specific analysis: e.g. private versus public universities
- Cross-country analysis
- Trend in time: e.g. students mobility
- Research output: publications, citations
- Research specialization: e.g. share of PhD students
- Teaching output: number of graduates, number of degrees
- Financial conditions: revenues, expenditure

Other sources of (indyvidual university) data:

- USA:Integrated Postsecondary Education Dataset (https://nces.ed.gov/ipeds/
- Australia: Australian Gvernment Department (https://www.education.gov.au/higher-education-publications)

New paper

Higher Education
https://doi.org/10.1007/s10734-026-01687-1

Funding sources and university patenting: an analysis of European higher education institutions

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Abstract

Although European universities account for no more than 10% of all patents, examining their patenting patterns remains relevant, given their contribution to breakthrough innovations and European technological competitiveness. We examine the role of university funding sources in patenting, addressing three key research gaps: (i) the reliance on limited, country-specific samples rather than pan-European data in most patenting-funding studies; (ii) the scarcity of evidence on the impact of the funding sources on patent quantity and quality; and (iii) the lack of precise estimates of interactions between university patenting, funding sources, 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 within-country 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 have more than twice the share of third-party revenues. This indicates that the very marked

A dataset on knowledge creation and patenting by European Higher Education Institutions (KC-HEI)

- Data from PATSTAT: 107,000 university patent applications to the IP5 patent offices used to derive large, micro-level dataset of nearly 2,900 universities in 31 European countries and 295 NUTS2 regions (2011–2019).
- Patent citations, OECD Patent quality indices Quality Indicators database
- ETER
- RISIS Patents
- WIPO: PATENTSCOPE Artificial Intelligence Index
- Eurostat Regional Statistics

Procedure

- A major challenge was identifying universities in PATSTAT.
- Many *psn _id* in PATSTAT actually refer to a single university:
  - Federal Institute of Technology Zurich or Trinity College Dublin described by as many as 80 or more different names in PATSTAT
- Our contribution: **a crosswalk between PATSTAT and ETER**
  - string similarity metrics (algorytm Levenshtein) + manual verification
  - unique correspondence between *psn_id* i *eter_id*
  - High matching rate for PATSTAT and ETER identifiers: **87%,** for 0.65-0.87 manual verification
  - **Consequently two samples**
    - Sample 1: 866 patenting European universities from 31 countries 1980-2019
    - Sample 2: 785 patenting universities and 2,102 non-patenting (2011-2019)

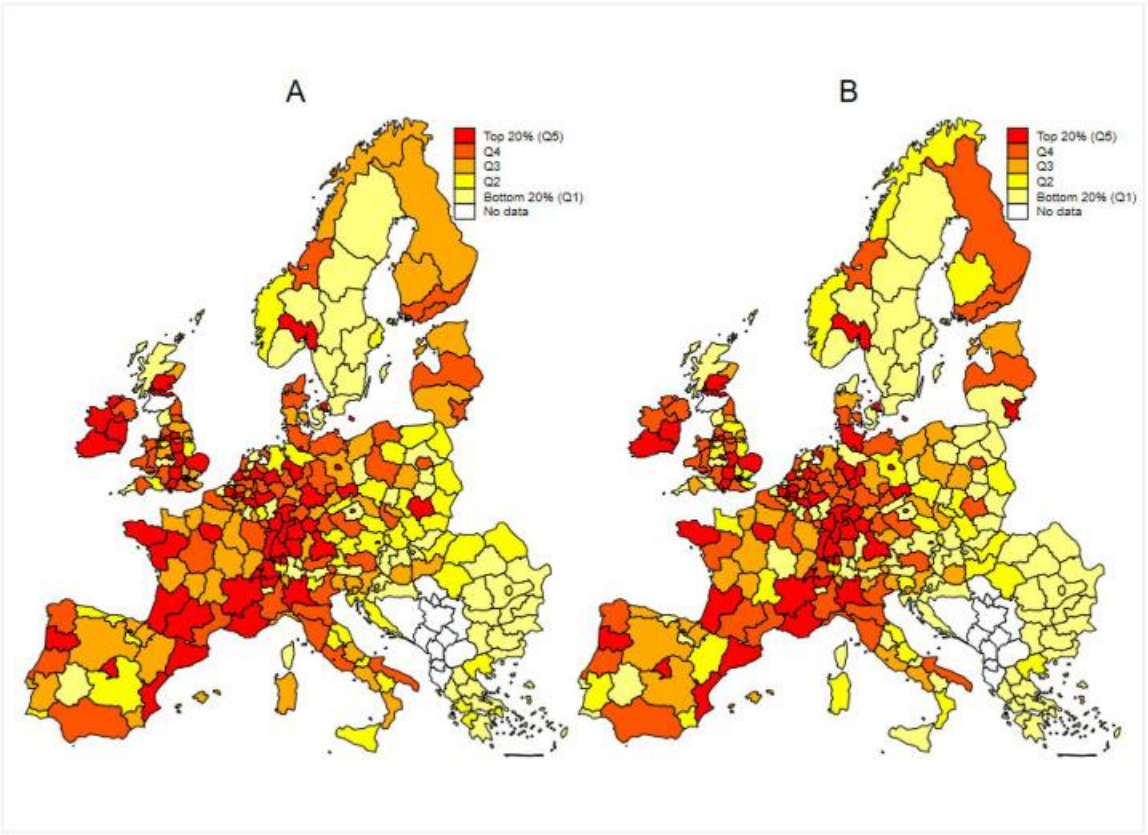


Fig. 1 Regional distribution of patenting by European HEIs. (**A** – patent applications, **B** – patent quality: citations), total 2011–2019. Note: Sample of 2,886 HEIs in 31 European countries (2011–2019); Iceland is not shown on the graph. Values for Sweden are likely to be underestimated due to professor's privilege. IP5 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 five groups according to university patent distribution: quintiles e.g. the top class in red corresponds to the top 20% of regions. Source: Authors' own elaboration using PATSTAT Global (Autumn 2022) and OECD Patent Quality Indicators database

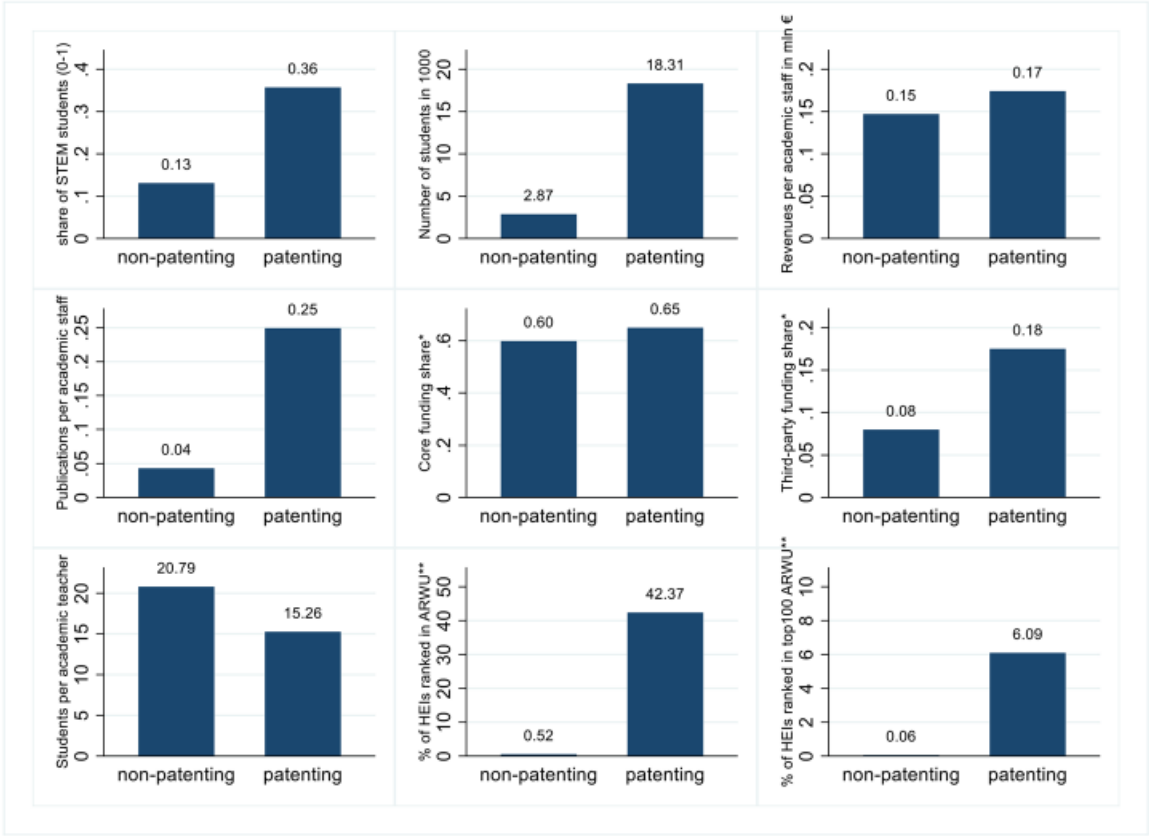
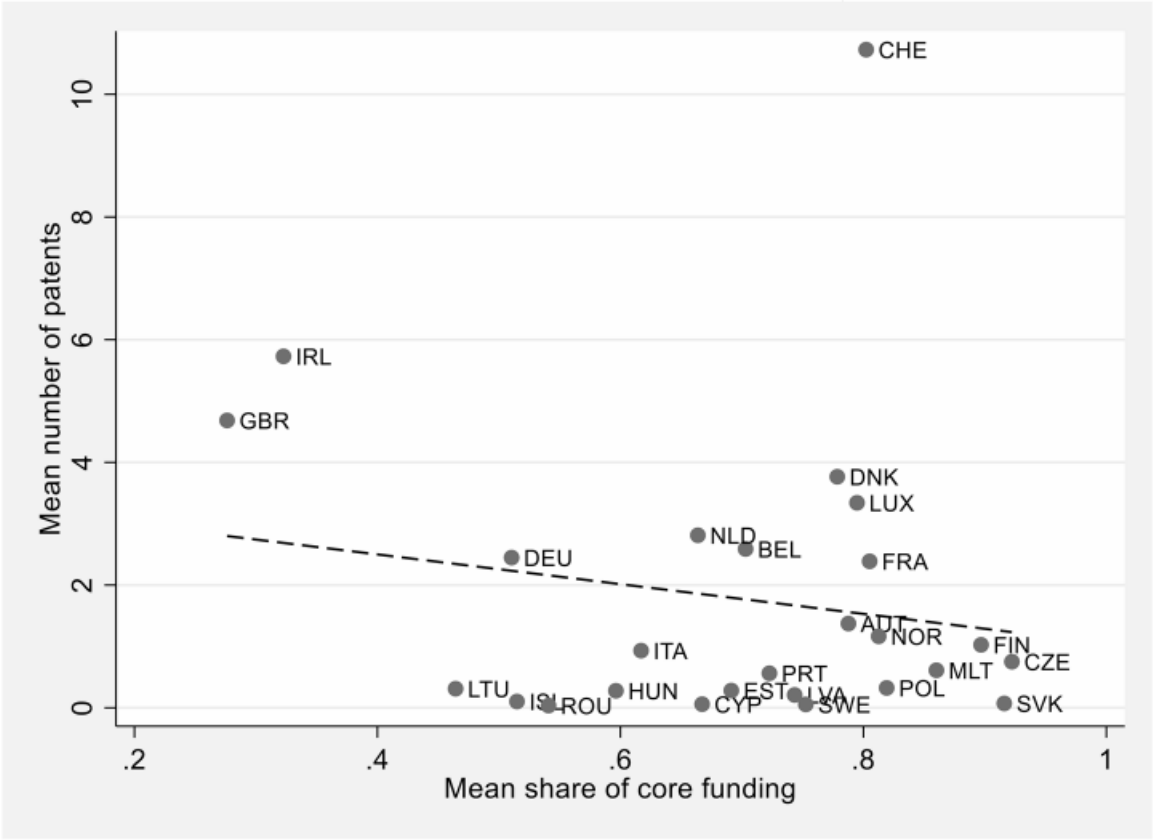


Fig. 3 Comparison of patenting and non-patenting HEIs in Europe – key features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Mean number of patents
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1
Mean share of core funding

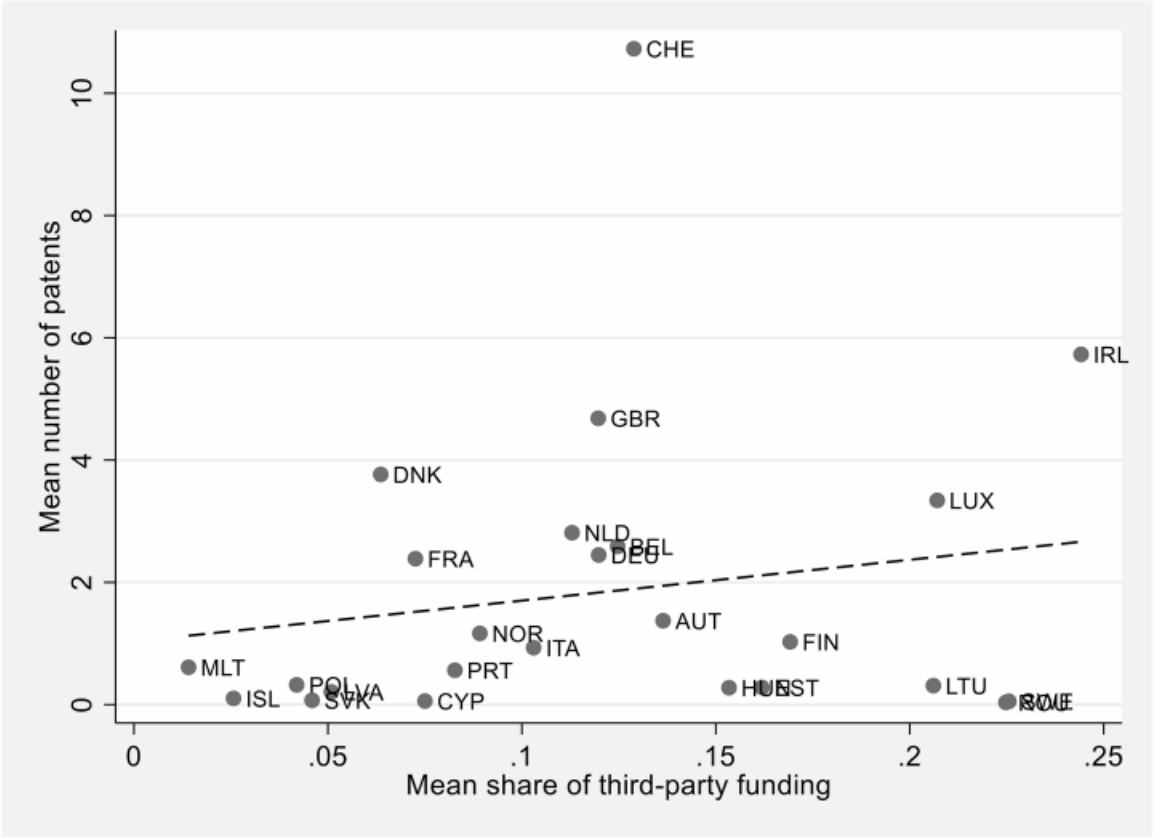

Fig. 4 Country-level correlation between universities' patenting and funding sources. Note: Mean national values. Source: authors' elaboration using PATSTAT Global (Autumn 2022) and ETER

Methodology

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

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

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

Results (1)

Table 3 Basic estimation results – determinants of direct patent applications and patent citations by HEIs

	Dependent variable: number of patent applications to IP5 patent offices			Dependent variable: forward citations of EPO patents #		
	(1)	(2)	(3)	(4)	(5)	(6)
Age_i	0.010***	0.013***	0.013***	0.008***	0.011***	0.011***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$GenUniv_i$	0.23	1.526***	0.930***	0.122	1.349***	0.886***
	[0.158]	[0.243]	[0.261]	[0.181]	[0.284]	[0.306]
$STEM_{it}$	6.020***	6.167***	6.023***	6.083***	6.861***	6.770***
	[0.277]	[0.411]	[0.433]	[0.317]	[0.479]	[0.509]
$Stud_{it}$	0.227***	0.228***	0.231***	0.149***	0.145***	0.145***
	[0.008]	[0.010]	[0.011]	[0.009]	[0.012]	[0.013]
$Stud\_acad_{it}$	−0.055***	−0.074***	−0.070***	−0.040***	−0.053***	−0.045***
	[0.004]	[0.008]	[0.009]	[0.005]	[0.009]	[0.010]
Pub_acad_{it}		10.467***	7.644***		7.232***	5.063***
		[0.672]	[0.740]		[0.783]	[0.870]
Rev_acad_{it}		1.35	2.819**		0.038	0.956
		[1.258]	[1.362]		[1.466]	[1.601]
$Core\_budget_{it}$			−1.102***			−0.475
			[0.399]			[0.469]
$Third\_party_{it}$			9.383***			8.028***
			[0.865]			[1.017]
N	14,833	9639	9018	14,833	9639	9018
R2	0.37	0.42	0.44	0.24	0.27	0.28
Number of Countries	31	26	25	31	26	25

All specifications include region- and time-fixed effects. Standard errors in brackets, * $p<0.10$, ** $p<0.05$, *** $p<0.01$

Results (2)

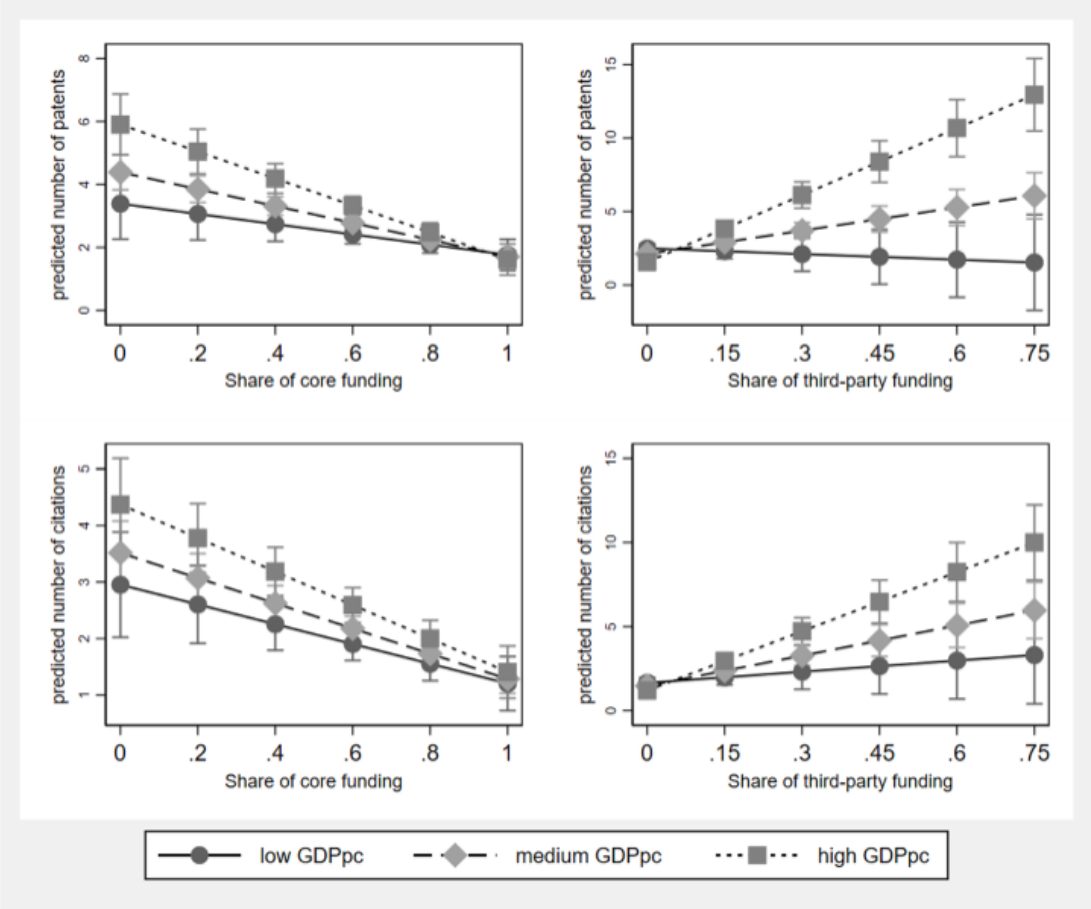

Fig. 5 Regional systems and university funding sources – patenting relationships: marginal plots from Eqs. (2) and (3). Note: Full estimation results are reported in Table A8 in the Appendix. Source: Authors' calculations using PATSTAT Global (Autumn 2022), ETER, OrgReg, OECD/STI Micro-data and Eurostat data

Conclusions:

- Only 27% of universities have at least one patent.
- Strong regional distribution
- Positive relationship between third-party funding and university patenting
- As the share of external funding increases, universities in medium- and high-income regions make more 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.
- A larger core budget share corresponds to fewer patents and forward citations, and the decline is greater among universities in the wealthier regions

Potential applications of KC-HEI

- **Analyses of the number of patents versus quality indicators**
  - patent citations, breakthrough patents (top 1% cited patents)
- **Determinants of university patenting activity uczelni**
  - Teaching load
  - Funding (total revenues, by source)
  - University size (number of students, academic staff))
  - Location
  - Institutional environment (professors' privilege)
- **Regional analyses** :
  - core-periphery patterns of knowledge creation
  - relationship between university patenting and economic growth and labour markets
- Patents by **technology fields**
- **AI patents**

Thank you for your attention

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