Working Paper Series
SWPS 2017-01 (January)

A Typology of European Research Universities. Differentiation, Layering and Resource Distribution

Benedetto Lepori, Aldo Geuna
and Valerio Veglio

University of Sussex

SPRU Working Paper Series (ISSN 2057-6668)

The SPRU Working Paper Series aims to accelerate the public availability of the research undertaken by SPRU-associated people, and other research that is of considerable interest within SPRU, providing access to early copies of SPRU research.

Guidelines for authors

Papers should be submitted to swps@sussex.ac.uk as a PDF or Word file. The first page should include: title, abstract, keywords, and authors' names and affiliations. The paper will be considered for publication by an Associate Editor, who may ask two referees to provide a light review. We aim to send referee reports within three weeks from submission. Authors may be requested to submit a revised version of the paper with a reply to the referees' comments to swps@sussex.ac.uk. The Editors make the final decision on the inclusion of the paper in the series. When submitting, the authors should indicate if the paper has already undergone peer-review (in other series, journals, or books), in which case the Editors may decide to skip the review process. Once the paper is included in the SWPS, the authors maintain the copyright.

Websites

UoS: www.sussex.ac.uk/spru/research/swps

SSRN: http://www.ssrn.com/link/SPRU-RES.html

IDEAS: ideas.repec.org/s/sru/ssewps.html

Research Gate: www.researchgate.net/journal/2057-6668_SPRU_Working_Paper_Series

A Typology of European Universities. Differentiation and resource distribution

Benedetto Lepori[a], Aldo Geuna[b,c] and Valerio Veglio[d]

Acknowledgments

The authors are grateful to one anonymous reviewer for the SPRU Working Paper Series (SWPS) for comments and suggestions. Thanks are due to the European Commission, ETER project, to the CWTS, University of Leiden, and to the Austrian Institute of Technology for providing access to the data. The paper has benefited from comments and suggestions received at the following seminar and conference presentations: Science and Technology Indicators 2015 in Sevilla, Politecnico of Milan and SPRU, University of Sussex seminar series. The authors acknowledge support from the European Union through the project, Research infrastructures for the assessment of science, technology and innovation policy (RISIS) (Grant agreement no: 313082).

a: Institute of Interdisciplinary Data Science (IDIDS), Faculty of Communication Sciences, Università della Svizzera Italiana, Via Lambertenghi, 10, Lugano, 6900 (Switzerland), blepori@usi.ch.
b: Department of Economics and Statistics Cognetti De Martiis, University of Turin, Lungo Dora Siena 100 A, 10153 Turin, Italy, Tel: +39 0116703891, Fax: +39 011 6703895; email: aldo.geuna@unito.it
c: BRICK, Collegio Carlo Alberto, Via Real Collegio, 30, Moncalieri Torino, 10024 (Italy)
d: Department of Management and Technology, University Bocconi, Milan, valerio.veglio@unibocconi.it

Abstract

The aim of this paper is to develop a theory-based typology of Higher Education Institutions (HEIs) based on three dimensions of differentiation, i.e. their *activity profile* (education vs. research), the *subject scope* (generalist vs. specialist) and *regulatory characteristics* which constrain the previous two. We examine the *financial environment* of HEIs as a possible selection mechanism. Particular attention is devoted to the identification of European Research Universities. By testing this typology on a large sample of European HEIs, we show systematic differences between types in their activity profile and in the level of funding, therefore providing evidence that types are associated with different market positioning. We identify a small group of research universities, characterized by a high level of research volume and intensity and by a volume of funding far higher than all other HEIs in the sample, suggesting that their emergence is critically linked to the concentration of resources.

Keywords: Academic Research, Higher Education Institutions, Universities, Ranking, Typology, resource allocation, concentration of resources

JEL codes: I23, I28, H52

1 Introduction

The European Higher Education System is highly diversified and fragmented. It is the combination of national systems that are the result of a long historical evolution. Despite attempts to develop policies and funding schemes at the European level, particularly concerning research (Edler and Kuhlmann 2011), regulation and funding largely remain at the national level. Comparative studies have highlighted the differences between European countries in terms of how higher education systems are regulated, funded and organized (Kyvik 2004; Nieminen and Auranen 2010; Jongbloed and Lepori 2015), which is frequently captured by contrasting continental European systems, characterized by mostly public state-regulated institutions and a largely historical funding system with the Anglo-Saxon-model, characterized by institutional autonomy and stronger orientation of funding to performance (Geuna and Martin 2003).

With only a few exceptions (Geuna, 1999; Daraio, Bonaccorsi, Geuna, Lepori and et. al. 2011, Schubert, Bonaccorsi, Brandt, et al 2014; Huisman, Lepori, Seeber, Frølich and Scordato 2015), much of the studies that analyze the provision and funding of teaching and research in Higher Education Institutions (HEIs include universities and all other tertiary education institutions) have been nationally oriented. The increased international mobility of students and researchers, international competition between higher education and research suppliers, the emergence of international rankings and the perception that European universities have a lower performance than their US counterparts (Albarrán, Crespo, Ortuno and Ruiz-Castillo 2010, Herranz and Ruiz-Castillo 2013) have recently stimulated a renewed interest in understanding if European Research Universities exist and what they are. This paper aims to answer to these questions.

Faced with the large diversity of European HEIs and of national systems, previous attempts at establishing a typology of European HEIs did not go beyond the distinction between a university and a college model (Daraio, Bonaccorsi, Geuna, Lepori and et. al. 2011, Schubert, Bonaccorsi, Brandt, et al 2014). We suggest that this is largely the outcome of an empirical approach, which did not root the typology in a conceptualization of the main dimensions of differentiation of HEIs. Therefore, building on configurational approaches in management research (Fiss 2007, Short, Payne and Ketchen 2008), we propose a typology based on three fundamental dimensions of differentiation: (a) their *activity profile* (education vs. research), (b) their *subject scope* (generalist vs. specialist) and (c) two *regulatory characteristics* that constrain HEI teaching and research offerings – i.e. whether they are publicly regulated – and the HEI mission (research vs. education).

Finally, we use the *financial environment* of HEIs as a selection mechanism to predict which types are expected to have a viable resource basis, ultimately reaching a final set of eight HEI types, including a research university type characterized by high volume and high intensity of research.

To test the typology, we make use of a dataset that includes more than 2,000 European HEIs derived from the European Tertiary Education Register (ETER; Lepori, Bonaccorsi, Daraio, et al 2015). First, by adopting fuzzy-set Qualitative Comparative Analysis (fsQCA; Ragin 2000, Fiss 2011), we are able to attribute most HEIs in our sample to a type, with the number of cases that do not fit being relatively low. This provides evidence that the typology adequately represents the diversity of European HEIs.

Second, we show that there are systematic differences between types in the level and composition of funding, therefore providing evidence that types are associated with different market positioning. We specifically show that the distinctive characteristics of HEIs that belong to the research university type is a volume of funding (in absolute levels *and* compared with the students' enrolments) far higher than all other HEIs in the sample.

Third, we show that two indicators of research excellence, i.e. research impact as the percentage of the publications in the top-10% cited by field (Waltman, Calero-Medina, Kosten, et al 2012) and the position in international research rankings, display a stronger association with membership to the research university type than to any other type, including the mixed research and education university, which constitutes the core of European higher education. However, in the European context, given the very small number of research universities, most of the research excellence is still accounted for by mixed universities.

The relevance of our work is threefold. First, we are able to develop a typology of European higher education, which represents fairly well the empirical reality. Second, we theoretically and empirically establish the link between the structure of the resource space (and therefore, public funding policies) and the emergence of the research university type. Third, we show that research excellence is critically linked to the concentration of a high amount of resources in selected HEIs. This suggests that variations between countries in terms of the volume of resources and in the funding allocation mechanisms largely accounts for the observed differences in research excellence between European countries (and, possibly, with the US).

2 Constructing a HEI typology

A typology, i.e. "a set of conceptually derived ideal types, each of them representing a unique combination of the organizational attributes that are believed to determine the relevant outcomes" (Doty, Glick and Huber 1993) is a useful tool to analyze the organizational behavior of organizations. Typologies allow for an understanding of the interdependencies between attributes, which would not be revealed by other methods, like regressions (Fiss 2011) and developing predictions concerning how outcomes are associated with configurations of organizational characteristics and with environmental contingencies (Doty, Glick and Huber 1993).

While ideal types must be distinguished from the observed cases, typologies are intimately linked to empirical observation (Doty, Glick and Huber 1993). Data exploration provides important clues into the main dimensions of distinction between organizations and, therefore, orient the development of a typology, while the degree of fit between ideal types and observed cases remains an important validity criterion (Drazin and Van de Ven, Andrew H 1985). Beyond the debate between theory-based typologies and empirical taxonomies, the two are more complementary than alternative (Meyer, Tsui and Hinings 1993).

We ground our typology on an understanding of HEIs as multifunctional organizations that position themselves in different "quasi-markets" where they provide services to audiences, like the state, students and companies (Deiaco, Holmén and McKelvey 2010). This positioning also influences the amount of resources an HEI is able to mobilize and therefore its (economic) viability. Of course, it is expected that the output and performance of individual HEIs is influenced by other characteristics, like strategy, level of autonomy and governance (Aghion, Dewatripont, Hoxby, Mas-Colell and Sapir 2010), but our focus will be on the broad typological distinctions.

Research on HEI diversity suggests the construction of a typology around three dimensions, i.e. the *activity profile*, the *subject scope* and the *regulatory characteristics* of the considered HEI (Van Vught 2009, Huisman, Lepori, Seeber, Frølich and Scordato 2015).

a) The *activity profile* characterizes the importance of education and research for the HEIs' positioning in the resource space.

In the so-called Humboldtian model, considered as the prototype of the modern university (Clark 1995), education and research were closely associated. However, this relationship has become more complex in previous decades. On the one hand, the massification of higher education has

generated pressures to differentiate HEIs' profiles, in order to protect universities from an increase in the number of students (Trow 1979). On the other hand, the US has witnessed the emergence of the research university as a specific HEI-type whose identity and market positioning are associated with research excellence (Geiger 1993).

We therefore propose three types of activity profiles:

- *The education-oriented HEI*. Education constitutes the core mission and the main activity, from which most of the resources are generated. Some research might be present, but not core in terms of mission, identity and resources.
- *The mixed HEI*. Both education and research constitute core missions and their integration is constitutive of their identity.
- *The research HEI*. Research is the main identity trait and source of market positioning. The research HEI is recognized and branded based on research reputation, even if the volume of education might be significant.

Third-mission is an increasingly important dimension of HEI activities (Daraio, Bonaccorsi, Geuna, Lepori and et. al. 2011), but we consider that, in the European context, these activities play a dominant role in only a minority of institutions. Therefore, we do not single out Entrepreneurial HEIs, for which third-mission activities are constitutive (Etzkowitz 2004), as a distinct type.

b) *Subject scope* characterizes the diversity of the subject domains covered by HEI activities (Clark 1995). Subject specialization is relevant for market positioning: HEIs that are active in many subjects cover a broader range of educational demands and therefore have higher enrolment, while specialized HEIs might leverage their distinctive identity to attract students. Data show that while European higher education is comprised of a large number of specialist HEIs, generalist HEIs dominate in terms of size and resources. (Van Vught 2009, Lepori, Probst and Baschung 2010). We therefore distinguish between two types, i.e. the *generalist HEI* covering most subject domains, and the *specialist HEI,* whose identity is defined by subject ("technical school", "Art school", etc.).

c) In public quasi-markets, public regulation plays a central role in determining the type of activities HEIs are allowed to develop and the resources they have access to. It is therefore relevant to introduce *regulatory characteristics* into the typology. We focus on two dimensions:

- *Publicly regulated*. Publicly regulated HEIs are part of the public system and have the right to receive public subsidies for their activities, while private HEIs usually have only limited access to public funds.
- The *HEI's mission*. While universities traditionally had a research and education mission, some public HEIs received a specific *educational mission,* particularly for countries which created a second sector of higher education, comprising HEIs called Hogescholen in the Netherlands, Fachhochschulen in Germany, colleges in the UK (before 1992) and in Nordic countries, Polytechnics in Finland, for which we adopt the name of Universities of Applied Sciences (Lepori and Kyvik 2010). It is well known that HEIs as strategic actors might depart from their regulatory mission, for example by trying to develop research and becoming more similar to universities ('academic drift'; Kyvik and Lepori 2010), while universities with a research mission might become educational-oriented when they cannot compete in research. The HEI mission attributed by the state however has important implications in terms of legitimacy, access to public resources and legal rights (for example the ability to award a PhD). Hence, we might expect a somewhat complete relationship between the mission and activity profile.

By combining activity profile and subject scope, we identify six combinations (Figure 1).

Figure 1. Activity types

		Activity profile		
		Education-oriented	**Mixed**	**Research-oriented**
Subject scope	**Generalist**	Generalist education-oriented HEIs, for example Universities of Applied Sciences. Example: Hogeschool of Amsterdam.	Generalist universities with a large educational component. Example: University of Bologna.	Research universities. Example: University of Oxford.
	Specialist	Specialist Education-oriented, for example music and art schools. Example: Academy of Fine arts in Rome.	Specialist universities with a large research component. Example: Polytechnic of Milan.	Specialized research universities. Example: Karolinska Instituut.

The introduction of regulatory characteristics yields 24 possible types, with each corresponding to a unique and mutually exclusive combination of organizational characteristics.

2.1 Market structure and financial environment

To be viable, HEIs need to occupy a market niche, where they have an advantage in the acquisition of resources with respect to competitors. Therefore, the structure of the resource space influences the types that will be more successful and their number, what in economics is defined as the market structure (van Witteloostuijn and Boone 2006).

We analyze the financial environment in terms of three characteristics, i.e. the origin of funds, whether allocation is competitive or not and whether it is joint or separated for education and research. Figure 2 presents six financial environments that affect the sustainability of HEI configurations.

The resource space can be divided between public and private. Private resources are provided by students and families in form of fees for education, as well by companies in form of grants and contracts for research. In most European countries, the amount of private resources is low (Geuna 2001; Jongbloed and Lepori 2015).

Core funding from the state for the general functioning of the HEI still constitutes the main source of funds for most public HEIs in Europe (Jongbloed and Lepori 2015). Core funding was traditionally distributed based on history, but the allocation criteria evolved in some countries to introduce some form of performance-based allocation (Hicks 2012). In a number of countries, core funding is allocated jointly for education and research, where HEIs with a research mission receive funds per student, including a research supplement. Other countries have split the allocation into an educational component (mostly student based) and in a research component, which might be performance-based, like in the UK (Geuna and Piolatto, 2016).

Increasingly public research funding is allocated via competitive research grants targeted to research groups and individuals (project funding; Lepori, Dinges, Reale, Slipersaeter, Theves and Van den Besselaar 2007). In most European countries, project funding covers less than one-third of total public research funding, and slightly exceeded the 50% mark in 2014 in only a few

European countries (Belgium, Czech Republic, Ireland, Poland and UK, as compared with 64% in the US[1]).

Figure 2. Structure of the financial environment

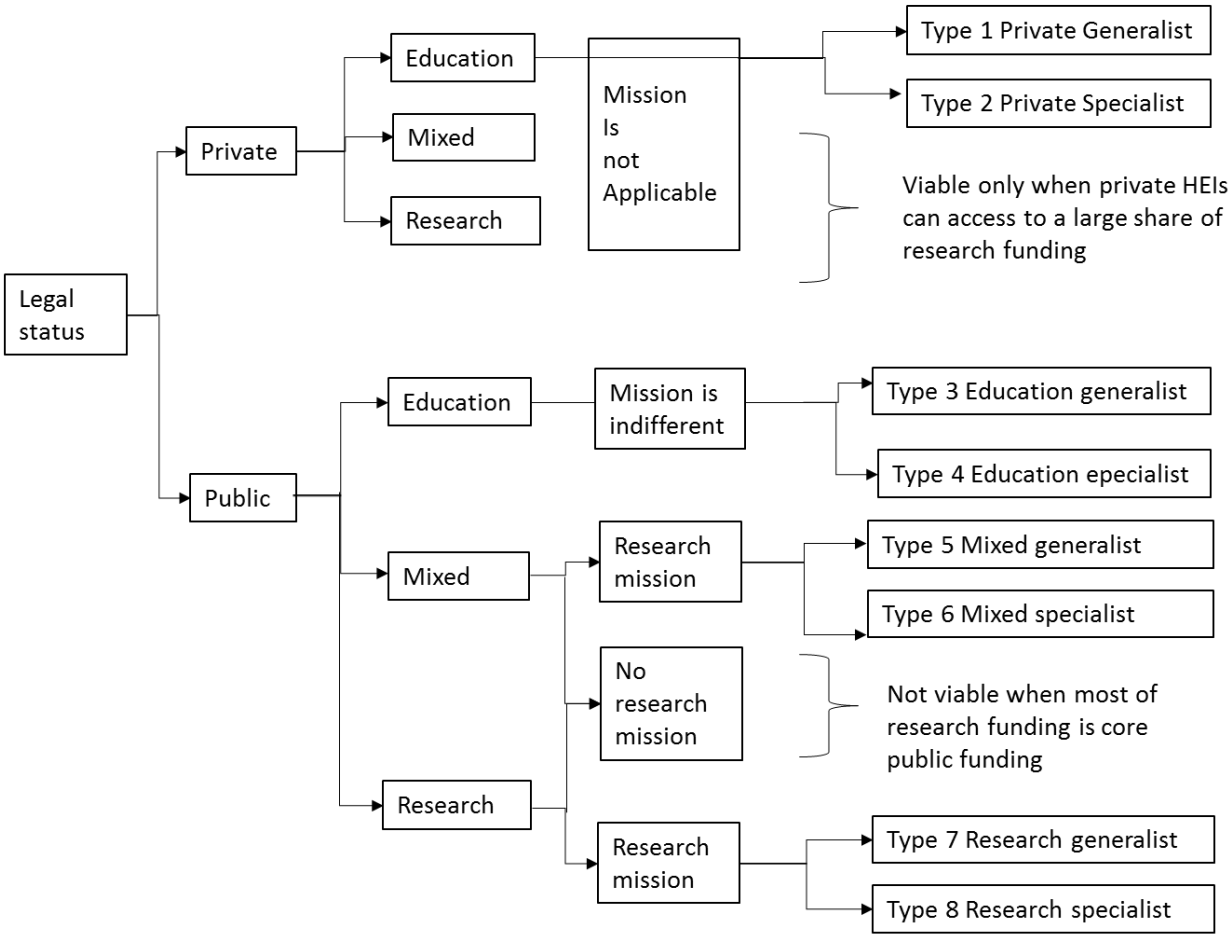
		Education	**Research**
Public	**Non-competitive mixed**	Historical core funding	
	Mixed	Student/professor-based core funding	
	Competitive separated	Student-based core funding	Performance-based core funding Project funding
Private	**Competitive separated**	Student fees	Research contracts

2.2 A typology of European Higher Education Institutions

Linking types with the structure of the financial environment allows for the development of predictions on which types can leverage a sustainable resource basis and on how resources will be associated with HEI activities (what we call the 'market positioning'). Configurations that do not match this criterion can be dropped from the empirical analysis (Elman 2005; Ragin 2000), therefore reducing the 24 possible configurations to only eight types (Figure 3 and Table 1). Furthermore, it allows for the development of expectations on the frequency of types and on the HEI's size based on accessible resources.

Figure 3. Decision tree for HEI types

[1] The data is courtesy of the Public Research Funding project (PREF, European Commission contract No. 154321).



Since in all European countries core public funding, which is available only to public HEIs, amounts to a substantial share of research funding, private HEIs are expected to be education-oriented. Therefore, only two configurations are foreseen, i.e. *private generalist* (type 1) and *private specialists* (type 2). Since resources come mostly from students, private HEIs are expected to focus on those subjects (like business) where students are willing to pay high fees. These HEIs are expected to account for a low share of enrolments and, even more so of staff, given the limited amount of resources.

Among public HEIs, we single out two education-oriented types, i.e. type 3 *educational-oriented generalist*, and type 4 *educational-oriented specialist* HEIs. Their resource basis is constituted by public subsidies for education. An educational mission is a sufficient condition for public HEIs to belong to these types, as these HEIs are excluded from core research funding, but some HEIs with a research mission might also be included, particularly if funding is separated between education and research. Since the amount of funding increases with the number of students, generalist HEIs expand by covering more subject domains and, therefore, are expected to be rather large in terms

of student enrolment. For specialized HEIs, subject identity represents their core positioning and, therefore, they are expected to be in very distinctive fields, like music, arts, architecture.

Among public HEIs with a research mission, we identify four types.

Mixed generalist HEIs (type 5) are public and have a research mission. Their size is expected to be fairly large, but with variations depending on the size of the student body. The main characteristic of this type is that HEIs "scale up" with student enrolment. *Mixed specialist HEIs* (type 6) are expected to be smaller given their smaller resource basis.

Type 7s are *research generalist HEIs*. In countries where student fees are deregulated or there is a significant share of competitive research funding, they can exploit their reputation for acquiring additional funding, and therefore are expected to have more resources per student than mixed HEIs. Since generalist HEIs cannot be too small in terms of enrolments, these HEIs are expected to be fairly large in terms of staff as well.

R*esearch oriented specialists* (type 8) are expected in fields like technology and health, where a large volume of research funding is available and should be smaller than their generalist counterparts.

Table 1. Typology of HEIs

N	Type	Configuration characteristics				Market and resources		Size	
		Activity profile	Subject scope	Legal status	Mission	Market positioning	Resource basis	Students	Staff
1	Private generalist	Education	Generalist	Private	Indifferent	Fields where students are willing to pay for education	Student fees	medium	small
2	Private specialist	Education	Specialized	Private	Indifferent	Fields where students are willing to pay for education	Student fees	small	small
3	Educational generalist	Education	Generalist	Public	Indifferent	General education in all fields, based on per students support from the State	Public subsidy for students	large	medium
4	Education specialist	Education	Specialized	Public	Indifferent	Education in very distinctive fields (high willingness to pay from the State)	Public subsidy for students	small	small
5	Mixed generalist	Mixed	Generalist	Public	Research	Education and research in all fields, based on student-based funding for education and research	Public subsidy for students (including a research component)	large/medium	large/medium
6	Mixed specialists	Mixed	Specialist	Public	Research	Education and research in fields characterized by a high level of research resources (science, health)	Public subsidy for students (including a research component)	medium	medium
7	Research universities	Research	Generalist	Public	Research	High reputation in research, students attracted by reputation and providing additional resources	Research grants and competitive core research funding	medium	large
8	Research specialist	Research	Specialist	Public	Research	General education and research in specific fields characterized by a high level of research resources (science, health)	Research grants and competitive core research funding	small	medium

2.3 Research questions

First, can we attribute HEIs to the types constructed theoretically?

We expect that HEIs belonging to types systematically display different characteristics, while cases that cannot be assigned to a type, or hybrid cases where assignment is ambiguous, are rare and can be explained by specific contingencies.

Second, are HEIs belonging to a type characterized by specific funding patterns, in terms of volume and composition of resources?

This would confirm that types are associated with different market positioning and support the role of the resource environment as a selection mechanism, therefore also building the link between public funding and the structure of the higher education system. Specifically, our framework leads to the expectation that HEIs belonging to the research generalist type are associated with a funding system where research reputation allows for the acquisition of additional resources, otherwise these HEIs will be disadvantaged when compared to the mixed type where research funding is based on students.

Third, do some types display a stronger association with research excellence?

We empirically test whether research universities are more excellent than mixed universities in terms of two dimensions: *consistency*, i.e. the extent to which membership to a type is associated with research excellence, and *coverage*, i.e. the share of research excellence in the higher education system which is accounted for by a type.

3 Data and descriptive statistics

3.1 Data

The analysis is based on the European Tertiary Education Register (ETER) database. It includes 2230 HEIs in 28 European countries (EU-28 except Luxembourg, Slovenia and Romania, plus Liechtenstein, Norway and Switzerland). ETER provides broad coverage of higher education (almost 100% in terms of students; Lepori, Bonaccorsi, Daraio, et al 2015). This extensive coverage is relevant for empirically testing a typology.[2]

[2] We exclude the only graduate school (Sant'Anna in Pisa) and three research institutes with a very low number of undergraduate students (The Cyprus Institute of Neurology and Genetics, The Institute of Cancer Research in London, Institut de physique du globe).

ETER provides for each HEI a set of data, including organizational descriptors, number of students and degrees (at the bachelor, master and PhD level), number of staff, expenditures and revenues.

This dataset has been matched with the number of publications in the Leiden Ranking (LR; Waltman, Calero-Medina, Kosten, et al 2012). 860 ETER HEIs were covered by the Leiden ranking with at least one publication, while the remaining were attributed null publications. ETER has also been matched with the number of participations in EU-FPs from the EUPRO database (Roediger-Schluga and Barber 2008). We have identified 861 HEIs with at least one EU-FP participation in 2012; all remaining HEIs have been attributed a null value.

While comparability problems of HEI data across countries are well-known (Bonaccorsi, Daraio, Lepori and Slipersaeter 2007), ETER made an effort to achieve standardization: definitions were codified in an handbook, relaying largely on official statistics (UOE 2013); systematic data checks were performed and deviant cases were cross-checked with national statistical authorities; finally, problem cases have been identified and flagged. Comparability problems might affect the classification of individual HEIs, but are unlikely to bias an analysis based on a large number of cases.

3.2 Variables and indicators

All variables refer to the calendar year 2012, respectively the academic year 2012-2013 (students). Since some data are missing, the effective sample size is different depending on the type of analysis performed. Five countries are completely excluded since some data needed for the classification are not available (Austria, Croatia, Iceland, Lithuania and Poland). Staff data are not available for four additional countries (Estonia, France, Greece and Latvia), while financial data are available for about half of the sample. We have computed the following variables (Table 2).

a) Size is measured by the number of academic staff (Full Time Equivalents). It includes employees who are involved in education and research, excluding technical and administrative personnel.

b) We measure *educational activities* by the number of students enrolled at the bachelor and master level (undergraduate students). We also compute two indicators: *teaching load* as the ratio between students and academic staff and *master orientation* as the ratio between master students and total undergraduate students.

c) Research activity is measured by three variables:

- The number of *PhD graduates* – graduates are preferred to students since data are more reliable.
- The number of *scientific publications* in the Web of Science, derived from the Leiden Ranking (Waltman, Calero-Medina, Kosten, et al 2012).
- The number of *participations to EU-FP projects*, derived from EUPRO (Roediger-Schluga and Barber 2008).

These three variables are highly correlated (lowest correlation 0.788**). We therefore construct a summary indicator of *research volume* as the average between the number of PhD graduates, the number of publications and the number of participations in EU-FPs, where each variable has been rescaled between 0 and 1. This indicator accounts for 90% of the variance in the three original variables, while being more robust (for example in respect to subject mix).

We compute two normalized variables as follows:

- *Research intensity* is computed as the research volume divided by the number of undergraduate students, rescaled between 0 and 1. This variable characterizes HEIs in terms of the relative importance of research vs. education, and is therefore used to classify HEIs in terms of their activity profile.
- *Research productivity* is computed as the research volume divided by the number of academic staff.

d) *Research excellence*. As a measure of *research impact*, we use the share of scientific publications among the top 10% of cited publications in their respective field (data from the Leiden ranking; Waltman, Calero-Medina, Kosten, et al 2012). We also use the *position in the Shanghai ranking* as a proxy for international research reputation.

e) *Subject Mix* is measured by computing a Herfindal index of the distribution of undergraduate students by the 10 fields of educational statistics (UOE 2013). This index ranges from 0.1, when students are equally distributed between fields, to 1 when students are concentrated in a single field. This indicator is correlated 0.77 with the same index computed for PhD students and, therefore, can be considered as representative of the subject mix in research as well. We further categorize specialist HEIs by their main field of specialization.

f) We include two variables for regulatory characteristics:

- *PhD awarding* is a categorical variable with value 1 if the HEI has the legal right to award a PhD, 0 otherwise.
- *Public vs. private* regulated is a categorical variable with value 0 when the institution is under public control or mostly financed by the state, 1 when the institution is under private control and mostly financed from the private sector (UOE 2013). Therefore, public HEIs also include a number of HEIs that are legally private, but are part of the public system and have the same funding system as public HEIs (for example KU Leuven and the Free University in Amsterdam.

g) *HEI revenues*. We include four variables:

- Total revenues in Purchasing Power Parities (PPPs), as a measure of the HEI's ability acquire resources.
- *Revenues per undergraduate student* in Purchasing Power Parities (PPPs), as a relative measure of resourcing in respect to the volume of education.
- The *share of third-party funds* (competitive grants, private contracts, etc.) in total revenues, which measures the ability of HEIs to acquire competitive research grants.
- The *share of tuition fees*, displaying the ability to raise private funds from educational activities.

Since their availability and quality is somewhat lower, revenue data are not used to attribute HEIs to types, but only as a characterization variable.

Table 2. List of variables

Name	Definition	N. of HEIs	Source
Size	Academic staff in full time equivalents	1652	ETER
Volume of education	Total students enrolled at bachelor and master level	2199	ETER
Teaching load	Total students at the bachelor and master level divided by academic staff	1638	ETER
Master orientation	Master students divided by total students at the bachelor and master level	2199	ETER
PhD graduates	Number of PhD graduates	2013	ETER
Publication output	Number of publications in the Leiden Ranking	2230	LR
Research volume	Average of PhD graduates, number of publications and number of participations to EU-FPs rescaled	1846	LR and ETER
European projects	Number of EU-FP participations	2230	EUPRO
Research intensity	Research volume / undergraduate students	1797	LR and ETER
Research productivity	Research volume / academic staff	1580	ETER
Research impact	Percentage of publication in the 10% top-cited	2230	LR
PhD awarding	1 = HEI has the right to deliver the PhD, 0 otherwise	2230	ETER
Publicly regulated	1 = public, 0 = private	2230	ETER
Subject mix	Herfindal index of the distribution of undergraduate students by subject fields	1992	ETER
Total revenues	Total revenues of the HEI in Purchasing Power Parities	1282	ETER
Third-party funds	Total third party funds acquired by the HEI in Purchasing Power Parities	1043	ETER
Tution fees	Total tuition fees paid by students in Purchasing Power Parities	1106	ETER
Revenues per student	Total budget in Purchasing Power Parities / total number of undergraduate students	1282	ETER
Share of Third-party funds	Third party funds / total revenues	1043	ETER
Share of Tuition fees	Tuition fees / total revenues	1106	ETER

3.3 Descriptive analysis

We run an explorative descriptive analysis, in order also to calibrate the variables for the typological analysis (Table 3).

Table 3. Descriptive statistics for selected variables

	Average	Stdev	Min	1Q	Median	3Q	Max	N
Size	566	884	0	59	198	659	5,999	1,652
Volume of education	7,423	11,516	-	685	2,675	9,929	167,645	2,140
PhD Graduates	62	155	0	0	0	42	2,125	1,850
Publication output	278	769	0	0	0	104	7,710	2,230
European Projects	13	41	0	0	0	4	523	2,230
Research impact	0.11	0.07	0.00	0.07	0.11	0.14	1.00	843
Subject mix	0.52	0.32	0.13	0.22	0.43	0.90	1.00	1,978
Total revenues	116,996,176	197,340,744	0	12,283,618	42,641,810	133,634,050	1,572,988,793	1,293
Revenues per Students	14,067	29,655	746	5,761	8,444	14,435	664,284	1,282
Share of Third-party Funds	0.11	0.12	0.00	0.03	0.07	0.16	0.86	1,043
Share of Tuition Fees	0.20	0.27	0.00	0.01	0.08	0.30	1.00	1,106

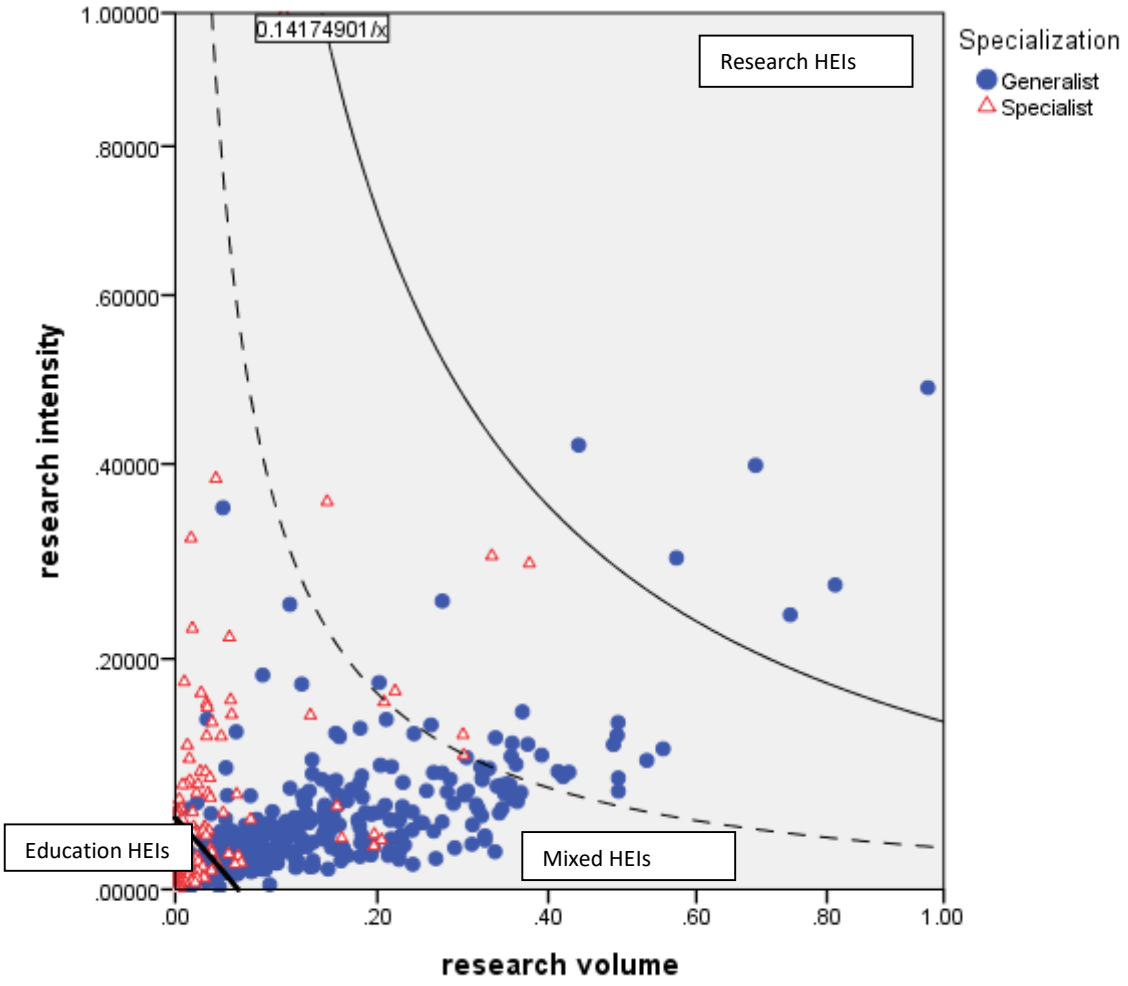
The distribution of size and of the number of students is almost lognormal – most of the HEIs in the sample are rather small, while there is limited number of giant HEIs. The two largest HEIs in terms of students are two distance education universities (in the UK and Spain), followed by Rome la Sapienza, Naples, Bologna, Wien, Hagen (on-line) and Madrid. The ranking of HEIs according to their number of staff (FTEs) is championed by some of the leading European research universities, such as KU Leven, TU Munich and University of Munich, Oxford and ETH Zurich.

The Herfindal index for the distribution of students by subject is bimodal, as shown by the quartiles, with many generalist HEIs and a large number of specialized HEIs, therefore supporting the distinction between the generalist and the specialist type.

The distribution of research activity is skewed, with more than half of the sample having no publications, PhD graduates or participations in EU programs. Interestingly, there are only a few HEIs without a sizeable publication output, which nonetheless participate in EU Framework Programs, (Lepori, Veglio, Heller-Schuh, Scherngell and Barber 2015).

Figure 4. Research profiles

The lines represent the thresholds used for the typological analysis for generalists (continuous line) and specialists (dashed line), respectively between mixed and educational HEIs (black line).



As shown by Figure 4, for generalist HEIs, research volume and intensity are strongly correlated, since the educational volume cannot be too small for HEIs covering many subject domains.

On the upper right-hand side, we identify HEIs with a comparatively large research volume *and* intensity, specifically those HEIs which can be considered as prototypes of the European research university, i.e. Oxford, Cambridge, UCL, Imperial college, ETH Zurich and EPF Lausanne. The HEIs in the middle part have sizeable research volume, but higher educational volume, like Rome la Sapienza on the bottom right. These cases broadly correspond to our definition of mixed HEIs. Finally, in the left bottom corner we find HEIs with both low research volume and research intensity: these include large universities with little research and educational providers, like distance education universities and Universities of Applied Sciences.

On the contrary, specialist HEIs can have high research intensity with low volume if an HEI is specialized in narrow fields, while there are also a few specialist HEIs who have large research volumes (the largest ones being Karolinska and TU Denmark). Specialists also comprise some HEIs with a profile similar to mixed universities and a large volume of education, like some large technical schools.

Finally, descriptive statistics displays large differences between HEIs associated with their regulatory characteristics, supporting their introduction into the typology (Table 4).

Table 4. HEI characteristics by regulatory characteristics (medians by group)

	publicly regulated	private	p-value*	Non PhD awarding	PhD Awarding	p-value*
	1619	608		1179	1051	
Size	340	50	0.000	73	600	0.000
Volume of education	4714	955	0.000	982	9186	0.000
PhD Graduates	5	0	0.000	0	53	0.000
Publication output	0	0	0.000	0	119	0.000
European Projects	1.0	0.0	0.000	0.0	4.0	0.000
Research impact**	0.11	0.08	0.010	0.08	0.11	0.001
Subject mix	0.326	0.605	0.000	0.578	0.266	0.000
Total revenues	52,623,359	5,180,796	0.000	14,599,258	97,611,384	0.000
Revenues per Student	8714.39	6139.29	0.000	6613.14	9847.12	0.000
Share of Third Party Funds	0.086	0.015	0.000	0.047	0.102	0.000
Share of Tuition Fees	0.059	0.647	0.000	0.091	0.075	0.158
*Mann-Withney two-tailed			""only the cases with publications			

On average, private HEIs are much smaller than public ones and more specialized by subject; they have a lower level of revenue per student, most of them have no research activity and are mostly financed through tuition fees. Indeed, there are only a handful of private universities in Europe with a sizeable research activity (Bocconi and Catholic university in Italy, University of Navarra in

Spain). This marks a clear difference with the US, where some leading research universities are private.

The difference between PhD awarding and non-PhD awarding HEIs is also clear-cut: not only is there a large difference in size, but (most) PhD awarding HEIs have a sizeable volume of research activities and (expectedly) receive more funding per student from the State, while non-PhD awarding HEIs are smaller and most of them are education-oriented.

4 Validating the typology

To validate the typology, we adopt set-theoretic methods as implemented in the fuzzy-set Comparative Qualitative Analysis (fsQCA; Ragin 2000). Unlike regression approaches, which analyze correlations between variables, set-theoretical methods understand social phenomena as relationships between sets and focus on analyzing membership of cases to sets (Schneider and Wagemann 2012).

QCA uses Boolean algebra to attribute cases to configurations based on the presence of different conditions. It has been extended to continuous variables in fuzzy set QCA (Ragin 2000, Fiss 2011), where continuous scores replace binary membership.

The first step is to identify variables for the four dimensions of the typology – activity profile, subject scope, publicly regulated and mission. The variables are calibrated, based on conceptual reasoning and on exploratory data analysis, on a [0.1] scale by defining three cut-off points (Table 5): a lower point below which there is no membership to the set (score = 0), a central point where membership is undecided (score=0.5) and a high point above which there is full membership (score=1).

Table 5. Variables and calibration

Variable	Definition	no membership	undecided	full membership
Activity profile research	product = (research volume) * (research intensity) rescaled	0	0.5	1
Activity profile mixed	sum = (research volume) + (research intensity) rescaled	0	0.04	0.08
Subject scope	Subject mix indicator rescaled	0.3	0.5	0.7
Publicly regulated	1 = public, 0 = private	0	na	1
Research mission	1 = HEI has the right to deliver the PhD, 0 otherwise	0	na	1
Research excellence	PPTOP10%	0.1	0.15	0.2

Activity profile. Following the results of the descriptive analysis, we operationalize the activity profile in terms of combinations of research volume and intensity.

We identify *education HEIs* as having both low research volume *and* low research intensity, operationalized in terms of the sum of these two variables rescaled from 0 to 1 against the maximum score (separately for generalists and specialists). The distribution of the scores presents a large mass on the null point (44% of the sample below 0.001) and a kick point slightly above 0.04 (i.e. 4% of the maximum score), which we suggest as the natural cut-off point. HEIs around the cut-off have around 100 PhD degrees, a few hundred publications and around 10 EU-FP projects in respect to a number of undergraduate students between 10,000 and 20,000. While such HEIs still have some level of research activity, it is so diluted that they do not fully correspond to our definition of mixed HEIs.

We characterize *research HEIs* as having both large research volume *and* intensity, operationalized in terms of the product between these two variables rescaled against the maximum score (separately between generalists and specialists). Since there are 14 cases above 0.60, while the next cases have a score of .36, we set a cut-off at 0.50. Finally, *mixed HEIs* are characterized by a large research volume *or* intensity, but not by both.

These thresholds can be considered as somewhat arbitrary. However, the goal of fsQCA is not only to classify cases, but also to test the association between the types and some output of interest, in our case research excellence. Moreover, fsQCA attributes continuous grades of membership, implying that cases can be compared based on membership scores rather than on a binary classification.

Subject scope. We construct a measure of students by field from the Herfindal index by setting cut-offs at 0.3 (0 = no specialization), 0.5 (0.5 = ambiguous) and 0.7 (1 = full specialization). When the Herfindal is below 0.3, no field can enroll more than half of all students, while when it is above 0.7 a single field enrolls at least 80% of the students. Therefore, an HEI with a Herfindal index of 0.4 will have a membership score to the specialized type of (0.40-0.30)/(0.70-0.30)=0.25 and will be considered as a generalist HEI. The logic of calibration is to focus on those variations in attributes that imply different membership to sets – two HEIs with Herfindal of 0.3 and 0.5 are quite different in their subject scope, while two HEIs with indexes of 0.8 and 1 respectively are both highly specialized.

Publicly regulated status is directly derived from corresponding variable.

As a proxy for a *research mission* we use the legal right to award PhDs. While this might an imperfect indicator, we argue that this right represents a stronger recognition of a research function than a generic research mission and is usually associated with differences in access to core research funding.

Cases receive a membership score to each type as the minimum score for each necessary condition, since fsQCA is looking at cases belonging to the intersection of sets. Then, the case is attributed to the type with the maximum score.

Consider the HEI type 5 in Table 1 (mixed universities). HEIs in this type are characterized as (activity profile mixed) above the threshold, (activity profile research) below the threshold, generalist, publicly regulated and PhD awarding. Therefore, the membership score of a HEI o this configuration can be computed as follows:

$$score_{5i} = MIN[((activity\ profile\ mixed)_i);\ (1-(activity\ profile\ research)_i);\ (1-spec_i);\ (1-private_i);\ (PhD_i)]$$

By construction, HEIs can have a score above 0.5 for only one type, since they are mutually exclusive, but there might be cases with low membership to all types, since some configurations have been dropped.

To check the consistency of the typology with data, we compute following statistics.

$$score_{\ j} = \sum_i score_{ji}$$

Where the sum runs over all HEIs belonging to type j. When the score is near to one, most cases attributed to that type have a high membership.

Silhouette (Rousseeuw 1987): $silhouette_j = \sum_i \frac{b(i)-a(i)}{\max\{a(i),b(i)\}}$

Where b(i) is the degree of membership to the type the case has been assigned, a(i) is the maximum membership to all other types and the sum runs over all cases assigned to the type j. s(i) runs from 0 to 1 and can be interpreted as a measure of classification ambiguity. Average silhouette by type is informative of the extent the cases assigned to each type display a strong contrast.

We define *unclassified HEIs* as cases where all membership scores are below 0.5 and *hybrid cases* as those where s_{ij} < 0.25, i.e. the first score is less than 25% higher than the second one.

fsQCA also allows for the measurement of the association of types with an outcome of interest. To this aim, an outcome condition is defined and membership of cases to that outcome is computed. Then the degree of association by type can be measured through two variables: *coverage*, i.e. the proportion of cases with high outcomes that belong to a type and *consistency*, i.e. the share of cases that belong to a type displaying the desired outcome. The rationale is *equifinality*, i.e. the fact that different configurations of attributes might lead to an outcome, but this association might be more or less strong.

For fuzzy sets, consistency and coverage can be computed as follows (Ragin 2006):

$$consistency_j = \frac{\sum_{i=1} MIN\ (u_{ij}\ , y_i)}{\sum_{i=1} u_{ij}}$$

$$coverage_j = \frac{\sum_{i=1} MIN\ (u_{ij}\ , y_i)}{\sum_{i=1} y_i}$$

Where y_i is the membership of case i to the output of interest and u_{ij} the membership of case i to type j. Consistency expresses to which extent cases with high membership to the type considered also display high membership to the output of interest, while coverage measures to which extent cases with high membership to the output also belong to one type.

We measure the association of types with a research impact, as measured by the share of publications in the top-10% cited. To this aim, the research impact variable is rescaled, with the low cut-off set to 0.1 (the world average) and the high to 0.2 (a share similar to the University of Oxford).

5 Results

5.1 Classification results and hybrids

Among the 1678 cases which can be classified, only 29 cases are not assigned to one type. Fourteen of them are private HEIs, including HEIs supported by foundations (Bocconi University; Jacobs University) and Catholic universities (Catholic University in Milan; University of Navarra), where there is a source of core research funding from private sources. Their small number supports our assumption that the importance of public core funding for research in Europe and

the limited private funding available are responsible for the educational-orientation of private HEIs. Obviously, we do not expect this result to hold for systems where most of the research funding is project-based (to which private HEIs usually also have access). The remaining 15 HEIs are public and with a sizeable research volume, but do not award PhDs. Thirteen of them are French schools, including some Polytechnic Institutes and Ecoles nationales supérieures, being very special cases of a system where the PhD awarding right and a research mission are not identical.

For the remaining HEIs, Table 6 provides the classification results and the measures of fit.

Table 6. Classification scores

Hybrid cases are defined as cases where the silhouette is below 0.25.

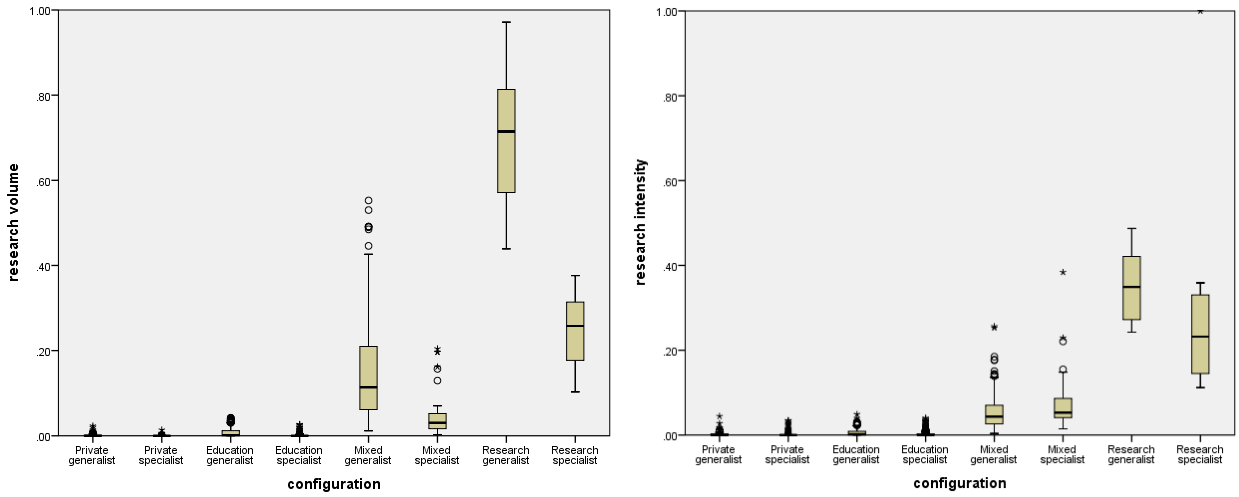
	Private generalist	**Private specialist**	**Education generalist**	**Education specialist**	**Mixed generalist**	**Mixed specialist**	**Research generalist**	**Research specialist**
N. total cases	106	275	489	407	313	45	6	8
N. hybrid_cases	13	27	24	32	18	8	1	1
Score	0.79	0.89	0.85	0.89	0.85	0.78	0.83	0.78
Silhouette	0.71	0.84	0.78	0.83	0.78	0.66	0.74	0.65
Consistency	0.01	0.00	0.07	0.02	0.36	0.22	0.93	0.60
Coverage	0.00	0.00	0.20	0.05	0.72	0.09	0.12	0.04

Fit statistics are quite good: average membership is high and silhouette is fairly high, while the number of hybrid cases is low, therefore showing that the types indeed correspond to well-defined groups of HEIs. The two hybrid cases for research universities are EPFL and TU Delft, which are very near to the cut-off between generalists and specialists.

Consistency and coverage with research impact are also relevant. Expectedly, the four educational types have a very low score for both. Research generalist and specialists have a very high level of consistency, but account only for 16% of coverage, as compared with 72% of the mixed generalist universities. In other words, in European higher education, mixed universities account for most of the research excellence, but their consistency score is lower. When lowering the threshold of research universities to 0.20, seven additional universities are included in the research university type, but the coverage of research impact increases to only 0.24. Furthermore, we show in section 5.3 that these five universities are more similar to mixed universities than to the six research universities. This result is therefore robust to different delineations of research universities.

As shown by Figure 5, our approach allowed for the building of a sensible categorization, where types are distinct by level of research volume *and* intensity.

Figure 5. Boxplots of research volume and research intensity by type



5.2 Characterizing groups of cases

As shown in Table 7, cases attributed to types are systematically different, also for variables which have not been used to identify groups. Particularly, different levels and/or compositions of resources characterize types, i.e. a high share of tuition fees distinguishes private HEIs, while research HEIs receive a much higher level of resources per student.

About half of PhD-awarding HEIs are education-oriented, displaying that a PhD is a necessary, but not a sufficient condition for research. In turn, non-PhD awarding HEIs are consistently classified as education-oriented, showing that the legal right of awarding the PhD still represents a watershed in terms of establishing HEI profiles, despite the claim of some UASs that having a research mission or some research activities is a sufficient condition (non-PhD awarding HEIs account only for 1.2% of the publications and 1.8% of the EU-FP participations in the sample).

Data also display systematic differences between types in terms of teaching load, the orientation towards bachelor vs. master, PhD intensity, research productivity and research impact. These differences support the insight that types correspond to different activity configurations and market positioning.

Table 7. Characteristics of groups

Medians by group

		Private generalist	Private specialist	Education generalist	Education specialist	Mixed generalist	Mixed specialist	Research generalist	Research specialist	p-value*	p-value**
Age		1996	1993	1983	1968	1919	1948	1826	1887		
Size		113	31	330	74	1,573	415	4,870	1,692	0.000	0.037
Volume of education		1,707	542	6,776	675	20,309	2,596	14,140	9,069	0.129	0.118
PhD graduates		0	0	0	0	239	66	1045	291	0.000	0.001
Subject mix		0.342	0.999	0.237	1.000	0.183	0.868	0.225	0.803	0.109	0.425
Educational Orientation		0.10	0.03	0.11	0.16	0.19	0.11	0.28	0.34	0.050	0.109
Teaching Load		19.21	16.75	20.35	9.31	12.55	12.08	3.51	3.66	0.000	0.026
Research productivity		0.000	0.000	0.000	0.000	0.008	0.009	0.015	0.018	0.001	0.004
Revenues per student		4,687	5,831	6,976	12,163	14,260	17,213	62,320	55,425	0.000	0.002
Share of Third Party Funds		0.010	0.019	0.071	0.034	0.149	0.146	0.394	0.433	0.004	0.002
Share of Tuition Fees		0.821	0.591	0.075	0.036	0.069	0.027	0.189	0.006	0.726	0.044
Research impact		0.081	0.000	0.086	0.055	0.132	0.101	0.205	0.159	0.000	0.010
PhD Awarding	No	51	211	237	261	0	0	0	0		
	Yes	42	37	228	114	295	37	5	7		
*Research vs mixed generalist, Mann-Witney, two-tailed					**Research vs mixed specialist, Mann-Witney, two-tailed						

Most of the *106 Private Generalists* are small, only 10 HEIs exceeding 10,000 students, including a number of distance universities, historical universities founded by the church in Catholic countries (PT and ES) and new universities in Central and Eastern European countries. They reflect specific situations where private HEIs acquired a market position, either because of a different organization, institutional reasons or new market opportunities in the Eastern part of Europe. Private HEIs are strongly focused on the bachelor level (only 10% of students at the master level) and have high student to staff ratios.

The 275 *Private Specialists* are smaller and essentially mono-subject. The largest group is in business and management (77 HEIs), particularly for the largest HEIs (the Norwegian Business School has more than 20,000 students). Among the smaller ones, there is more diversity, including health and welfare (27 HEIs), social sciences (56 HEIs) and arts and humanities (20 HEIs). Overall, private HEIs account for only 7% of undergraduate students.

With 489 HEIs and 33% of the undergraduate students, *Educational Generalists* are an important component of European higher education. Roughly half are Universities of Applied Sciences in binary countries. A first group of universities belonging to this type are the UK 1992-universities, displaying how the distinction with historical universities has been maintained despite having acquired the right to award PhDs; a second group is composed by new universities in countries that do not have a binary system, like France, Italy and Spain, where the increase in enrolments was absorbed by universities. In terms of educational volume, they can be rather large (up to 50,000 students), but their level of resourcing is much lower than mixed HEIs. The *Educational Specialists* are a large group (over 400 HEIs) characterized by the smallest size among all groups

and mostly composed by schools of arts and music (183 HEIs have arts and humanities as main field, followed by 47 HEIs in Engineering and 39 in business and management).

Overall, the four education-oriented types account for 76% the HEIs in our sample and for 44% of the students, but for only 6% of the scientific publications and 10% of PhD students.

The 313 *Mixed Generalist* HEIs are the core of European higher education, comprising 52% of all students, 61% of staff and 82% of scientific publications. Not only do they include the largest European universities, only 44 of them are below 10,000 students, thus displaying how a critical mass of students is required in this group, which includes most ancient European universities.

The large majority of the 45 *Mixed Specialist* HEIs are technical universities (such as Polytechnic University in Milan, Turin, Barcelona and Madrid; 25 HEIs), and a small number of medical (The Royal College of Surgeons in Ireland; 4 HEIs), business (London Business School; 4 HEIs) and art schools (Courtauld Institute; 5 HEIs). Except for their subject specialization and smaller size, they are not very different from their generalist counterparts, while their subject focus is quite different than the specialist education-oriented HEIs.

The *Research Generalist* group is composed of six universities that have a large research volume when compared to education (none of them has more than 25,000 students), i.e. Cambridge, Oxford, UCL, Imperial College, ETH Zurich and EPFL. These universities have a much higher level of resources per student and lower teaching load than their mixed counterparts; they are also more focused on master education (masters are more related to research). Research excellence is outstanding – these are the top European universities both in terms of research impact and include all five European HEIs in the top-25 of the Shanghai ranking.

Finally, the *Research Specialist* group includes three medical schools (Karolinska, Hannover, London School of Hygiene and Tropical Medicine) and five technical schools (TU Delft, Technical University of Denmark, Chalmers and Royal Institute of Technology in Sweden and Technical University of Athens). They are larger, have more resources and a higher impact than their mixed counterparts.

5.3 A focus on research universities

In this section, we provide a deeper analysis of research universities by moving beyond a binary classification to the analysis of membership scores. The goal is twofold: first to look at whether there are some universities which are similar to the research university type among the mixed

university group; second, to investigate the association between research and educational activities and resourcing.

We limit the analysis to 318 HEIs in the mixed and research university generalist types in order to reduce heterogeneity[3]. These universities account for 53% of students and 65% of academic staff, but for over 80% of all research output. With the exception of Karolinksa (research specialist), this group includes 29 out of 30 European HEIs classified among the first 100 of the Shanghai ranking, so they can be considered as representative of research excellence in Europe.

As a first step, we construct subgroups based on their membership scores to the research university type (see Table 8).

Table 8. University characteristics by membership score to the research universities type

Group	1	2	3	4	p-value*	p-value**	p-value***
Membership score	>0.50	0.20-0.49	0.10-0.19	<0.10			
N	6	7	36	270			
Size	4,788	3,778	2,585	1,412	0.337	0.223	0.000
Volume of education	13,830	26,786	24,514	18,775	0.051	0.717	0.026
Research productivity	0.015	0.014	0.012	0.007	0.485	0.483	0.000
PhD degrees	1040	953	524	195	0.445	0.056	0.000
Publication output	6469	4731	3322	911	0.181	0.045	0.000
Teaching Load	3.26	6.39	8.36	13.53	0.002	0.130	0.000
Revenues per Student	61,428	29,053	23,409	12,806	0.002	0.428	0.000
Research impact	0.204	0.178	0.164	0.125	0.005	0.093	0.000
Shanghai top-25	5	0	0	0			
Shanghai top-100	5	4	16	4			
* group 1 vs group 2 Mann-Withney two-tailed			** group 2 vs group 3			*** group 3 vs group 4	

Group 1 is composed of six research universities, while group 2 includes seven additional universities which display a high research volume, but lower research intensity than the top group (KU Leuven, Heidelberg, Manchester, Edinburgh, Bristol, Wageningen, Pierre et Marie Curie). We highlight two main differences, i.e. universities in group 1 (the "research universities") are much better funded (as compared to their volume of education) than group 2 (the "near followers") and are more excellent.

The 36 universities in group 3 are similar to those in group 2, but slightly less funded and less productive in research. Differences however are not statistically significant. Universities in group 2

[3] The only distance university in this group (The Open University) has been excluded given its volume of education is far higher than all other universities, which would affect some of the statistical analyses.

and 3 have a high level of research impact and nearly half of them are included in the top-100 of the Shanghai ranking.

Finally, universities in group 4 are significantly lower in size, research productivity and impact when compared with the first three groups.

To further disentangle the relationship between variables, we run a factor analysis on size, revenues, educational volume, research output and research excellence. The analysis extracts two factors, corresponding to 75% and 13% of the variance respectively (Table 9).

Table 9. Factor analysis: rotated component matrix

	Research orientation	Educational orientation
Size	0.758	0.546
Total revenues	0.760	0.492
Educational volume	0.122	0.949
EU-FP participations	0.930	0.005
Number of Publications	0.908	0.314
PhD degrees	0.833	0.374
Research impact	0.952	0.148
Varimax rotation with Kaiser normalization		

Factor 1 is associated with research output and excellence, while factor 2 is associated with educational volume. The size and resource variables load onto both factors, showing that university size and resources can be decomposed into two dimensions: along dimension 1, universities grow in terms of research output and excellence, while along dimension 2 in terms of educational volume and, to a lesser extent, publication volume and PhD degrees.

Figure 6. Universities' position in the educational and research dimension

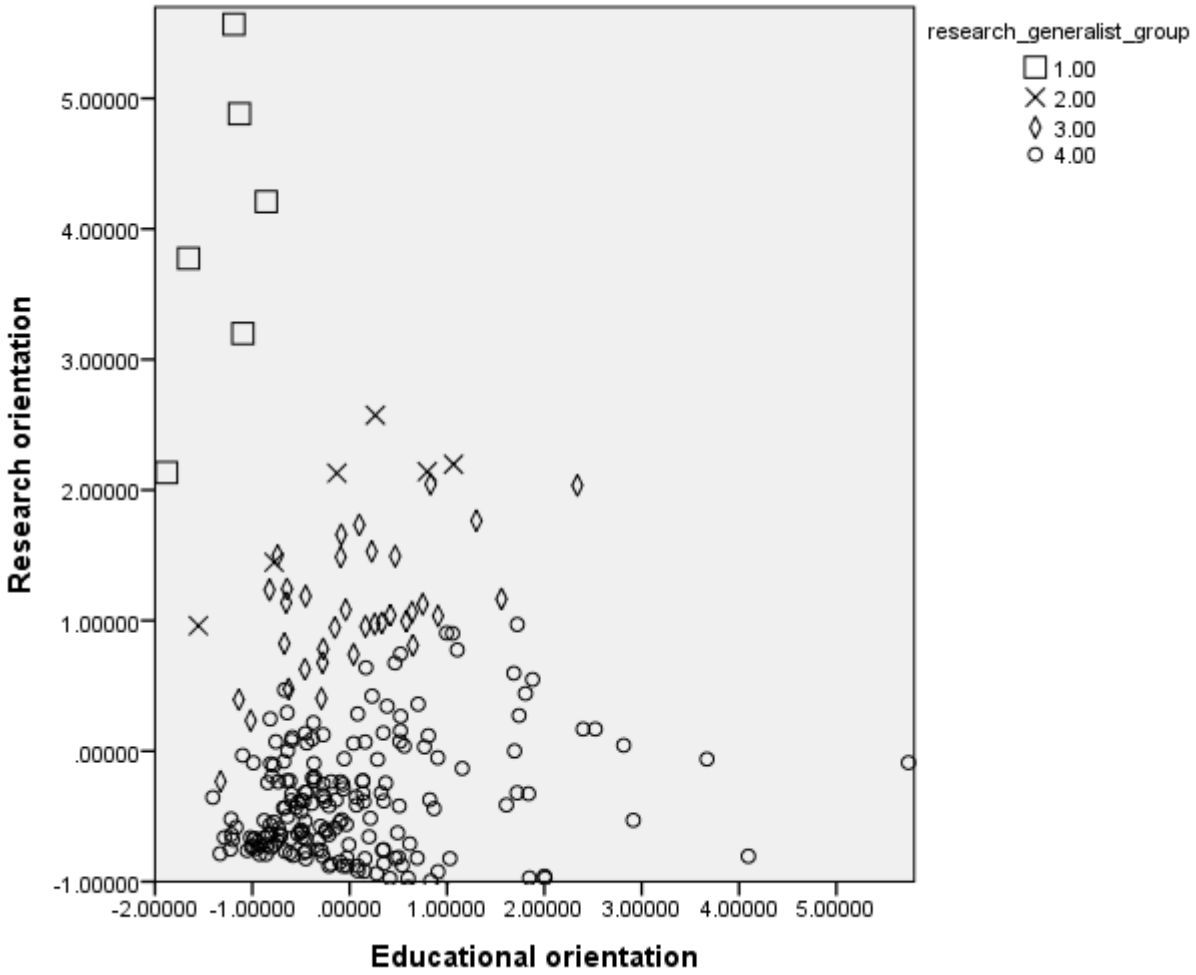


Figure 6 plots universities using the respective factor scores. Given the loadings, size and revenue grows with the distance from the origin. Therefore, large universities can be divided into three groups: the six research universities (very strong research orientation), a number of universities with both larger research and educational components (corresponding to universities in groups 2 and 3 in Table 7) and, finally, a group of large educational providers (enrolments above 50,000 students), which, given their size, reach sizeable volumes of scientific publications, but are low in terms of research excellence.

This analysis leads to two main conclusions. First, we can identify a first circle of six European research universities that reach similar levels of excellence as the top-US research universities, and a second circle of 43 very good universities that do not acquire enough resources to reach a similar level as the top universities worldwide. Second, membership in these groups is strongly associated with the level of resources per student, supporting our hypothesis that the acquisition of a large volume of funding plays a critical role in the emergence of research universities.

6 Discussion and conclusions

The analysis presented extends our understanding of the structure of European higher education and of the factors associated with research excellence. We have been able to develop a typology of Higher Education Institutions based on their positioning in the resource space and show that it represents fairly well the main axes of diversity in European higher education.

Such a typology already represents an important contribution to our field of study: it summarizes the diversity of HEIs into a limited number of types and reveals underlying associations between dimensions of interests. This is even more important in the European context, where common patterns tend to be hidden by the diversity of national systems. The existence of such patterns indirectly confirms the core assumption of configurational approaches, i.e. that the number of viable combinations between organizational characteristics is not very large (Fiss 2011). A typology also represents a useful tool for research, as it identifies the main dimensions of essential heterogeneity researchers' should control for to build sensible comparisons.

At a substantive level, our results provide a differentiated and in-depth view of the typological diversity of European higher education. We first provided evidence of the limited role of private HEIs in the European context, particularly concerning research, and we explained this by the small size of the resource space available to them, in systems where most of the resources are public and accessible only to publicly regulated HEIs.

Second, we were able to identify a large group of educationally oriented HEIs, which enroll more than one third of undergraduate students. Interestingly, such HEIs are present both in binary countries, where differentiation has been achieved through the creation of a second sector of higher education with a prevalent educational mission, and in unitary countries, where many newly founded universities have a limited research activity. On the one hand, these findings qualify the statement of a lack of differentiation between research and education in European higher education (Bonaccorsi 2009), showing that educationally oriented HEIs play a significant role in the system and that this type is broader than the (legally defined) college model. On the other hand, our results suggest that, beyond the specific national policy design, differentiation is associated with more general patterns in the allocation and repartition of resources.

Third, we have provided advances in the delineation of research universities and in understanding the factors that lead to their emergence. We have been able to delineate a first circle of internationally excellent universities, broadly comparable with US research universities, and a

second circle of 43 very good and internationally reputed universities. The analysis demonstrates however that most of the research excellence in Europe is distributed into the so-called 'mixed universities' and remains therefore invisible when looking at university-level data, as it is too dispersed. Moreover, our data suggests that the emergence of research universities is strongly associated with the concentration of a high level of resources in selected universities, without a parallel increase in the number of students. The top-level research universities we identified consistently have very large budgets and a much higher level of resources per student than their mixed counterparts. Interestingly, the two countries hosting top-level research universities adopted divergent policy approaches in concentrating resources. In Switzerland, the two federal universities are explicitly attributed a research excellence mission and, to this purpose, receive higher levels of funding than other universities, while in the UK the competitive research funding system allows top-ranked universities to accrue a much higher level of resources than other universities (Geuna and Piolatto 2016).

This leads to what we consider the major contribution of this study, i.e. establishing the connection between the structure of the resource space and HEI differentiation. In our framework, HEI types are associated with a different market position and exploit different parts of the resource space. We derived two predictions, which are supported by the empirical analysis: first, the size of the resource space available to each type (its 'ecological niche') will determine its prevalence within the system and, second, HEI types will display different levels and composition of resources. Such an approach allows for the establishment of the connection between an economic understanding of HEIs as competing in 'quasi-markets' and the political science focus on public governance and the regulation of higher education, as the latter influences the level and characteristics of resources available to each type.

This approach links the emergence of HEI types with some general characteristics of the resource space, which can be generated by different forms of policy intervention, including top-down decisions on how to distribute funds and competitive allocation mechanisms. It therefore provides a framework for comparative analysis of national policies going past the specificities of national political settings and governance mechanisms borne by history. A natural extension of our paper is therefore to analyze the prevalence of HEI types by country and to associate it with the structure of national resource spaces (and with the respective policies generating it), particularly in terms of the level of competition for resources and the share of third-party funding (Nieminen and Auranen

2010). In this respect, our framework leads to predictions, which could be tested empirically, by exploiting the natural experiment constituted by the presence of more than 30 different higher education systems in Europe.

Our analysis is not without limitations, however. We highlight two of them, which in turn open important directions for extensions. First, every typology developed on the grounds of empirical data runs the risk of having been constructed *ad hoc* for that specific dataset. In a statistical sense, the significance of a typology cannot be established since it has been constructed to optimize the fit with the data (a limitation which is even stronger for cluster analysis, given it sole reliance on data analysis). However, since the typology we developed is largely generic, it could be tested on the US system. Its specificities in terms of higher education funding are expected to lead to differences in which types are present and their role – for example, the role of private HEIs in research is expected to be more significant given the higher share of tuition fees and third-party funds.

Second, as usual in typological studies, our analysis was cross-sectional and therefore allows for the identification of lasting associations, but not their causal mechanisms. For instance, that research universities are better funded does not imply that suddenly concentrating a large amount of resources will transform a university into a highly reputed international university, as the association we observe is the outcome of endogenous and self-reinforcing mechanisms. Nevertheless, our results are not without policy implications: first, they suggest that the existence of a *potential* for concentrating resources associated with reputation is a *necessary* condition for the emergence of research universities and, second, that for smaller countries this potential can also be achieved through political decision-making, whereas large countries might need reputation-based allocation mechanisms given the large number of HEIs involved.

At a more theoretical level, a typology introduces an important distinction between continuous change (within types) and discrete change, when HEIs move from one type to another, and suggests that the underlying mechanisms are quite different. Longitudinal studies combining suitable methods for discrete and continuous processes to analyze both types of change would be at place here. The distinction is also relevant for policy purposes, as the two types of change are likely to require different policy interventions: for instance, increasing the reputation of *existing* research universities might be achieved through gradual interventions, like providing more funds and stronger incentives; however, when the type is absent in a national system, a broader range of

interventions might be required, also including institutional restructuring, while creating stronger incentives for performance to mixed universities would not necessarily lead to the desired outcome. In this respect, a typology is an important policy tool to understand the extent to which the outcome of policy interventions is constrained by the structure of the HEI population and, therefore, to select the best mix between creating new types and changing the framework conditions for the existing HEIs.

7 References

Aghion, P., Dewatripont, M., Hoxby, C., Mas-Colell, A. & Sapir, A. (2010). The governance and performance of universities: evidence from Europe and the US. *Economic Policy, 25(61)*, 7-59.

Albarrán, P., Crespo, J. A., Ortuno, I. & Ruiz-Castillo, J. (2010). A comparison of the scientific performance of the US and the European Union at the turn of the 21st century. *Scientometrics, 85(1)*, 329-344.

Bonaccorsi, A. (2009). Division of academic labour is limited by the size of the market. strategy and differentiation of european universities in doctoral education. In M. McKelvey & M. Holmén(Eds.) *Learning to compete in European universities* (pp. 90-127). Cheltenham: Edward Elgar.

Bonaccorsi, A., Daraio, C., Lepori, B. & Slipersaeter, S. (2007). Indicators on individual higher education institutions: addressing data problems and comparability issues. *Research Evaluation, 16(2)*, 66-78.

Clark, B. R. (1995). *Places of inquiry: research and advanced education in modern universities* Berkeley, Los Angeles, London: University of California Press.

Daraio, C., Bonaccorsi, A., Geuna, A., Lepori, B. & et. al. (2011). The European university landscape: a micro characterization based on evidence from the Aquameth project. *Research Policy, 40(1)*, 148-164.

Deiaco, E., Holmén, M. & McKelvey, M. (2010). What does it mean conceptually that universities compete? In M. McKelvey & M. Holmén(Eds.) *Learning to compete in European Universities* (pp. 300-328). Cheltenam: Edward Elgar.

Doty, D. H., Glick, W. H. & Huber, G. P. (1993). Fit, equifinality, and organizational effectiveness: A test of two configurational theories. *Academy of Management Journal, 36(6)*, 1196-1250.

Drazin, R. & Van de Ven, Andrew H (1985). Alternative forms of fit in contingency theory. *Administrative Science Quarterly, 30(4)*, 514-539.

Edler, J. & Kuhlmann, S. (2011). Integration of european research systems: A multi-dimensional phenomenon In D. Jansen(Ed.) *Towards a European Research Area* (pp. 71-93). Baden-Baden: Nomos.

Elman, C. (2005). Explanatory typologies in qualitative studies of international politics. *International Organization, 59(02)*, 293-326.

Etzkowitz, H. (2004). The evolution of the entrepreneurial university. *International Journal of Technology and Globalization, 1*, 64-77.

Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal, 54(2)*, 393-420.

Fiss, P. C. (2007). A set-theoretic approach to organizational configurations. *Academy of Management Review, 32(4)*, 1180-1198.

Geiger, R. L. (1993). *Research and relevant knowledge: American research universities since World War II* Oxford: Oxford University Press.

Geuna, A. & Piolatto, M. (2016). Research assessment in the UK and Italy: Costly and difficult, but probably worth it (at least for a while). *Research Policy, 45(1)*, 260-271.

Geuna, A. (2001). The changing rationale for European university research funding: are there negative unintended consequences? *Journal of Economic Issues, XXXV(3)*, 607-632.

Geuna, A. & Martin, B. (2003). University Research Evaluation and Funding: An International Comparison. *Minerva, 41*, 277-304.

Herranz, N. & Ruiz-Castillo, J. (2013). The end of the "European Paradox". *Scientometrics, 95(1)*, 453-464.

Hicks, D. (2012). Performance-based university research funding systems. *Research Policy, 41(2)*, 251-261.

Huisman, J., Lepori, B., Seeber, M., Frølich, N. & Scordato, L. (2015). Measuring institutional diversity across higher education systems. *Research Evaluation, 24 (4)*, 369-379.

Jongbloed, B. & Lepori, B. (2015). The funding of research in higher education: Mixed models and mixed results. In Souto-Otero, M., Huisman, J., Dill, D.D., de Boer, H., Oberai, A.S., Williams, L.(Ed.) *Handbook of Higher Education Policy and Governance* (pp. 439-461). New York: Palgrave.

Kyvik, S. (2004). Structural Changes in Higher Education Systems in Western Europe. *Higher Education in Europe, 29 (3)*, 393-409.

Kyvik, S. & Lepori, B. (2010). *Research in the non-university higher education sector in Europe* Dordrecht: Springer.

Lepori, B. & Kyvik, S. (2010). The research mission of Universities of Applied Science and the future configuration of Higher Education systems in Europe. *Higher Education Policy, 23*, 295-316.

Lepori, B., Probst, C. & Baschung, L. (2010). Patterns of subject mix of higher education institutions: a first empirical analysis from the AQUAMETH database. *Minerva, 48(1)*, 73-99.

Lepori, B., Bonaccorsi, A., Daraio, A., Daraio, C., Gunnes, H., Hovdhaugen, E., Ploder, M., Scannapieco, M. & Wagner-Schuster, D. (2015). *Establishing a European Tertiary Education Register. Final Report* Brussels: European Commission.

Lepori, B., Veglio, V., Heller-Schuh, B., Scherngell, T. & Barber, M. (2015). Participations to European Framework Programs of higher education institutions and their association with organizational characteristics. *Scientometrics, 105(3)*, 2149-2178.

Meyer, A. D., Tsui, A. S. & Hinings, C. R. (1993). Configurational approaches to organizational analysis. *Academy of Management Journal, 36(6)*, 1175-1195.

Nieminen, M. & Auranen, O. (2010). University research funding and publication performance - an international comparison. *Research Policy, 39*, 822-834.

Ragin, C. C. (2006). Set relations in social research: Evaluating their consistency and coverage. *Political Analysis, 14(3)*, 291-310.

Ragin, C. C. (2000). *Fuzzy-set social science* Chicago: University of Chicago Press.

Roediger-Schluga, T. & Barber, M. (2008). R&D collaboration networks in the European Framework Programmes: data processing, network construction and selected results. *International Journal of Foreseight and Innovation Policy, 4(3-4)*, 321-347.

Rousseeuw, P. J. (1987). Silhouettes: a graphical aid to the interpretation and validation of cluster analysis. *Journal of Computational and Applied Mathematics, 20*, 53-65.

Schneider, C. Q. & Wagemann, C. (2012). *Set-theoretic methods for the social sciences: A guide to qualitative comparative analysis* Cambridge University Press.

Schubert, T., Bonaccorsi, A., Brandt, T., De Filippo, D., Lepori, B., Niederl, A., Schmoch, U., Slipersaeter, S. & NIFU STEP, O. (2014). Is there a european university model? new evidence on national path dependence and structural conver-gence. In A. Bonaccorsi(Ed.) *Knowledge, Diversity and Performance in European Higher Education: A Changing Landscape* (pp. 47-83). Cheltenam: Edward Elgar Publishing.

Short, J. C., Payne, G. T. & Ketchen, D. J. (2008). Research on organizational configurations: Past accomplishments and future challenges. *Journal of Management,* .

Trow, M. (1979). *Elite and Mass Higher Education: American Models and European Realities* Stockholm: National Board of Universities.

UOE (2013). *UOE data collection on education systems. Volume 1. Manual. Concepts, definitions, classifications* Montreal, Paris, Luxembourg: UNESCO, OECD, Eurostat.

Van Vught, F. (2009). *Mapping the higher education landscape. Towards a european classification of higher education* Milton Keynes, UK: Springer.

van Witteloostuijn, A. & Boone, C. (2006). A resource-based theory of market structure and organizational form. *Academy of Management Review, 31*, 409-426.

Waltman, L., Calero-Medina, C., Kosten, J., Noyons, E., Tijssen, R. J., Eck, N. J., Leeuwen, T. N., Raan, A. F., Visser, M. S. & Wouters, P. (2012). The Leiden Ranking 2011/2012: Data collection, indicators, and interpretation. *Journal of the American Society for Information Science and Technology, 63(12)*, 2419-2432.

Recent papers in the SPRU Working Paper Series:

December

Why Researchers Publish in Non-Mainstream Journals: Training, Knowledge Bridging, and Gap Filling. Diego Chavarro, Puay Tang, and Ismael Ràfols

November

Multicriteria Mapping Manual - Version 2.0. Josie Coburn, Andy Stirling

Lost in space? NASA and the changing public-private eco-system in space. Mariana Mazzucato, Douglas K. R. Robinson

October

Open Innovation: Revealing and Engagement in Open Data organisations. Franz Huber, Francesco Rentocchin and Thomas Wainwright

September

The Triple Challenge for Europe: The Economy, Climate Change and Governance. Jan Fagerberg, Staffan Laestadius, Ben Martin

Serendipity: Towards a taxonomy and a theory. Ohid Yaqub

Understanding the Intensity of UK Policy Commitments to Nuclear Power. Emily Cox, Phil Johnstone, Andy Stirling

Deep Transitions: Emergence, Acceleration, Stabilization and Directionality. Johan Schot, Laur Kanger

July

Precaution in the Governance of Technology. Andy Stirling

User-made Immobilities: A Transitions Perspective. Laur Kanger, Johan Schot

June

Financing Renewable Energy: Who is Financing What and Why it Matters. Mariana Mazzucato, Gregor Semieniuk

Fossil Energy in Economic Growth: A Study of the Energy Direction of Technical Change, 1950-2012. Gregor Semieniuk

Suggested citation:
Benedetto Lepori, Aldo Geuna, Valerio Veglio (2017). *A Typology of European Research Universities. Differentiation, Layering and Resource Distribution*. SPRU Working Paper Series (SWPS), 2017-01: 1-35. ISSN 2057-6668. Available at: www.sussex.ac.uk/spru/swps2017-01

SPRU – Science Policy Research Unit
University of Sussex
Falmer, Brighton, BN1 9SL,United Kingdom
SWPS Website: www.sussex.ac.uk/spru/research/swps
SPRU Website: www.sussex.ac.uk/spru
SPRU Twitter: @SPRU