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The European university landscape: A micro characterization based on evidence from the Aquameth project

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A B S T R A C T

This paper provides a new and systematic characterization of 488 universities, from 11 European countries: Finland, France, Germany, Hungary, Italy, Netherlands, Norway, Portugal, Spain, Switzerland and UK. Using micro indicators built on the integrated Aquameth database, we characterize the European university landscape according to the following dimensions: history/foundation of university, dynamics of growth, specialization pattern, subject mix, funding composition, offer profile and productivity.

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1. Introduction

Public debate increasingly is acknowledging the role of universities as strategic actors in the creation and diffusion of knowledge. Policy debate, however, often is based largely on country level statistics, country level scoreboards, and some international rankings of universities based on a few variables. Higher education and science and technology (S&T) policy scholars have warned systematically about the risks associated with aggregate data covering highly heterogeneous and policy-dependent institutional systems; nevertheless, the gap between detailed qualitative and comparative studies and aggregate statistical analyses is growing. This situation is unfortunate.

In this paper, we propose a quantitative approach that characterizes the main features and functioning of European universities using internationally comparable micro data on individual units. Until recently, such a 'micro' approach was difficult due to lack of comparable international data on individual universities in Europe. Our study exploits a new and detailed database, built within the EU Aquameth (Advanced Quantitative Methods for the Evaluation of the Performance of Public Sector Research) Project, carried out under the PRIME Network of Excellence (6th Framework Programme). The Aquameth database integrates micro data, available at the level of the individual university, for 11 European countries, based on census information, covering the period 1994–2005. All university institutions in all 11 countries are included, which overcomes the intrinsic limitations of information based on highly heterogeneous populations and small numbers. These micro data are built using administrative information extracted from various official national sources not usually available to researchers. Unlike official country level statistics produced by the OECD or Eurostat, this information is not based on a common definitional methodology. The difficult task of making it comparable ex post was achieved through extensive, expert examination of all administrative definitions and empirical evidence available, conducted by the Aquameth team in 2004–2007.

Existing empirical evidence comes not from primary (survey) data collected by universities, but from secondary data, available at national ministry or some other institutional level; it is not published and/or is not comparable across countries. The Aquameth project wanted to explore the availability, accessibility and comparability of data, and the feasibility of constructing an integrated European level dataset. Countries were selected based on the simple criteria of availability and accessibility of secondary data for research. In the first round, Aquameth 1, six countries were selected: Italy, Norway, Portugal, Spain, Switzerland and the UK. Aquameth 2 extended this list to include France, Hungary and the Netherlands. The consolidation round consisted of the inclusion of Germany and Finland and data completion for the other countries. The evidence reported in this paper is based on the final updated database built on these 11 countries, covering 488 universities.

The main objective of the paper is to characterize the diversity of the European university system and to propose a first (rough) interpretation of the position of individual universities in the European landscape. Our accomplishment of this goal is dependent on the availability and quality of the data. The paper provides an evidence based interpretation of the current position of European universities in the international competition. In what follows, we show their position in terms of their creation, size and growth, horizontal and vertical diversity and pattern of differentiation. We exploit the potential of boxplot representations by comparing the range, median and quartiles of the variables distributions within and across countries.

This paper draws on and completes previous exploratory analyses (see Bonaccorsi and Daraio, 2007) of a sub-sample of countries and variables, and focuses on characterizing the European university system. The paper is structured as follows: Section 2 briefly discusses some of the most recent policy issues related to universities in Europe. Section 3 introduces the theoretical background and the main research questions, setting the scene for the empirical analysis. Section 4 describes the methodological framework used for the construction of the integrated database, presents the Aquameth dataset and discusses various comparability issues. Sections 5 and 6 present the empirical evidence and Section 7 concludes by summarizing the main results and calling for structural action at European level, to conduct a systematic integration and build a coherent micro database of European universities.

In the companion online Appendix to this paper, we provide some detailed tables, the main sources of information by category of data, and the structure of the Aquameth database. This Appendix is available at the PRIME website (http://www.prime-noe.org/) in the Aquameth project section. It is intended to contribute to the building of more accurate data in the future.

2. The policy debate on European universities: towards more evidence-based discussion

Universities suddenly have become the focus of intense academic and policy interest across Europe. On the academic side, universities are increasingly the subject of comparative science policy and economic (Geuna, 1999; Kyvik, 2004; Van Vught, 2004; Masten, 2006; Vincent-Lancrin, 2006; Dewatripont and Thys-Clement, 2008) as well as econometric analysis (Marsh, 2004; Ehrenberg, 2004). On the policy side, a large number of contributions from various international organizations, such as the OECD, propose future scenarios for higher education (OECD, 2006) and draw attention to the need to increase investment per student (Boarini et al., 2008). The European Commission has finally included universities on the perimeter of its policy, and has produced several ambitious communications (EC, 2003, 2005, 2006), which were included in the Green Paper on the European Research Area (EC, 2007a,b). This paved the way to an ongoing and comprehensive strategy supported by several High Level Expert Groups, and several research projects. According to the European Commission, 'European universities are not at present globally competitive' (EC, 2003, p. 2), mainly because they are over-regulated by Member States, underfunded and inflexible (EC, 2005), with the consequence that they are 'generally good on average, but with a very limited base of universities at world level' (EC, 2007a,b, p. 3). This umbrella diagnosis provoked heated debate. The European University Association mandated several policy reports challenging this view (EUA, 2005a,b, 2007), and the League of Research Universities produced a position paper (LERU, 2006).

It should be noted that this interest has been spurred, at least in part, by the publication since 2003, of international university league tables or rankings. Despite their glorious history, European universities are not ranked high, particularly in tables based mainly on research output. Rankings have a number of limitations, which have been discussed and criticized in the specialist literature (van Raan, 2005; Dill and Soo, 2005; Frey and Rost, 2008; Harvey, 2008), and can be extremely misleading, as stated in the Berlin principles (CHE, 2006), but are appealing because they save on scarce resources. However, they have generated intense academic and policy debate: several policy papers have called for a radical reform strategy (Jacobs and van der Ploeg, 2006; Thissen and Ederveen, 2006; Van der Ploeg and Veugelers, 2008; Aghion et al., 2008).

It is interesting that one of the recent policy papers, which summarizes some of the available evidence on European universities, suggests that 'perhaps the most important conclusion for policy making at this stage is to invest more in data and analysis' (Van der Ploeg and Veugelers, 2008, p. 100). In sharp contrast to this recommendation, to a large extent, debate has been based on a quite limited empirical base. Most discussion is based on macro-level data produced by the OECD, UNESCO and the European Commission or – more recently – on existing national and international rankings. This is a major limitation because there are large numbers of universities in Europe (of the order of dozens per country), that are very diverse and very interdependent. To an extent, it could be said that there is no such animal as a 'European university'.

3. Theoretical background and research questions

As already noted, theoretical and empirical debate on the future of the university sector in Europe is wide ranging. It has been fostered by an increase in national government policy reforms and, for the first time in the history of European integration, by the active involvement of the European Union and its institutions, namely the European Commission. It is our contention that there is no sound empirical and comparative base to most of this debate. In most cases, discussion is on the basis of conceptual reconstructions of largely qualitative historical and descriptive accounts of national situations. Aggregate statistics (usually national level) on education or research are offered as support to these narrative reconstructions. In a few cases, statistical evidence is available, on samples of universities whose representativeness is rarely discussed with any seriousness. In general, most the policy debate is oblivious to detailed empirical knowledge.

The Aquameth database, which is described below, is the first large enough sample of comparative data to properly address some of the most relevant policy questions. Although the best data available to give empirical content to the investigation, they are only a preliminary effort towards creating a proper data infrastructure for the development of evidence based policy at European level.

Comparable data on individual universities allow us to shed light on the process of new university creation, the size distribution of universities and the dynamics of growth. The research questions addressed in this paper are organized along the topics of horizontal diversity, vertical diversity, and pattern of convergence or path dependency in European countries.

3.1. Horizontal diversity

The first research question deals with horizontal diversity in the higher education system. Teichler (1988, 2005) defines horizontal diversity in terms of the mix of subjects taught. Wide horizontal diversity means that universities are free to define a subject mix according to their own strategies, offering courses and degrees to differentiated student audiences. Diversity implies both disciplinary differences and different teaching methodologies. In one sense, this notion has a clear economic counterpart in the notion of horizontal product differentiation, or the offering of products with diverse bundles of characteristics. The notion of diversity is at the core of the authoritative report on the future of tertiary education, produced by the OECD, where diversity 'implies that distinct courses or institutions serve distinct objectives, receiving and responding to distinct streams of students' (OECD, 2008, pp. 40–41).

Disciplinary or subject mix is an interesting empirical problem because the available evidence suggests that most structural parameters, such as cost per student, are more variable across subject mixes within the same university, than across universities (Filippini and Lepori, 2007). In other words, the particular configuration in the horizontal diversity landscape is likely to influence the degrees of freedom and the courses of action of universities in the long term. We show in this paper that it is extremely difficult to collect standardized European data on subject mix, at the level of disciplines, without resorting to simple student attendance statistics (i.e. with no reference to inputs, such as academic staff or expenditure).

However, we go beyond the narrow definition of horizontal diversity and extend this notion to two other dimensions – research and knowledge transfer. Most European universities engage simultaneously in education and research. This is formally reflected in their mandate, based on laws and administrative accreditation procedures. However, mandates and activities do not always coincide. For example, is there horizontal diversity in the way that teaching and research are combined? Can we see diversity in the type, scope, reach and targets of research activities? These questions call for a classification of research activities that could be controversial. Larédo (2007) proposed a classification of universities based, among other things, on the geographic scope of research activities: universities may engage in world class academic competition, with researchers publishing mainly in international journals, but also may commit to sustaining the national professional community by producing relevant research, or may act as proximity knowledge producers, addressing the specific needs of the regional economic and social environment. Thus, the maximum or average reach of university activity could be an indicator of the type of research produced. Unfortunately, such information is not readily available. International publications data do exist, but standardized data on national and regional output do not. A related indicator might be share of international academic staff, but again this information is not readily available.

According to a large literature, not reviewed here, modern universities are responsible for providing direct input to society and the economy by engaging in such activities as patenting, licensing, creation of spinoff companies, consulting, advising public administrations and engaging in public debate (activities that sometimes are subsumed under the title third mission). How are these activities carried out by universities? Here we can expect wide horizontal diversity, in the sense that universities may be more or less committed to a third mission, depending on their strategies, based on the trade-offs between these activities and pure academic research, for example.

To sum up, there are at least three sources of horizontal diversity: the disciplinary subject mix in education, the type of research activity, the degree of involvement in third mission activities; we are interested in the extent of horizontal diversity among European universities. Bonaccorsi and Daraio (2007) suggest that horizontal diversity should be seen as the positioning of the university in the multidimensional space of outputs, represented by observable vectors of quantities. The Aquameth dataset enables some preliminary exploration in this direction. This paper does not provide answers to the above questions, and we describe only the data that are available and that can be used to present some evidence of the heterogeneity of European universities with respect to subject domains.

3.2. Vertical diversity

Vertical diversity refers to the position of the university in a hierarchy of quality based on several indicators. As in the case of horizontal diversity, this notion corresponds nicely to the economic notion of vertical differentiation, or the quality layer, in product markets. Products nearer the top of the quality layer dominate products that are lower down in the layer, based on overall superiority rather than a different mix of characteristics. Bleiklie (2008) suggests that a hierarchy of quality of university service provision can be established in three ways. First, through accreditation, i.e. government creates a hierarchical classification and allocates institutions to these categories. Second, by rankings or the production of indicators that allow universities to be compared based on a set of common performance features, with or without automatic implications in terms of funding. Third, in relation to funding, where an implicit hierarchy is established based on the differential abilities of the universities to compete for and win funding, mainly for research.

Historically, the most important example of full-scale vertical diversity is the reform that was put in place in California in the 1960s. The California Master Plan (1960) created three separate layers: research universities (the University of California system), applied research and teaching universities (state universities), and undergraduate level teaching universities (community colleges) subdivided into liberal arts colleges and vocational training or professional colleges. This system provided strong vertical differentiation and also flexibility in permitting, under certain credit conditions, upward mobility of students, from one layer to the next (Rothblatt, 1992; Kerr, 1995; Altbach, 2001; Geiger, 1996; Trow, 2006). In some European countries this vertical differentiation is accomplished by separating vocational training from university education, i.e. by the length of the degree course: vocational institutions offer courses of less than three years, while universities offer bachelors and masters course (in the Bologna system, 3 + 2 years). According to Meek et al. (1996) institutional differentiation greatly facilitates the functional differentiation or division of labour.

Apart from this institutional setting, are there other elements of vertical diversity, exemplified by hierarchical rankings? One important example is the vertical diversity in the quality of academic research. No European country has the institutional separation between research, and applied research and teaching universities, such as applies mostly in the US. However, many governments have adopted a funding strategy that de facto creates a hierarchy based on these criteria (e.g. the Netherlands, Switzerland, the UK: see Bonaccorsi, 2009 for the case of PhD education). This is an extremely sensitive area: witness, for example, the way that European universities, governments, stakeholders, media and public opinion react to the publication of international university rankings. Data on international publications, for example, show significant inter-university variability, which cannot be explained in terms of variation in individual productivity. In some senses, there is a de facto hierarchy in scientific productivity, although this is not institutionally embedded.

The notion of hierarchy is clearly accepted in the US and Anglo-Saxon countries, such as the UK and Australia, but is quite far removed from the cultures of, say, Germany and the Scandinavian countries, where there is an egalitarian tradition (Kerr, 1995; Kogan et al., 2000; Bleiklie, 2003). In Sweden, for instance, acceptance of a formula-based funding system, which involves the allocation of a part of the research funding for universities on the basis of competitive performance, has taken several years, and was implemented for the first time in 2009.

3.3. *Convergence vs path dependency in the dynamics of differentiation*

The third broad research question refers to the dynamic pattern of differentiation in the higher education system: 'The question to be discussed is the extent to which the various countries converge to a common structural model for the organization of higher education – either a binary system which is the most common model today, or a unified but hierarchical system as in the United Kingdom' (Kyvik, 2004, p. 393). According to Kyvik (2004) and Scott (1995), European higher education systems fall into five groups: university-dominated, dual, binary, unified, and stratified. In university-dominated systems (basically, just Italy) there is no differentiation since all post-secondary training is confined to universities. Dual and binary systems allocate university education and vocational training to separate institutions, while unified systems (UK, Spain) have absorbed vocational training institutions within universities, amalgamating previously separate experiences. Finally, a stratified system does not exist in Europe in the pure form of the US system, although some of its characteristics are present in the French system.

Meek et al. (1996) suggest that there are two contrasting perspectives on the evolution of university models: convergence or path dependence. The convergence thesis predicts that one of the following models will prevail: (a) universities and vocational training institutions will be decreed by law to be separate institutions; (b) universities will dominate the higher education system: they will absorb vocational training institutions and converge to a unitary system characterized by internal hierarchization.

The binary system is the most popular in Europe: according to Kyvik (2004), it has been adopted by the Netherlands, Germany, Belgium, Sweden, Norway, Ireland, Greece, Portugal, Denmark, Finland and Switzerland. While its stability is assured by strong institutional separation, there is evidence that the non-university sector is increasingly adding research activities to its mandate, which is producing some overlaps with universities (academic drift). The pattern of university dominance is clearly visible in the UK, and in the Anglo-Saxon countries more generally. There are several arguments supporting the view that a unitary system eventually will be associated with hierarchization. First, non-university institutions are driven to adopt university values and norms by powerful imitation and social pressures. This phenomenon, known as academic drift, results in greater homogeneity (Neave, 1983).[1] Second, since vocational training is subsumed within the university system, there is a need for a clear hierarchization among previously university institutions. The absorption of vocational training institutions within the university system (by law or through mergers), is promoting demand for some hierarchy in funding. Third, there is a more general trend towards new forms of integration of teaching and research within the so-called Mode 2 production of knowledge (Gibbons et al., 1994), which is demanding that all higher education institutions should be research active. On the other hand, the institutional, path dependency thesis sees significant resilience in the vocational training sector and that a pattern of hierarchization pattern is far from established. In this view, a variety of solutions has emerged based on national and institutional path dependency. According to this perspective, we do not see convergence, because under an apparently similar institutional structure a variety of solutions is emerging (Musselin, 1999; Bleiklie, 2001; Kogan et al., 2000). The trend, beginning to emerge in Austria, Germany, the Netherlands and Switzerland, for the non-university sector to engage in research, is proof that the structural dynamics of academic drift may survive even in binary systems where institutional separation is legally established.

In dynamic terms, the debate on convergence or path dependence is at the core of the related issue of marketization. In most OECD countries, particularly the USA, the UK, Ireland, Australia, Canada and Israel, there has been a drive towards an increased

[1] Counter strategies in a number of European countries, aimed at preserving an elitist element within the higher education system through the creation of a binary or stratified system, have failed. The idea that an effective formal division can be established and maintained, between institutions that focus on pure research and those that take a more utilitarian approach to knowledge production, in order to protect the former against 'external influences', has so far been unsuccessful. While non-university institutions have tried to become research institutions, research universities have never given up more formal, applied research and vocationally-oriented education programmes. Experiments at formal divides have broken down for the reason that attempts to isolate the 'scientific' core have been based on premises (the aim of preserving elite status) that underestimate the forces of 'academic' and 'applied' drift within higher education. In other words, it illustrates the way that the 'scientific core' expands, while at the same becoming integrated with 'social', more utilitarian demands and needs in new settings (Bleiklie, 2003).

share of the university budget from private sources. These include: student fees ('user pays' principle); contract research for industry; contracts, grants and donations from private foundations; and sale of licences or products. The impact of more private sources of funding on the autonomy, long term independence, equity of access and cultural vitality of universities is the subject of passionate debate (Meek, 2000). A common theme in this debate is whether marketization will promote reduced horizontal diversity and increased hierarchization. We provide some evidence related to funding structures that enable an empirical appreciation of the magnitude of this problem in Europe.

Summing up, the overall aim of this paper is to provide comparable and standardized data on a number of input and output variables, for several European countries, to demonstrate the feasibility of a project to provide large scale, statistical micro data on universities, and to show the importance of these data for evidence based policy. To do so we need to explicitly address a number of difficult methodological issues, which is the focus of Section 4.

4. Methodological framework

4.1. Unit of analysis

First, we would argue that the university institution is an appropriate level of analysis. This is not obvious. Most economics of research and innovation and related policy making routinely use national level aggregate data, in the traditions of the OECD's Frascati and Oslo Manuals. While these data are of value for analyses and decision making, they mask internal differences in national systems and do not allow an appreciation of specificities. The main reason for taking the university as the unit of analysis is that the problem of attribution of inputs (in particular, human resources, funding, and physical capital) to specific units of output, is manageable at the university level.

Moving to lower levels of aggregation (e.g. department) is a good strategy when evaluating only research, but makes the problem of the joint output (with teaching) almost intractable in most disciplines. When evaluating research, it is possible that the laboratory/research group rather than the department or institute is the most relevant unit of analysis (Knorr-Cetina, 1995; Larédo and Mustar, 2001). The allocation of inputs to specific types of outputs requires the specification of time budget allocation shares, but practical experience (e.g. in the bottom up process of producing statistics for the OECD) shows that these data are not reliable. Moving to a higher level of aggregation, such as the regional or national system, emphasizes the problem of comparability. While other units of analysis may be better for analysing research and higher education individually, universities are the level at which budgetary and other important decisions on the recruitment of academic staff and funding allocations are made. Thus, examining micro data on individual universities is a legitimate methodological choice.

4.2. Observed and unobserved heterogeneity

Of course, choosing this level of analysis does not solve every problem. Universities are collections of departments and schools with large internal heterogeneity (Kyvik and Skovdin, 2003). This introduces the classic comparing apples and oranges problem (Junor et al., 2006). This is such a serious problem that the most recent exercise to classify European universities (CHEPS, 2008), concludes by calling for further research, rather than offering a final solution. In principle, we are of the view that an appropriate solution might be a theory-based characterization, although current data availability makes this a remote possibility (Larédo, 2007). There are several dimensions of heterogeneity that make the problem of classification very difficult:

- scope (generalist, specialist);
- subject mix (disciplines);
- coverage of educational activity (vocational training);
- coverage of research activity (Public Research Organizations – PROs);
- governance (public, private).

The first two dimensions are related to heterogeneity created by large internal differences across scientific and educational disciplines in terms of cost structure, capital intensity, type of scientific output, and number and type of publications. They may introduce large distortions, because costs per student and other indicators differ widely across disciplines (Filippini and Lepori, 2007). Specialist universities, usually related to applied disciplines (medical schools, technical universities, business schools) cannot be compared with generalist universities that cover a wide spectrum of disciplines. Generalist universities, in their turn, exhibit large differences depending, for example, on the presence or absence of a medical school, or on the relative size of the Human and Social Sciences disciplines. Although there is no systematic evidence to support this statement, we would argue that these differences do not depend on country-level factors.

The issue of coverage, on the other hand, is largely dependent on the national institutional tradition. A large body of the literature on higher education investigates the general features of national systems (Clark, 1983; Amaral et al., 2002, 2003); this issue is particularly relevant in Europe where national and regional higher education contexts are more diverse than in the USA. Some countries consign vocational training to separate higher education institutions, which usually cannot offer PhD degrees; in others, all higher educational activities are conducted by the universities. Therefore, in unitary systems vocational training comes under the universities (as in Italy) and in dual systems, university and vocational training are separated (as in Germany).

Another country-level source of heterogeneity comes from the relative importance of PROs for performing research. In France and, to a lesser extent, Germany, where a large part of the country's research is performed in institutions external to universities, allocating outputs to production units may be problematic and unobserved heterogeneity may lead to poor allocation of inputs and outputs. This diversity demands multi-layer empirical analysis and careful comparative discussion. Finally, there is the general issue of governance, which is significantly different in different countries. Private universities are comparatively more important in the Latin countries (Spain, Portugal, and to a lesser extent Italy) and in Eastern Europe (Teixeira et al., 2007). In some cases they satisfy otherwise unfilled education needs, particularly in the case of Eastern Europe after transition. The quality is very variable, however, ranging from top level and research-oriented universities (e.g. in Italy San Raffaele for medical research and Bocconi University for economics and business) to low level degree awarders in weakly regulated markets. In addition, the constitutional architecture assigns responsibility for universities to national government in most countries, and to regional or state governments in federal countries such as Spain or Germany (see on these issues Huisman and Kaiser, 2001; Kyvik and Skovdin, 2003; Kyvik, 2004).

Heterogeneity is a serious issue and has been an occupation of the Aquameth project from its inception. The approach adopted was to disentangle each separate source of heterogeneity, examine the available indicators, and formulate explicit schemes for the classification or inclusion of dummy variables. Each dimension relates to the underlying comparability scheme, which helps with interpretation of the data.

4.3. Comparability across countries: problems and solutions

The approach to comparability in the Aquameth project differs sharply from the approaches followed by major international organizations, governments and policy analyst groups, which tend to use country level statistics, aggregated following the Frascati and Oslo Manuals. Aggregate statistics allow observation of one moment in the distribution (average value) and ignore all other moments and associated indicators, such as range, variance, coefficient of variation or skewness. This needs to be highlighted because almost none of the variables of interest to policy making have a normal distribution. For example, the distribution of researcher's scientific productivity is highly-skewed, due to cumulative factors, path dependency and self-selection. The construction of a dataset for analysis at the microlevel is a risky exercise. There are no standardized definitions or statistical units and institutional differences are so great that the same word(s) may take on totally different meanings in different countries. National policy has a profound effect on a country's university system, so the research design needs to incorporate regular updating of legislative and administrative changes.

The Aquameth project addressed these issues by developing a multi-method approach. First, each country in the initial phase of the project was subjected to extensive case study to identify recent policy changes and major trends. National case studies allow consideration of the heterogeneity of institutional frameworks and impacts of constantly changing policies. Second, a comparative analysis was conducted to highlight data comparability problems and possible solutions (Bonaccorsi et al., 2007) Third, where data comparability could be demonstrated, these cases were integrated in the dataset.

The above exercise constitutes a major advance in the economics and political science of higher education, since most existing work is based on national datasets or comparative analysis. Aquameth is the first example of a large dataset of European universities where the unit of analysis is the universities from 11 countries, identified by a census, providing a sample of 488 institutions. The main categories of variables in the Aquameth database are organized in the following broad areas: General information on the higher education institute; Revenue; Expenditure; Personnel; Education production; and Research and technology production. Table 1 presents a detailed list of the variables; Table 2 shows the number of universities in the database by country.

Appendix A (available at the PRIME website) illustrates the time series coverage by country, and the data available by research area.

Many of the problems described have been resolved reasonably satisfactorily; thus, we can be reasonably confident of comparing apples with apples. The main solutions are:

- for variables subject to strong heterogeneity based on the national institutional setting and policy, we built normalized variables around the national average (e.g. funding structure) or ran separate analyses by category (e.g. private universities vs public universities);
- countries where national structural differences with respect to the distribution of research output between universities and PROs are large (e.g. France) were excluded from the comparisons on research output;
- for variables subject to heterogeneity based on subject mix and scope, we classified the universities in two ways: (a) as specialist or generalist, depending on the student population distribution (see below); (b) using a dummy variable for the presence of medical school (not shown in this paper);
- for further analyses involving subject mix and differences across disciplines, the data are broken down into four disciplinary areas (Human and Social Sciences, Engineering and Technical Sciences, Natural Sciences, and Medicine) and separate analyses conducted;
- for the structural variables, we built a classification according to size, and ran separate analyses by size category.

Table 1
Main categories in the Aquameth database.

Area	Categories
General information	Year of foundation
	Region (NUTS)
	Type (university, technical college, etc.)
	Governance (public, private)
	University hospital (dummy)
	Specialization
	Number of fields covered
Revenues	Total revenues of the university
	Tuition and fees
	Government appropriations
	EU and other international funding
	Private funding (profit and non-profit)
	Asset revenues
	Other revenues
Expenditures	Total expenditures
	Personnel expenditures, where possible divided between personnel categories
	Current expenditures
	Capital expenditures
	Other expenditures
Personnel	Total academic staff (Headcount or FTE)
	Full professors
	Associate professors
	Researchers
	Other academic staff
	Technical and administrative staff
Education production	Number of enrolled students
	Number of foreign students
	Number of graduates (where applicable split into long cycle and short cycle graduates)
	Number of PhD students
	Number of PhD degrees
	Number of master students
	Number of master degrees
Research and technology production	ISI publications
	Patents
	Spin-off companies
	R&D revenues
	R&D expenditures

Not all the analyses are shown in this paper.

The dataset is organized in the four fields of Natural Sciences, Medicine, Engineering and Technical Sciences, Human and Social Sciences. We constructed these fields by building a concordance matrix between classes of ISI publications to represent research output, and classes of OECD standardized academic disciplines to represent teaching activity. Thus, our fields represent relatively *homogeneous* collections of inputs (academic staff) producing both teaching and research in the same area of output rather than indi-

Table 2
Number of universities in the Aquameth database (488) by country.

Country	No. of universities	Period
CH	12	1994–2003
DE	72	1998–2003
ES	48	1994–2004
FI	20	1994–2006
FR	88	1994–2006
HU	16	2001–2004
IT	79	1995–2005
NL	13	1994–2004
NO	10	1995–2003
PT	14	1997–2002
UK	116	1996–2003

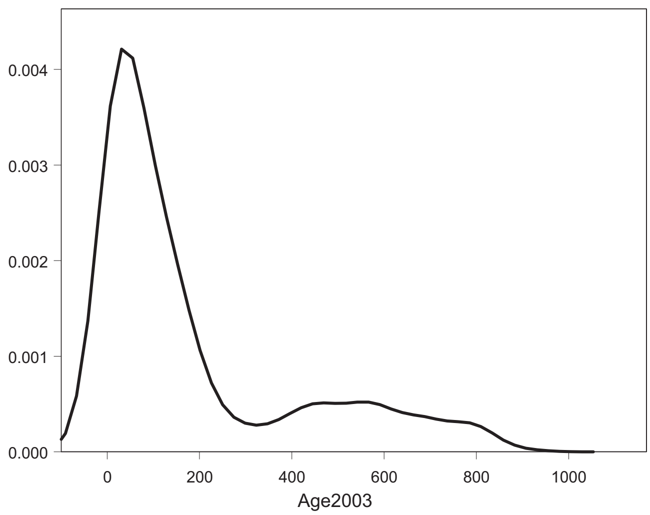

Fig. 1. Kernel distribution of European university ages (Aquameth sample, 11 countries, $n = 488$).

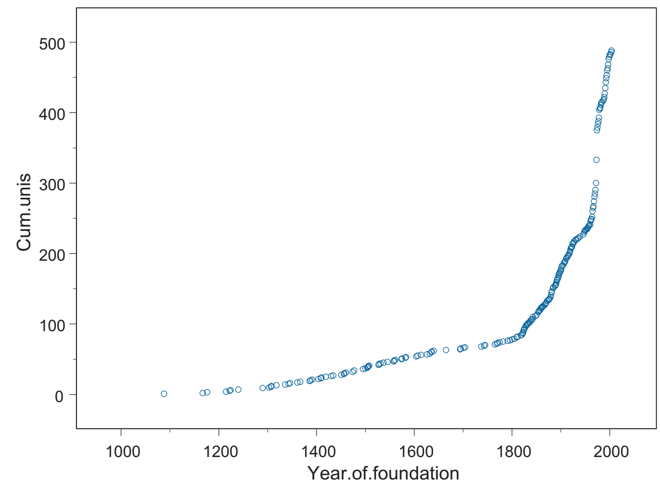

Fig. 2. Cumulative number of universities by year of foundation.

vidual departments or schools. Controversial assignments were discussed extensively during the project and substantial consensus was achieved.[2]

There is no alternative to in depth examination of the qualitative characteristics of national institutional contexts to give a robust meaning to any proposed indicator. Bearing in mind these issues, we describe our characterization of European universities in Section 5. It should be noted that the variables we analyse contribute to an overall interpretation of the status and competitiveness of European universities, which are summarized in Sections 5 and 6, and provide evidence-based support for policy reform.

5. Opening the black box of country level data

5.1. The dynamics of the creation of universities in Europe

The process of creating a new university is dependent on several historical factors and shows no strong regularities. The kernel distribution of university age (Fig. 1) shows two peaks at around 100 years and at 500 years.

To understand the origins of this age structure, we need to inspect the distribution over time. The cumulative distribution has demonstrated linear growth since the Middle Ages up to the end of the 18th century, followed by exponential growth starting in the 19th century (Fig. 2). The cumulative distribution in the 20th century, shows a further acceleration after 1970 (Fig. 3). The most recent dynamics seem to follow the waves of entry into higher education of large populations of young people, immediately after the Second World War, during the 1960s and 1970s, and after 1990.

If we look at national differences in the history of university creation (Fig. 4), several patterns emerge. The large European countries, with the exception of Spain, show the presence of a considerable number of universities in the Renaissance period. Italy and France historically are considered the birth places of the university institution. France dominates in terms of number of universities established before 1800. After 1800, the UK established a large number of new universities, some of which initially were polytechnics and subsequently were awarded university status. Most of the large European countries, including Spain, but with the interesting exception of the UK, exhibit a sharp increase in the

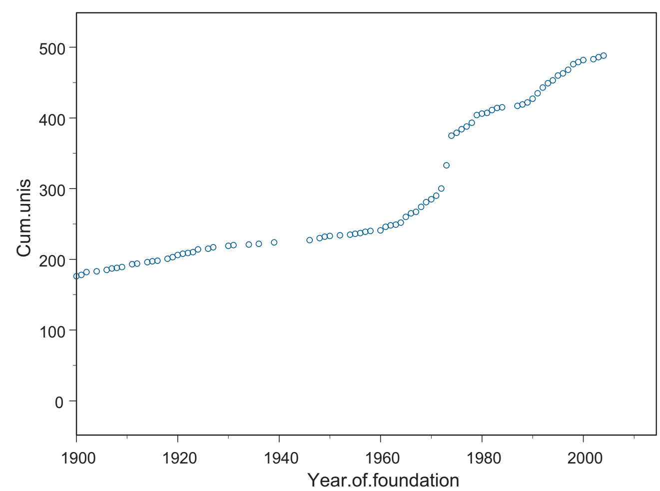

Fig. 3. Cumulative number of universities by year of foundation. 1900–2000.

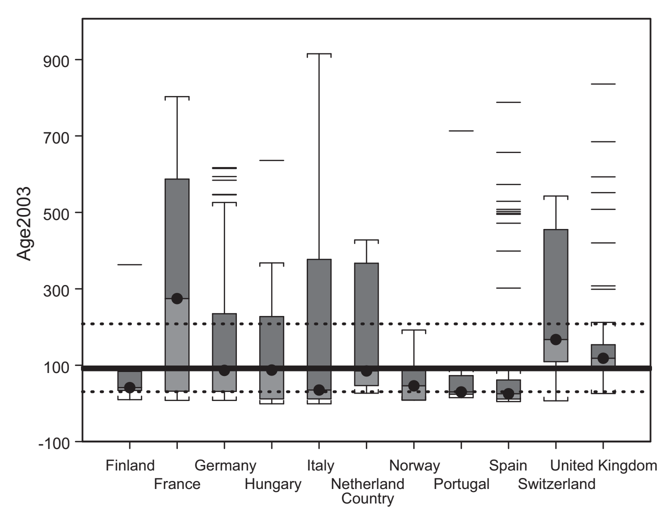

Fig. 4. Boxplots of university ages by country. The bold horizontal reference line is the European median (91.5), the horizontal dotted reference lines are the European first (31) and third quartiles (208.25). The European values are computed on all the Aquameth dataset.

[2] Details of the procedure are available on request from the corresponding author.

number of universities from 1970. The historical dynamics sheds light on an important institutional difference. Faced with a second wave of mass higher education in the 1960s and 1970s, the UK government, in the early 1990s, upgraded the status of some of its polytechnics rather than creating new universities similar to the already existing institutions. This increased the educational supply without congesting the research universities. Polytechnics were invited to invest in research (of the more applied type), while keeping at their core the traditional education mission. This resulted in strong internal differentiation.

A similar dynamics can be seen in some of the small European countries, although there are some 'outlying' very old universities in Portugal and Hungary (see Fig. 4, which shows the distribution of university ages by country). In the case of Hungary, its entire higher education system developed in a disconnected way due to its turbulent history. Fig. 4 shows the following patterns: (a) Italy and France have the oldest institutions and 75% of their universities are spread along the university age distribution, indicating a continuous pattern of foundation of new institutions; (b) the UK, Spain and Portugal have fewer very old universities, and many are outliers; (c) the Germanic countries (Germany, the Netherlands, Switzerland) and, to an extent, Hungary, had very few Mediaeval universities that continued for more than two centuries, which makes the median age of their universities relatively young; (d) the universities in Norway and Finland are all very new. In general, the distributions are highly skewed, as the box plots in Fig. 4 show.

To sum up, universities are among the oldest surviving institutions, with those in Europe being among the most ancient. Micro data allow a finer interpretation of the dynamics of creation:

- the take-off of universities in terms of their establishment follows the pattern of entry into the Modern Age, via the creation of nation states, and subsequently the industrial revolution: first the UK, then France and Germany, followed by Italy, and finally Spain and Portugal;
- controlling for location, the first universities were in large urban centres, and only later did they start to be established in smaller urban centres, according to a clearly discernible core-periphery pattern;
- a large increase in absolute university creation occurred in the 20th century (Fig. 2), spreading knowledge across social classes and territories in the already industrialized countries;
- a sharp acceleration can be identified in the period after the Second World War, and particularly after the 1970s (Fig. 3);
- in terms of inter-country differences in the age distribution (Fig. 4), it is clear that each country has its own historical pattern of university creation since many boxes lie outside the European range (dotted lines in Fig. 4: France, Italy, the Netherlands and Switzerland), while Germany, Spain and the UK have many outliers;

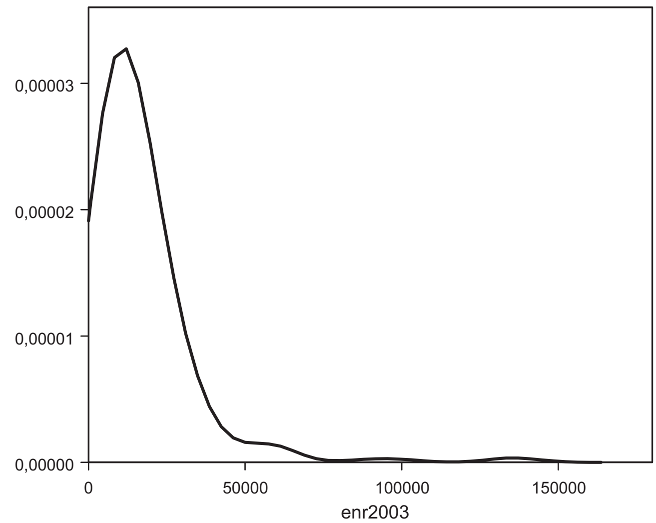

Fig. 5. Kernel distribution of size (undergraduate students). Year 2003.

- controlling for subject mix, universities created in the last quarter of the last century include a few specialists, but are still largely generalist;
- in general, specialist universities are younger.

Thus, rather than responding to new segments of social demand (over social classes and territories) and offering specialized education services, universities *replicated the dominant generalist model at the territorial level*. Peripheries did not want specialist universities, they wanted their own general universities, or preferred to start with a few disciplines and replicate the generalist model over time.

5.2. Size distribution, concentration and growth

The impact of size on university performance is controversial (Brinkman and Leslie, 1986; Dundar and Lewis, 1995). Universities are unevenly distributed with respect to size measured by either student or academic staff numbers. Fig. 5 shows an extremely thin long tail on the right of the distribution, while almost all of the density is located at below 50,000 students.

Very large universities (more than 50,000 undergraduate students) are usually old institutions in large cities, or in medium-sized cities that attract students from other regions. The largest universities in the UK (the Open University for distance learning), Spain and Italy exceed 130,000 students (Table 3), which is a very large number: the largest German university has around 60,000 students, and the largest in France around 40,000. It seems that these very

Table 3
Descriptive statistics on size (undergraduate students). Year 2003.

Country	Min	First quartile	Mean	Median	Third quartile	Max
CH	893	3683	7356	7386	9650	19,104
DE	1888	8849.75	18,629	16,812	24,300	59,777
ES	6197	12,423	28,109	25,050	33,777	133,591
FI	229	2119	7354	4818	12,392	31,304
FR	2005	10,668.25	16,414	16,061	22,303	40,489
HU	3128	7205.75	15,675	11,485	26,851	32,486
IT	262	9035.75	23,896	15,651	32,379	132,537
NL	4385	10,888	14,438	16,055	17,035	24,637
NO	1986	4120.75	10,246	6,579	15,439	30,056
PT	2348	4927	10,698	7969	16,438	23,294
UK	0	5474	12,035	10,471	20,005	139,299

Note: The UK university with the highest number of student is the Open University for distance learning. UK universities with zero undergraduate students are universities that specialize in postgraduate education. They are excluded from analysis as appropriate.

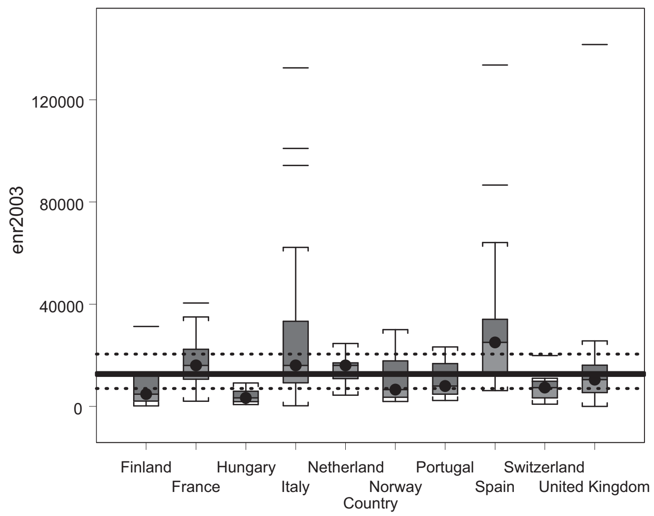

Fig. 6. Boxplots of size (undergraduate students), year 2003 by country. The bold horizontal reference line is the European median (12,676), the horizontal dotted reference lines are the European first (6996) and third quartiles (20,506.5). European values are computed on all the Aquameth dataset.

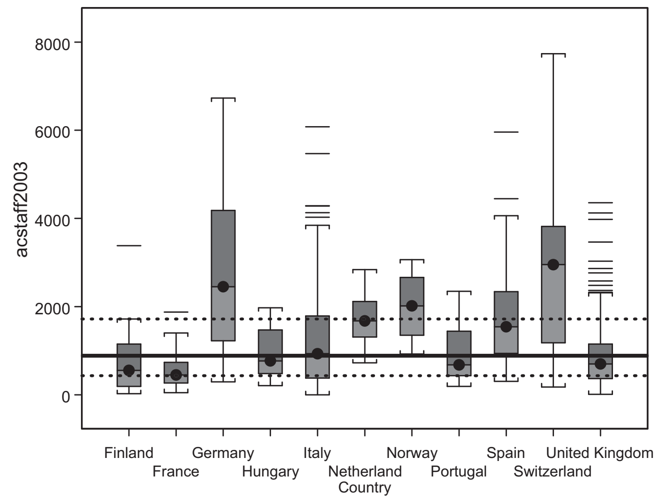

Fig. 8. Boxplots of size (total academic staff), year 2003 by country. The bold horizontal reference line is the European median (882.5), the horizontal dotted reference lines are the European first (434.75) and third quartiles (1720.5). European values are computed on all the Aquameth dataset.

large institutions are outliers in the distribution, while the range of variation does not exceed 50–60,000 students (Fig. 6).

The size distribution with respect to numbers of academic staff (Fig. 7) has a similar shape, but the long tail on the right is fatter. Comparability of data is extremely complex due to national definitions and the practical employment of academic staff conditions.

The national boxplots (Fig. 8) show that Germany and, particularly, Switzerland have larger endowments of academic staff. In the case of Germany, academic staff numbers might be overestimated because, especially research/teaching assistants, work part time and/or occupy temporary positions. In all other countries the median value is in the range 500–2000, with Italy, Spain and the UK with the largest number of outliers. In the case of Italy, the count includes only permanent positions, although large numbers of temporary staff are employed.

In the case of France, as is evident from the boxplot, academic staff numbers appear relatively small, because the French data include only full and assistant/associate professors (*maîtres de conferences*), estimated to represent 67% of all teachers and researchers at universities. Also, these data do not include researchers located in the university who are working under the supervision of other PROs such as the Unité Mixte del CNRS. Based on these idiosyncrasies, French data are not comparable.

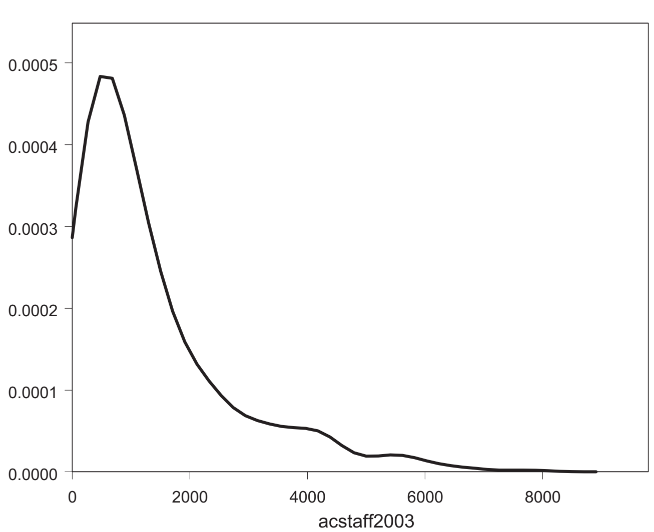

Fig. 7. Kernel distribution of size (total academic staff). Year 2003.

Table 4 presents various measures for the concentration of students in universities: cr4, cr8 and cr20 are concentration ratios by country, which give the percentage of students in the first 4, 8 or 20 universities respectively, ordered by decreasing numbers of enrolled students. The Herfindahl index (H), shown in Eq. (1), gives the sum of the squares of the share of enrolled students in individual universities (q_i). Finally, the Normalized Herfindahl index (N_H), described in Eq. (2), ranges from 0 to 1 and, unlike the Herfindahl (H), does not depend on N (the number of firms in the market). Usually, a value of the N_H index smaller than 0.1 indicates a non-concentrated industry and, as shown by Table 4, this applies to all the European countries in the Aquameth dataset.[3]

$$H = \sum_{i=1}^{n} q_i^2 \tag{1}$$

$$N\_H = \frac{(H - 1/N)}{1 - 1/N} \tag{2}$$

Herfindahl-type indexes can be used to measure the level of specialization of an institution (see Williams and van Dyke, 2007 and Williams, 2008); however, it is not easy to implement this across different national systems.

Taking into account the size distribution and the concentration, we can suggest a taxonomy based on number of students or number of academic staff (see further detail in Tables B1 and B2 in the Appendix available at the PRIME website). The taxonomy includes five size categories:

- very small (<500 undergraduate students, or <50 academic staff);
- small (500–2000 undergraduate students, or 50–200 academic staff);
- medium (2000–20,000 undergraduate students, or 200–2000 academic staff);

[3] We computed the concentration indexes reported in Table 4 on the variable Total academic staff: the results for non-concentration were virtually the same.

Table 4
Concentration of universities by size (enrolled undergraduate students). Year 2003.

Country	cr4	cr8	cr20	Herfindahl index	N	Normalized H
CH	57.51	89.66		0.122	12	0.043
DE	14.27	26.20	52.24	0.020	72	0.006
ES	25.24	39.86	68.73	0.034	48	0.014
FI	47.61	75.77	100.00	0.096	20	0.049
FR	9.56	17.56	38.19	0.014	88	0.003
HU	54.60	83.19	–	0.104	14	0.035
IT	22.06	35.58	62.44	0.028	79	0.015
NL	45.16	78.26	–	0.090	13	0.014
NO	74.03	95.93	–	0.173	10	0.081
PT	52.97	82.46	–	0.100	14	0.031
UK	15.86	22.40	39.13	0.020	116	0.012

- large (20,000–50,000 undergraduate students, or 2000–5000 academic staff);
- very large (>50,000 undergraduate students, or >5000 academic staff).

We found that this taxonomy represents the bulk of the distribution, leaving a few cases to the extreme classes. It appears that in all countries the medium size category (from 2000 to 20,000 students) is the most representative and accounts for 45–90% of the distribution. Medium-sized and large universities absorb the bulk of the distribution.

With respect to growth, using the Aquameth database we can calculate the compound growth rate over intervals of different lengths, from the initial to the final year of the available time series (see Table 2 for details). Growth rates generally refer to the whole period 1996–2003. Table 5 reports the average annual growth rates by country and size category.

Among the very small and small universities, Italy stands out showing growth rates of 9.5% in the former case and 5% in the latter, due also to the creation of a large number of new institutions from the mid 1990s onward. A dynamics of fragmentation seems to be at work in Italy. Followers in the small category achieve growth rates of only 3% (Switzerland) and 3.8% (Germany). Medium sized universities, taken together, have grown at less than 1% per year in the period, and in Germany decreased by 2% per year. Hungary is an exceptional case in that its medium-sized universities experienced average annual growth of 10%. Large and very large universities show negative growth rates in almost all countries, and especially Germany and Spain (minus 3% in both cases). In the Netherlands and Norway the large universities show negative growth, while in Italy the large universities show slight increases and the very large universities show slight decreases. Hungary, again, is an exception insofar as its large universities show annual growth of 7%. On average, the dynamics in Europe is a slow redistribution of large and very large universities, and entry of new small universities at the bottom.

Table 5
Compound rates of growth in percentages (enrolled students).

Country	Very large	Large	Medium	Small	Very small
CH	–	–	−0.64	3.09	–
DE	−3.29	−3.29	−1.94	3.76	–
ES	−0.12	−0.04	0.5	–	–
FI	–	0.17	0.42	0.17	0.63
FR	–	0.02	0.17	–	–
HU	–	6.87	10.31	0.59	–
IT	−0.13	0.22	0.6	5.01	9.49
NL	–	−0.03	0.09	–	–
NO	–	−0.03	0.13	−0.15	–
PT	–	0.14	0.21	–	–
UK	0.2	0.36	0.37	0.65	0.25

Analysis of the data on the size distribution provides the following stylized facts:

- the size distribution is skewed (Figs. 5 and 7), meaning small entities are proportionally more present;
- in a few countries (Spain and Italy) there are some extremely large universities; these are located in very large cities, are generalist and are old;
- the smaller countries (Finland, Hungary, Netherlands, Portugal, Switzerland, Norway) do not have large universities (Fig. 6);
- the minimal size is very small almost everywhere (Table 3);
- looking at cross-country size differences measured by enrolled students, with the exception of Spain and Italy, most national distributions fall within the European range (dotted line in Fig. 6); this means that the size distribution is subject to structural constraints that cut across national contexts; this does not apply to academic staff (Fig. 8), where numbers are higher in the Germanic and Nordic countries, outside the European range.

These features of the size distribution have implications for the ranking of European universities. The following remarks should be considered. First, top ranked European universities are larger than similarly ranked US universities; this means that, due to the lack of correlation between scientific quality across departments, European universities must be larger than their competitors in order to enter the ranking league, *ceteris paribus*. Second, top ranked European universities have large medical schools. Third, universities located low down in the size distribution have a negligible probability of being in the rankings, unless they are specialized in research. Fourth, international rankings do not relate research output to size: they either ignore relative indicators (e.g. publications per unit of academic staff) or give them low weights. Consequently, smaller universities with highly correlated scores (typical of the US but not the European system) are ranked higher than larger universities, which display long tails indicating lower quality. Thus, there are basically two types of universities in the rankings for Europe: (1) very large, generalist, but non-differentiated, universities (e.g. Rome and Milan in Italy, Madrid and Barcelona in Spain, Helsinki in Finland), and large research oriented universities (particularly in the UK, Switzerland and the Netherlands); (2) small or medium-sized universities, particularly in the smaller countries, for those countries that have differentiation along research and financially support research intensive universities (Switzerland, Netherlands).

It might seem that these two categories are relatively underrepresented in the European countries. The relatively poor performance of European countries may be the result of a combination of a massive educational load and lack of differentiation. Excellent departments might be embedded in large generalist universities, which, overall, do not qualify for entry into the league tables. To reach definitive conclusions, further investigation is needed.

6. Positioning universities in the European landscape

6.1. Some evidence on horizontal diversity: the subject mix

The heterogeneity of universities with respect to subject domains is an issue in higher education, where much of the research focuses on the features of different subject domains and their classification (Becher and Trowler, 2001; Sarrico and Dyson, 2004), as well as on the dynamics of change and differentiation, which are seen as major driving forces of higher education (Clark, 1996). Heterogeneity emerges also in the context of institution-level studies, with empirical evidence showing that differences between higher education institutes in terms of subject mix may be large, and may account for large variations in higher education institution-level indicators and significantly influence comparisons between individual institutions. A number of studies show that the differences in costs per student across subject domains are large and systematic, with medicine at the top followed by natural sciences and technology, and social sciences and humanities less expensive on average (Jongbloed et al., 2003; Johnes, 1990). Also, Filippini and Lepori (2007), using disaggregated data at disciplinary field level in the Swiss case, show that differences between domains are systematically larger than differences between individual higher education institutes and that this pattern is consistent across a wide range of indicators, including students per professor, education and total costs, number of PhD students, and number of degrees. However, discussion rarely goes beyond simple qualitative accounts of these differences. Although some classes of specialized institutions have been identified, such as technical schools and business schools, their role in the entire higher education system has not been analysed. There are major differences among higher education institutions, including the presence or absence of a medical school, which have an impact on their costs, however, to our knowledge no systematic mapping has been undertaken (at least in the European context).

A preliminary approximation was made as part of the Aquameth project and is based on the distinction between generalist and specialist universities. Based on previous analysis we define a university as specialist if more than 75% of undergraduate students are enrolled in just one field, or more than 90% of undergraduate students are enrolled in two fields. A university is defined as generalist otherwise. We are aware that there may be borderline cases, where a slight deviation from the thresholds defined above might have a major influence on their status. For this reason, we propose a *sensitivity analysis*, where thresholds can vary, to check whether classifications are stable. These classifications could be used to carry out comparative analyses based on single categories. Table B3 in the Appendix presents the categories per university size (measured as the number of undergraduate students). We would expect that the larger the university the higher would be the probability that the university is generalist. However, a few countries, such as the UK and Switzerland, have specialist universities that are large and very large in size. This is an interesting indicator of the degree of differentiation in the university profile. Specialist universities may lean towards entering numerous fields of education during their life cycle, unless the institutional context prizes specialization even in large size institutions.

The Aquameth project collected data disaggregated by scientific field, using the four domain classifications mentioned earlier (Human and social sciences, Technical sciences, Natural sciences, Medicine). This was feasible for most countries in the sample in the case of students, and was feasible for some countries in the case of staff. It was possible also to map Web of Science publications data to this scheme although bearing in mind the different coverage of the Web of Science across scientific domains. Methodologically, this exercise is complicated by the multi-input and multi-output nature of higher education institutions; for example, there is no reason why the distribution of students across subjects should match the distribution of scientific publications or staff, even though they may be related. The simplest choice in terms of availability of data, which would be to use number of students by domain to characterize subject mix, could produce misleading results if differences in the orientation towards education vs research between domains, are large and systematic, as the data for Switzerland would suggest (Filippini and Lepori, 2007).

Ideally, one should calculate the distribution of different types of inputs and outputs and then explore their relationship, an option that is not really feasible with the data available. We resorted to the simpler strategy of using the number of academic staff (as Full Time Equivalent – FTE) as the basic measure of the effort invested in each domain. The advantage of this is that these data are usually available and are more robust than budgetary data; the limitation is that it disregards differences by domain in terms types of costs (related e.g. to different shares of capital costs) and staff composition.

Preliminary analysis of five countries (Finland, Italy, the Netherlands, Norway and Switzerland) for year 2001 produces some quite interesting patterns, and some variations between subjects and countries (Lepori and Baschung, 2008).

It would seem that specialist institutions are largely technical science universities, with practically all institutions with large technical departments specialized in the field (possibly also including those with large natural sciences departments). The next largest group of specialist institutes is specialized in human and social sciences, but these are smaller organizations and, in all countries, account for a small share of the total staff in the field. Specialist natural sciences (the only case being SISSA in Trieste) and medical (small higher education organizations in Italy) institutions are rare.

The second major pattern refers to medicine, which shows a different pattern of concentration. In the sample considered here, only 40% of institutions have sizeable medical departments (larger than 200 FTE), while the 10 institutions with the largest departments concentrate about half of the total staff in the field. However, these are not specialist institutions, in fact they are the largest generalist universities in their respective countries, e.g. the University of Rome in Italy, University of Zurich in Switzerland, and University Oslo in Norway.

The final group of institutions is composed of universities without a significant school of medicine, but with other significant domains (although not technology); the typical profile of these institutions is two-thirds of the academic staff in human and social sciences and the remainder in natural sciences and technology; these universities on average are small, and younger than the generalist higher education institutions with medicine faculties.

These results are preliminary and require deeper investigation; however, at the level of large subject domains, there are distinct patterns of specialization, probably a legacy of medicine being one of the core fields in the case of the old universities, while technical sciences became the focus of specific institutions later on in the evolution of the university. There are also significant differences among countries, with some institutions more specialized (in Finland and Netherlands), while in Italy the generalist university is the dominant model, with technology mostly located in generalist institutions. Clearly, further research is needed to build a full multi-criteria classification.

Table 6 presents the following stylized facts:

- generalist universities are the dominant model in Europe;
- pure specialist universities are mainly in engineering (polytechnics, technical universities, ecoles polytechniques), human and social sciences, and to a lesser extent, medicine;
- specialist universities are fewer in number and generally younger than generalist universities; consequently, due to the visibility

Table 6
Classes of HEI by subject mix (Finland, Italy, Netherlands, Norway and Switzerland, year 2001).

Type	Category	Subclasses	N.	Staff FTE	Avg. staff
Specialist	Natural sciences HEI		1		
Specialist	Technical HEI	Pure technical HEI	10	10,812	1081
		Natural-technical HEI	4	18,481	4620
Specialist	Humanities and Social Sciences HEI	Business schools	3	3372	1124
		Other	19	5017	264
Specialist	Medical HEI		2	1268	634
General	HEI with strong Medicine		8	18,626	2328
General	HEI with Medicine		44	135,775	3086
General	General HEI without Medicine		37	34,930	944
Total	Total		128	228,281	1797

Table 7
Sources of funding (percentages).

Category of funding	CH	ES	FI	HU	IT	NL	NO	PT	UK
Tuition and fees	2.09	17.67	nr	nr	14.72	5.61	0.00	5.82	23.69
Government funding	83.14	67.10	72.94	89.15	75.37	75.89	92.63	63.90	47.05
EU and other inter. Funding	1.81	2.69	4.42	3.26	0.26	1.33	1.27	6.06	2.42
Private funding	8.78	1.44	22.64	6.54	5.97	6.87	3.76	24.23	6.29
Asset revenues	4.17	0.54	0.00	0.00	2.03	0.00	0.00	0.00	1.53
Other funds	0.00	10.56	0.00	1.06	1.65	40.00	2.34	0.00	19.01
Total	100	100	100	100	100	100	100	100	100

Note: nr = not relevant.

effects outlined above, they are not frequent in international rankings;
- the UK, the Netherlands and Switzerland are exceptions where national policies oriented towards differentiation have served to strengthen several technical schools, often with strong linkages between engineering and science (e.g. ETH Zurich or EPFL in Switzerland).

On the basis of this preliminary study, we can say that specialist universities are in an immature stage of development in most European countries.

6.2. Some evidence on vertical diversity and patterns of differentiation: funding structures

Analysing the sources of university funding is difficult, due to lack of comparable administration definitions. The Appendix A included at the end of this paper provides national definitions of items that appear in universities' financial reporting. A few remarks need to be made:

- other funds in the UK includes donations, which are a significant portion of the total budget for many universities, and revenues from goods and services (Crespi, 2007);
- private funding in Portugal includes government research contracts that are bid for competitively; it is not possible to disentangle these two components (Teixeira et al., 2007);
- private funding in Finland includes funding from non-government agencies as well as firms;
- student fees in Germany include large amounts from other sources (especially revenue from medical treatment in university hospitals) and are not comparable.

It can be seen, therefore, that it is almost impossible to compare the share of private sector funding across the whole sample. With this caveat, we can point to several interesting points that emerge from Table 7:

- universities receive 47% of their funding from government in the UK; in other countries the range is between 64% (Portugal) and 93% (Norway); Germany is at 56% but the data are not comparable;
- countries such as Italy, the UK and Spain, rely on student fees for between 15% and 24%, while in the Scandinavian countries (Finland, Norway, the Netherlands) and Hungary student fees are very low;
- with the exception of Portugal and Finland (not comparable for the reasons stated above), private funding does not exceed 6% of the total funding.

It seems that universities in most European countries (except the UK) do not have much room for manoeuvre. If student fees cannot be increased, either because they are already high (Italy, the UK, Spain), or because it is not politically acceptable (Finland, Norway, the Netherlands, Hungary), and if private funding does not exceed a share of around 5–6%, then universities will remain reliant mainly on government funding. However, there is some evidence that, over time, the composition of total research funding has changed from mostly general (block) funding to project funding (Geuna, 2001; Lepori et al., 2007; Potì and Reale, 2007). The universities can perhaps manipulate this composition to their advantage.

To summarize, comparative data from Aquameth (Table 7), which extends and confirms the CHINC (Changes in University Incomes: Their Impact on University-Based Research and Innovation) project survey based results, suggest the following observations. First, universities trying to diversify sources of income ('differentiation of inputs') need to increase the relative share of non-government funding, namely, student fees, private income and other sources. Second, the data show that the range of and the variance in the indicators for share of non-government sources are extremely low, e.g. the number of universities exhibiting double the average national level of the share indicator are only a few units across Europe. Finally, we see some (but rather slow) movement towards diversification of funding sources, or differentiation in inputs, probably hampered by the legal framework and traditional governance.

6.3. Some evidence on vertical diversity: postgraduate education

The proportion of postgraduate students, particularly doctoral, on total undergraduate education in a university is informative

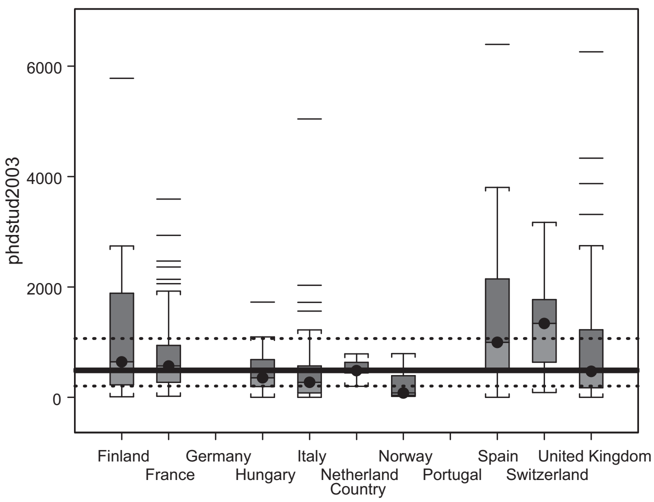

Fig. 9. Boxplots of PhD students by country. Year 2003. The bold horizontal reference line is the European median (487), the horizontal dotted reference lines are the European first (204) and third quartiles (1066.75). European values are computed on all the Aquameth dataset.

about the strategic choices open to the university. Doctoral students compete with undergraduates for the time of professors, and for laboratory and other space. In fields characterized by international competition and mobility of PhD candidates, universities are attractive to potential PhD students only if they have dedicated staff time and facilities, and teach courses in English. Consequently, a university that wants to compete internationally in doctoral education must maintain the ratio between PhD and undergraduates at a certain threshold (Bonaccorsi, 2009).

Fig. 9 depicts the distribution of PhD students by country and shows that European universities vary widely although the biggest variability is in countries with selective policies for providing PhD courses such as Switzerland, the UK, the Netherlands and Hungary. Some of this variability is related to the tradition in Switzerland for students to complete their doctoral education early on in their careers, in order to improve their chances of entry to the job market.

Table 8 shows the ratio of PhD degrees awarded per 100 undergraduate students, with the coefficient of variation of the ratio across countries. The ratio is very high for Switzerland and the UK, and much higher in the Netherlands than in any other country. While this ratio is high in some universities in Italy and France, these institutions are the exceptions in these countries and do not influence the overall distribution.

6.4. *Some evidence on vertical diversity: scientific production*

Scientific production is proxied by the number of international papers published in refereed journals (Fig. 10). This definition is clearly very crude, does not give sufficient recognition to the Human and Social Sciences (see e.g. Hicks, 2004), and ignores non-ISI publications. Also, crude indicators such as publications per unit of academic staff may be misleading either due to the numerator (differences in pattern of scientific production across disciplines, hence across universities with different subject mixes) or to the denominator (differences in the time involvement of academic staff in research). At the same time, national level data should not be overly biased by differences in subject mix, given that the predominant model is the generalist university which includes several disciplines. Showing distributions (boxplots) rather than aggregate national level data, enables deeper investigation and correction of possible errors. Since we use a definition of research production based on ISI publications, accepting the limitations of this definition, our evidence adds to that offered by most rankings based on the same source. We consider a simple indicator of scientific productivity, namely the number of international (ISI) publications per unit of academic staff, and we explore the distribution of this indicator by country (Fig. 11). Note, data for France and Germany are missing.

Table 8
Indicators of structural differentiation of universities in doctoral education. Some descriptive statistics on the indicator PhD recipients per 100 undergraduate students.

Country	Average value	Maximum value	Standard Deviation	Variation coefficient
CH	2.71	5.16	1.57	2.45
ES	0.50	1.37	0.26	0.07
FI	0.67	1.60	0.35	0.12
FR	0.63	3.11	0.60	0.36
HU	0.36	1.15	0.43	0.18
IT	0.29	3.05	0.37	0.14
NL	1.59	4.06	0.83	0.69
NO	0.65	2.22	0.70	0.49
PT	0.44	0.75	0.18	0.03
UK	1.42	43.48	4.18	17.46

In terms of productivity, i.e. number of publications per unit of academic staff (Fig. 12), the Dutch system seems to be the best performer, followed by the UK. The remaining countries exhibit similar levels to the median value, with Norway and Finland slightly better than this level. Italy has several outliers and productivity close to the UK leaders.

If we examine the trade off between research production and teaching load, Fig. 12 shows a clear negative relation. We can see also that large universities are subject to more severe trade-offs, since few are located along the horizontal axis of scientific productivity, while almost all exhibit high values for student load. For medium-sized universities, the trade off seems to be less stringent, although still identifiable.

Data from the Aquameth project enable identification of the elements listed below, using crude (but informative) proxies for research productivity such as international publications per unit of academic staff, and the ratio of PhD to undergraduate students:

- there is little differentiation across universities for average productivity, such as publications per unit of academic staff, which indicates that the group of research-intensive or research-

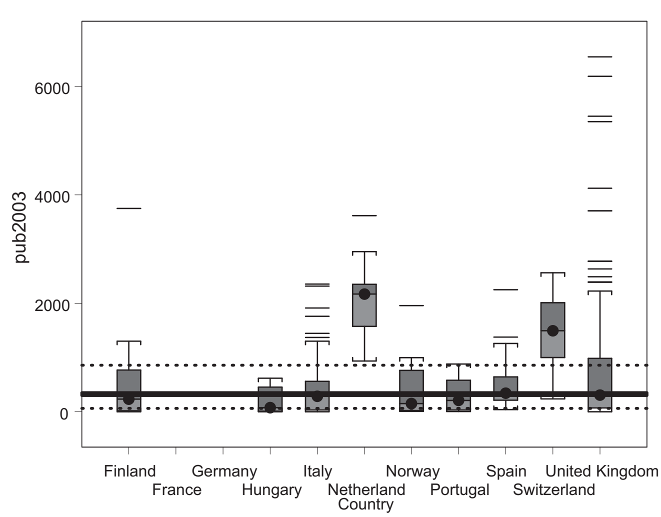

Fig. 10. Boxplots of total publications by country. Year 2003. The bold horizontal reference line is the European median (324), the horizontal dotted reference lines are the European first (61.5) and third quartiles (858). The European values are computed on all the Aquameth dataset.

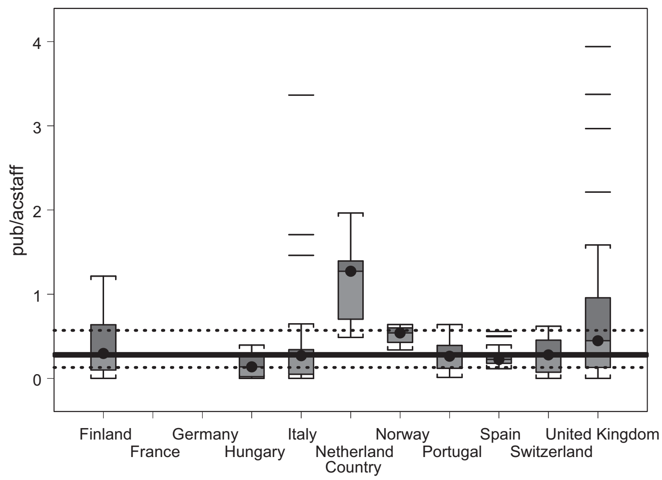

Fig. 11. Boxplots of publications per academic staff by country. Year 2003. The bold horizontal reference line is the European median (0.28), the horizontal dotted reference lines are the European first (0.13) and third quartiles (0.57). European values are computed on all the Aquameth dataset.

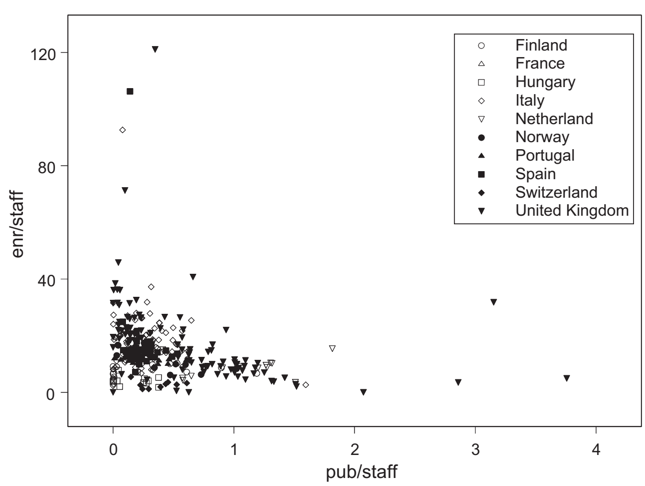

Fig. 12. Plot of publication intensity vs undergraduate per academic staff – total.

oriented universities is not so large as to shift the distribution (Fig. 11), and that all countries except the Netherlands and the UK are within the European range (dotted lines);

- boxplots (Fig. 11) show that there are a few universities whose research productivity is at the upper extreme of the national and European distributions; important exceptions are the UK, the Netherlands and Switzerland;
- a crude indicator, such as the ratio of PhD to undergraduate students (Table 8) shows little differentiation among countries with the exception of the UK, the Netherlands and Switzerland.

7. Conclusions

This paper provides a first analysis of European universities along the dimensions of age, size and growth, horizontal and vertical diversity and pattern of differentiation. Combining the empirical evidence discussed above produces a quite clear pattern: only a few European countries encourage differentiation according to university research output and competitive funding. In most countries universities are characterized by the absence of correlation (concentration) between research, funding and top researchers: excellent researchers do not receive better structural funding (although they probably win more competitive funding), thus the universities they belong to do not necessarily come at the top of the international rankings.

More research is needed to confirm these preliminary findings. This paper is based on the first large scale effort to build a data base of all the universities in a large number of European countries to enable comparative analysis. The data are based on administrative census data, i.e. from a survey of university administrations, collected and annotated by an international team of researchers. The Aquameth dataset makes it possible, experimentally, to shed light on a number of issues of great interest to academic and policy debates, and paves the way to standardized data at national statistical office level and more rigorous and informed policy making. The evidence in this paper points to the need for policy decisions based on empirical evidence at micro level, to complement the broad analyses at aggregate (national) level.

The micro approach followed in the project constitutes a first step towards closing the gap between individual case studies and studies based on aggregate national statistics. There is great potential for rigorous micro data gathering and data analysis exercises at European level: the Aquameth project shows that this kind of approach is both feasible and useful. The project demonstrates that the integration of micro-data at European level, taking account of all possible comparability issues, is feasible. The project combined the collection of data and indicators with new methodologies in econometrics (using both parametric and nonparametric tools such as conditional efficiency models, see Bonaccorsi and Daraio, 2007), long term theoretical investigation of the evolution of higher education and knowledge production, and attention to the relevant policy debates.

In a midterm perspective, we hope that the experimental work carried out by the Aquameth project can be standardized and normalized, in a professional way, at the level of national and European statistical offices.[4] There is a need for full scale validation, standardization and exploitation of data, in addition to work to complete time series.

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Appendix A. Definitions of funding

See Table A1.

[4] After this paper was submitted, the Aquameth team created the EUMIDA (European University Micro Data) Consortium and was selected by the European Commission to conduct the 'Feasibility Study for Creating a European University Data Collection (RTD-C4/AR-D(2008)559189)' July 2009 to August 2010.

Table A1
Definitions of funding by country.

Country	Tuition and fees	Government funding	EU and other international funding	Private funding	Asset revenues	Other funds
CH	Fees	General and contracts funding from central and regional Governments + other prog (not divided by subcategories)	EU and international funding	General and project funding form private sector (profit and non-profit) plus services revenues (revenues from continuing education and service activities)	Patrimonial funds	–
DE	Administrative revenues: revenue which has been earned by the university for services (without research), e.g. revenue from medical treatment, selling publications, selling agricultural products, etc.	Current income from state budget	–	–	–	–
ES	Student fees	Funds provided by central and regional Government plus other public institutions funds	EU funding	Private funds	Patrimonial funds	Other funds (financial ass-ests + financial liabilities + real investments)
FI	Not relevant. In the Netherlands there are no tuition or fees for students in public higher education institutions		EU funding	Funding from domestic and international private firms and non government agencies	–	–
FR	–	–	–	Only project-based funding and services activities	–	–
HU	Not relevant because only a small part of students has to pay tuition fees. The data is not available.	General and contracts funding from Government	EU and international funding (grants and contracts)	General and project funding form private sector	–	Other revenues
IT	Tuition and fees	Funds provided by the national Government and other public institutions. In 1999 and 2000 includes only funds from Ministry of University and Research (in 1999 only ordinary transfers – FFO)	EU and international funding. Up to 1998 only EU funding	Current and capital funds from business sector and from organization other than public insitutions. Up to 1998 data refers only to private sector; In year 2000 it includes all funds received from organizations other than Ministry of University and Research.	Income from the investment of general endowments (including interest or dividends, bank interest or rents from real prop-erty) + patrimonial alien-ations + borrowing.	Other revenues. 2000 figure refers to borrowing funds.
NL	Tuition and fees	General and contracts funding from Government	All international grants (may even formally be grants from private foundations from abroad)	General and project funding form private sector (profit and non-profit)	–	Income from interest and from sales & services (excluding contract income and fees)
NO	Not relevant. In Norway there are no tuition or fees for students in public higher education institutions	General and contracts funding from central Government plus contracts funding from regional Government. For years 1995–1997 includes all contract funding and also funding from the Research Council of Norway	EU and international funding	Funding from private sector	–	Other revenues
PT	Tuition fees – student fees (UG)	Government Funding – formula (mostly enrolments by groups of disciplines)	EU and international funding	Private funding – postgraduate fees; net balances from previous years; contracts with public and private institutions		Other revenues not relevant

Table A1 (*Continued*)

Country	Tuition and fees	Government funding	EU and other international funding	Private funding	Asset revenues	Other funds
UK	Students fees: total income from the educational activities only	Total funding from general budget and central government: total income from the higher education funding councils only	This variable includes all income in respect of externally sponsored research carried out by the institution and funded by the EU plus overseas institutions	This variable includes all income in respect of externally sponsored research carried out by the institution and funded by UK Industry and/or UK Charities	This variable includes the full amount of the income from the investment of general endowments. This includes the income earned from the capital of the endowment whether arising from the interest or dividends on investments, bank interest or rents from real property.	This variable includes all income in respect of services rendered to outside bodies, including the supply of goods and consultancies, all non-research income from UK central government bodies, non-departmental public bodies, UK local authorities and UK health and hospital authorities, all non-research income for services rendered to industrial and commercial companies and public corporations operating in the UK; income received from UK health or hospital authorities for the funding of any employees of the institution, including posts in academic teaching, except those relating to the provision of a service and income from property rights and licences. PLUS other funding from assets
		Total funding from research contracts and central government: total income from the office of science and technology (research councils) and other UK Government				

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