Cross-country analysis of higher education institutions' efficiency: The role of strategic positioning

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Abstract. Universities are highly heterogeneous institutions and this diversity needs to be acknowledged when assessing their performance. Using an unbalanced panel that covers a 3-year period (2011-2013) with 761 observations coming from 307 universities located in 8 European countries, this study examines the extent to which strategic choices regarding international positioning and scope determine how efficient universities are in the allocation of their internal resources. Three main groups of universities are identified, according to their internationalization and scope: world-class, flagship and regional. Next, we model universities' objective function as a mix of teaching, research and third mission endeavours, and efficiency scores are calculated. In so doing, a meta-frontier analysis based on data envelopment analysis is used, to consider potential structural differences across the three groups of institutions. This approach allows comparing efficiency frontiers across groups and relative to a common frontier. In a second stage, a truncated regression analysis is performed in order to determine the external factors shaping inefficiency. Implications for policy and practice within and between groups are discussed.

Keywords. efficiency, higher education institutions, international comparison
JEL Codes. I23

1. Introduction

Universities are key actors in promoting the economic development of countries (Hanushek, 2016), and serve as a major source for fostering innovation and well-being (Smith, 2007). For this reason, policy makers care about the performance of universities, and invest resources and energies to make them more productive and able to provide the society with the necessary levels of teaching and research. Therefore, the financial crisis in 2008 and subsequent years posed severe challenges for public budgets to be dedicated to the development of universities' activities. In this vein, academic institutions are asked to improve their efficiency, through increasing their ability to produce more results (graduates, publications, applied research projects, etc.) with the available resources – and, in many cases, even to work with less resources. The issue of universities' productivity is particularly stark in Europe, as previous studies demonstrate that European ones have lower performance than their US counterparts (Aghion et al., 2010), the regulation setting being one major cause of this difference. A recent study by Wolszczak-Derlacz (2017) also suggests that US 4-year academic institutions are slightly more efficient (not only highly performing) than European ones, the latter being also characterized by higher heterogeneity. The European Commission is well aware of the necessity of strengthening the efficiency and effectiveness of higher education in the Area, and dedicated one specific stimulus to this objective in its last Communication to Member States (European Commission, 2017).

Universities are not all similar each other, thus. They have very different traditions and using their operational and strategic autonomy (Fumasoli et al., 2014) they develop their activities in quite heterogeneous way. To the extent that universities are conceived as autonomous organisations, they can develop specific strategies and diversified plans which can result in different mixes of teaching, research and engagement with society. In this vein, the evaluation of their performance cannot assume that each institution is pursuing the same objectives, and hypotheses can be formulated about the relationship between strategic choices and performance/efficiency. Strategic choices can be thought, in first approximation, to deal with the orientation towards internationalization and/or regional needs, i.e. to the primary needs to be served and goals to be reached. According to this choice, universities then adjust their "mission-mix", i.e. the intentional decision to devote priority, attention and effort to one or more of the missions described above – teaching, research and third mission – for coherence with the strategic goals of international/regional positioning (a description of this dynamic is in the section §2.1).

The aim of this study is to investigate the extent to which strategic choices regarding international positioning and scope are associated with the efficiency of universities in the allocation of their internal resources for the production of a given set of outputs. The specific research questions answered in this paper are three:

- How efficient are universities in the eight European countries under analysis?
- Which are the main characteristics of universities associated with their efficiency?
- How are universities grouped according to their strategic profile, and how is the average efficiency different across groups?

There are two main assumptions embedded in the above research questions that must be made explicit. First, following Altbatch and Knight (2007) we pose that the exposure to a growing internationalisation of higher education is affecting universities' strategic choices. Specifically, universities have to decide whether they want to compete in the international market – becoming "world-class" institutions (Levin et al., 2006; Deem et al., 2008), or in the national market as flagship universities (Douglass, 2016) or to be more oriented to regional/local market. If the strategy is to become a global player – i.e., world-class universities – we expect the emphasis to be placed on maximizing research outputs. Conversely, flagship universities will be more focused on the teaching mission, while universities serving regional markets will prioritise the establishment of fruitful university-industry partnerships. Second, in the European arena, universities differentiate themselves within countries, through making choices that characterise groups across countries. Therefore, we expect to observe universities from different countries sharing similar strategies. It would be interesting then to show whether performance is different across these groups, by grouping them – after the estimation of efficiency – and describing their characteristics and results.

This article innovates the existent literature in four main ways. First, we argue that universities are highly heterogeneous and that this diversity needs to be considered when analysing how these institutions perform. Specifically, in this paper we posit that sources of heterogeneity come from the strategy and the positioning, therefore, the interpretation of efficiency scores should be done in the light of these choices. Accordingly, we study efficiency, but we interpret the results by grouping universities that share a similar strategy. We do so by using meta-frontier analysis, an approach that allows us to compare efficiency frontiers across groups and relative to a common frontier for the full sample. Second, prior studies examining universities' efficiency have mainly concentrated in teaching and research outputs but neglected the so called "third mission" activities, such as knowledge and technology transfer to companies and society. We posit that despite teaching and research are key actions for satisfying society's knowledge demands, universities' *raison d'être* cannot be fully understood if such activities are not considered. Indeed, the contemporary university is expected to offer innovative solutions through knowledge transfer mechanisms that foster links with businesses. Similar to Berbegal-Mirabent et al. (2013) and de la Torre et al. (2017) we model universities' objective function using indicators for teaching, research and third mission outcomes. Third, literature examining cost efficiency and technical efficiency of universities has mainly adopted a country-specific approach, lacking studies that offer a broader view of the phenomena. Thus, taking advantage of recent projects capturing micro data from different European countries, this study complements the recent works of Daghbashyan et al. (2014), Daraio et al. (2015a) and Bolli et al. (2016), which offer a look across several European countries. Fourth, we move a step further in the characterization of the universities' heterogeneity by enriching the available datasets, integrating the European Tertiary Education Register (ETER) with PATSTAT, the European Patent Office's (EPO's) Worldwide Patent Statistical Database. In our opinion, it is necessary to draw information from different sources for gathering as many details as possible about single academic institutions, to provide a better glance about the strategic choices taken by them as well as to describe their activities.

The importance of this paper stems from obtaining a greater insight on how European universities address their multiple objective function. The ultimate goal is to shed new light on how these institutions align their internal resources and capabilities with their strategic vision. The reminder of the paper is organised as follows. Section §2 summarises the literature review. Specifically, this review focuses on previous works that deal with the problem of heterogeneity when assessing how higher education institutions (HEIs) perform. Next, in Section §3 the data and variable selection are described. The methodological approach chosen for the empirical analysis is also defined. Section §4 offers the results, with a discussion presented in Section §5. The final section §6 provides the concluding remarks, policy implications and future research lines.

2. Literature review

2.1. Strategic positioning of HEIs

Higher education institutions are not a homogenous set of organisations, and the academic debate nowadays agrees on the existence of a degree of diversity across them. While it is widely recognised that the three core missions of universities are teaching, research and the so-called "third-mission", it is also clear how different institutions develop heterogeneous capacity for these functions. Some universities specialise in research activities, while others in teaching – and others aim at maintaining an equilibrium between them. The idea that "one-size-fits-all" model of university can represent a kind of "standard" is now abandoned, and the institutional diversity is accepted as the new paradigm (see, for example, the analysis by Huisman et al., 2007 about the degree of differentiation within some Western higher education systems).

Adopting an economic perspective, the heterogeneity of universities' activities and missions can be interpreted as the result of different strategies adopted by them. Using Warning (2007) words, "*the strategic groups concept claims that the existence of heterogeneity within an industry is due to different strategies of the firms in that industry*" (p. 51). When considering the university sector, economic theoretical models clearly illustrate the possibility that universities compete each other on the basis of choices related to specialisation in teaching or research (Del Rey, 2001; De Fraja & Iossa, 2002). In such a context, the problem of measuring the performance of institutions which deliberately decide to differentiate from others by means of different missions is relevant (see also section §2.2). A possible approach is to try aggregating the performance dimensions into a single composite indicator (as in Gnaldi & Ranalli, 2016). An alternative way is to employ methods that allow assessing multiple outputs and weighting them differently according to the strategic profile – and this is the approach taken in this paper.

Differentiation between institutions is not a problem that deals with single countries. When analysing and comparing universities across countries, the problem of modelling their strategy becomes even more compelling. In his articulated analysis of higher education in Europe, the book edited by Bonaccorsi (2014) gives evidence of substantial heterogeneity across universities both between and within countries. When tackling directly this issue, Schubert et al. (2014) conclude: *"(...) there might be a European university model that is characterised by high differentiation and a division into teaching-only and research-conducting institutions. (...) analysing these clusters by country we also find (...) important heterogeneity*" (p. 79).

A related issue that exacerbates the problem associated with diversity of universities' missions and activities is that of rankings. A trend in the globalisation phenomenon for higher education is the development of rankings that formulate judgments about institutions on the basis of their performance indicators for teaching and research, without considering the explicit differences in their strategy and action. The evident risk behind this cultural movement is that rankings can become a hegemonic force that works towards homologation instead of differentiation (see the discussion in chapter §1 of the book by Hazelkorn, 2015)[1]. Moreover, as it is happening in other contexts like USA – where rankings are adopted since a longer time – they can also affect the available resources to universities through direct and indirect channels (Jin & Whalley, 2007). In the discussion of the results, the present paper provides some information about the correlation between efficiency scores and measures determined by rankings.

With the aim of considering properly the differentiation of academic institutions, we propose a classification based on different strategic choices that can result into three groups: world-class, flagship and regional/local universities. For defining world-class universities, we rely upon the discussion in Levin et al. (2006). The authors, adopting a view based on international rankings, claim that world-class is always a positional definition, referring to those

[1] Some authors propose an articulated and new statistical method to try reducing this risk, by using more sophisticated rankings techniques – see Daraio et al. (2015a).

universities that are at the top in terms of academic reputation. Given that the latter is always subjective, the concept tends to coincide with being at the top of international rankings, which are influenced by the ability of attracting scholars worldwide and by the research performance (number of publications and their impact). The analysis proposed by Altbach and Salmi (2011) also points at characterizing world-class academic institutions as research universities primarily. The idea of a flagship university is advocated by Douglass (2016), who propose a set of criteria for identifying its main features. According to this view, a flagship university is, normally: generally comprehensive and research intensive, highly selective but also broadly accessible, engaged in national economic development and public service, intended in educating talented leaders, sufficiently publicly funded, and focused on institutional self-improvement. These institutions are prestigious under academic standards, but they do not aim at climbing international rankings. Lastly, regional/local universities are those that have the primary mission of serving the needs of the territory in which they operate. The student body is composed mainly by those whose families live in the surrounding areas. Funding is provided publicly and through grants offered by local companies for developing projects of knowledge transfer to foster the local competitiveness. Usually, these universities do not have a strong research profile, at least as measured by publications and citations.

We are fully aware of the limits of this classification (it can be overly simplistic) and of the strong assumptions implied by the literature about the strategic orientation and coherence of actions at university level. Nevertheless, we use these broad definitions as an instrument for depicting a general distinction across institutions, using parameters and concepts that are general enough to be applied in grouping universities in the international (European) comparison. Later in this paper (section §4.1) we propose a selection of variables to realise the practical grouping of the institutions under analysis in the three groups proposed here.

2.2. How to deal with heterogeneity across universities' missions and activities

Despite the calls for a homogenisation of the European higher education system, in an increasingly globalised context, universities have designed different strategies to differentiate themselves from their competitors and thus, have followed different paths based on their strengths and institutional vision. This heterogeneity, due to differences in size, structure, institutional frameworks and geographic location, depicts a complex but challenging context for assessing universities' performance.

From a literature review it is possible to observe different methodological approaches aimed at dealing with the problem of how to capture the heterogeneity of universities when comparing such institutions. A first group of studies are those using methods based on expert selection of the classification criteria and threshold parameters. Studies following this approach typically rely on indicators such as the level of education provided, the range of disciplines, the age or history (being particularly relevant in the UK or US context), pre-existing university typologies (e.g., Carnegie Foundation in the USA) (McCormick & Zhao, 2005), specialisation or education/research strategic goals (Warning, 2004; Johnes, 2006), or funding modes and locations (Johnes & Yu, 2008). While this approach is valid, main criticisms refer to the *a priori* selection of a few metrics (Abankina et al., 2016).

A different approach consists in applying clustering or grouping techniques, resulting in groups of universities that are sufficiently uniform yet significantly different from each other (Howells et al., 2008; Bonaccorsi & Daraio, 2009). A set of parameters are selected capturing a wide range of aspects concerning the structure, the activities conducted, the presence of specific incentives, or the characteristics of the territory. Such a division into uniform groups is expected to help in the design of higher education policies. For instance, Howells et al. (2008) and Berbegal-Mirabent et al. (2013) propose the use of a non-hierarchical cluster analysis (K-means), which is based on the Euclidean distance between vectors of the standardised values of the variables under analysis. Through this procedure observations are classified according to the similarities of organisational and environmental dimensions.

There is, however, a third group of studies which, modifying traditional linear programs (i.e. Data Envelopment Analysis, DEA) and Stochastic Frontier (SF) techniques, are able to reduce the influence of outliers and control for heterogeneity problems (Aleskerov et al., 2017). One way to do this is using random parameters for modelling the cost function of universities (Johnes & Salas-Velasco, 2007; Johnes & Schwarzenberger, 2011). The idea behind this approach is that HEIs are acknowledged to be different; therefore, the cost function they face should be distinct (Johnes & Johnes, 2009). The works of Agasisti and Johnes (2015), and Johnes and Johnes (2016) go a step further in this direction. Their novelty lies in the estimation of latent class and random parameter stochastic frontier models of a multiproduct cost function. Alternative approaches to account for observed and unobserved factors that generate heterogeneity include the use of SF models based on the Generalised Maximum Entropy method (Laureti et al., 2014), or a combination of bootstrap DEA and Multidimensional Scaling (de la Torre et al., 2016a; 2018). More recently, Gralka (2018) argues that for an accurate estimation, two types of efficiency (linked to heterogeneity) should be distinguished, namely varying short-term (i.e. transient) and stable long term (i.e. persistent) efficiency. Using a panel dataset (2001 to 2013) containing information from 73 German public universities, the author tests different configurations and concludes that this distinction permits more precise policy implications as both components provide different types of information.

2.3. Cross-country studies of universities' efficiency

Studies analysing how universities perform are abundant, though, with a primary focus on a specific university or a given country (see Rhaiem, 2017 for an exhaustive literature review). Attempts to compare HEIs from different countries, although rare, have also been conducted. The absence of a sound amount of research is twofold (Agasisti & Haelermans, 2016): the difficulty to compare datasets from different sources and the differences of HE systems' structure. One of the pioneer works comparing universities from two countries is the study conducted by Agasisti and Johnes (2010). Using DEA, the authors compare the technical efficiency of universities in the UK and Italy and conclude that English institutions tend to outperform their Italian counterparts. Similarly, in Agasisti and Pérez-Esparrells (2010), Spanish and Italian universities are compared, being the Italian institutions the ones achieving higher average efficiency scores. A similar exercise has been repeated comparing Italian and German universities (Agasisti & Pohl, 2012; Agasisti & Gralka, 2017).

Despite these studies have brought new insights both on cross-country variations in cost efficiency and on the impact of institutional factors on efficiency variation, the current internationalised landscape asks for new studies able to better characterise and compare the performance of HEIs. In this respect, using data provided by the OECD from its annual database Education at a Glance, Agasisti (2011) provided one of the first attempts of an efficiency analysis in an international comparison with aggregated data about 18 countries. Focusing on the teaching dimension, he found that heterogeneity of HEIs within a country (due to size, staff composition and subject mix) helps explaining efficiency differentials.

In the recent years, thanks to the harmonisation of the European HE's landscape and to the significant advancements in collecting and processing large amounts of information (big data science), several projects have been launched (i.e. AQUAMETH[2], EUMIDA[3], ETER[4]) collecting reliable data from different sources, countries and years. These efforts materialise in comprehensive datasets which contain valuable information for the different stakeholders of the HE systems. Researchers have also realised about the potential of exploiting such datasets, yet, studies adopting a cross-country perspective are still limited. In this respect it is worth mentioning the works of Bonaccorsi and Daraio (2007, 2009). Using data from the AQUAMETH project the authors found that universities across European countries perform very differently, even when comparing universities with similar legal status and activities, revealing that they follow different strategies. Also in the EU-context Daraio et al. (2011) categorised the sources of institutional diversity into a horizontal and a vertical dimension. Horizontal diversity is analogous to product differentiation, that is, based on their own strategies, universities are free to define the course offering (subject mix), the target audience (undergraduates, graduates, PhD), and the teaching methodologies. This notion of horizontal diversity is also extended to the type of research and the degree of commitment in third mission activities. The chosen configuration is expected to influence the performance of the university in the long term. Contrarily, vertical diversity refers to the positioning of the university in a hierarchy of quality of university service provision. According to Bleiklie (2008) this hierarchy, similar to the concept of vertical differentiation, can be established through accreditation, by rankings (i.e. scientific production and internationalisation), and in relation to funding. An interesting example is the study of Wolszczak-Derlacz and Parteka (2011), where the authors use a two-stage analysis to measure the technical efficiency for 259 HEIs from 7 European countries and explore the determinants of inefficiency. Their results reveal a high variability of scores within each country. Other recent endeavours adopting a cross-country perspective have investigated how and why does cost efficiency of universities differ across European countries (Daghbashyan et al., 2014), the efficiency in the production of research quality when simultaneously accounting for the volume of scientific production and the teaching realised (Daraio et al., 2015a), the economies of scale and specialisation (Daraio et al., 2015b), the effect of competitive funding on university production (Bolli et al., 2016), the differences in the

[2] The Advanced Quantitative Methods for the Evaluation of the Performance of Public Sector Research (AQUAMETH) project, carried out under the PRIME Network of Excellence (6th Framework Programme), integrates micro data (at the level of the individual university) for 11 European countries, based on census information starting in 1994.

[3] European University Micro Data Consortium (EUMIDA), a large-scale study supported by the European Commission from 2009 to 2011, aimed at testing the feasibility of a regular data collection of microdata on HEIs in all EU-27 Member States plus Norway and Switzerland.

[4] The European Tertiary Education Register (ETER) is a European Commission initiative, which aims at providing data on HEIs in Europe. It is an Erasmus+ project financed by the European Commission.

provision of teaching (Veiderpass & McKelevey, 2016), and the comparison of European and American universities' efficiency (Wolszczak-Derlacz, 2017).

The current literature lacks an attempt of modelling European universities' efficiency by taking explicitly into account their strategic profile, i.e. their choices of differentiating each other's along the line of outputs produced. The current paper aims at filling this gap.

3. Methodology

3.1. Data and sample

Data for the empirical analysis come from the European Tertiary Education Register (ETER), one of the most comprehensive databases on European HEIs. It is a European Commission initiative that provides data on a number of basic characteristics of HEIs including geographical position, educational activities, staff, finances and research activities. Currently, ETER includes information from 2,764 HEIs in 36 countries. Aiming at comparing institutions with similar characteristics, for the purpose of this study, the sample was restricted to universities – that is, excluding universities of applied sciences and other types of HEIs. We also gathered information from PATSTAT, the European Patent Office's (EPO's) Worldwide Patent Statistical Database, which offers bibliographic patent data for more than 100 patent offices. Though both ETER and PATSTAT databases cover a wider variety of university-related data, data availability highly differs across countries. Therefore, given the variables of interest from which we could obtain full data, our final sample is an unbalanced panel that covers a 3-year period (2011-2013) with 761 observations coming from 307 universities located in 8 different countries (Belgium, Switzerland, Germany, Italy, Lithuania, Portugal, Sweden and United Kingdom). Although the final sample for our analysis is substantially smaller than the population in the initial dataset, it still serves the main purpose of the paper which is that of demonstrating the effect of mission's heterogeneity on the estimates of their efficiency, as considered in a cross-country comparison.

Table 1 shows the main descriptive statistics of universities included in the sample.

[Table 1] around here

3.2. Method

First of all, a proposal to group European universities is realised, according to some indicators that reflect their strategic positioning. The objective is to compare universities with adequate peers. To proceed with this analysis two factors are considered based on the literature reviewed: level of internationalisation and third-party funding. The reasoning behind this choice is twofold. Internationalisation of education – both in terms of students and staff – is a top priority. Universities are expected to promote cooperation between HEIs from different countries and contribute to the generation of a highly qualified pool of open-minded and internationally experienced people (Raponi et al., 2016). Yet, not all universities are prepared to equally respond to the needs of all stakeholders – local, regional, national and international – therefore, they must prioritise their choices and act accordingly (de la Torre et al., 2018). We want to capture this effect by accounting for the share of foreign students and share of international academic staff. Equally relevant is the third-party funding, composed of contracts from the public sector and from private companies – mainly for research purposes – and grants from public funding agencies. This indicator reveals how active a university is in generating revenues from sources such as industry, non-profit organisations, and research councils. At the same time, this indicator shows the commitment of the university with the modernisation agenda of universities to balance core, competitive and outcome-based funding (Jongbloed & de Boer, 2012), as well as their ability to interact with the territory surrounding it. For each year and indicator, we computed the median. Then, universities were grouped according to whether they were above or below these values. Three main groups emerged: world-class universities, flagship universities and regional universities – which characteristics are discussed later in this paragraph.

Once universities are classified to reduce heterogeneity issues, efficiency scores are calculated. The selection of a methodological tool that allows at measuring how efficient universities has always been controversial, and this is mainly due to the lack of good estimation approaches, to problems in defining or clearly identifying the true production function, or to problems related to the sample under analysis. Because the purpose of this paper is not that much to design a complex model, but to have a robust one able to reflect the multiple outputs universities produce, Data Envelopment Analysis (DEA) has been selected as the technique through which to approximate the production frontier. The specific characteristics of universities – multiple inputs and/or outputs and the absence of market prices – make this approach, rather than other parametric approaches, a more reliable technique (Barra & Zotti, 2016). Furthermore, the large amount of existing works in the higher education field using DEA widely supports its use (De Witte & López-Torres, 2017). In this paper, we use a bootstrap version of DEA (Simar & Wilson, 2000), with the aim of ensuring statistical robustness to the efficiency scores estimated.

DEA assumes that any production unit (i) can produce $\mathbf{y} = (y_1, \ldots, y_M) \in R_+^M$ units of output with $\mathbf{x} = (x_1, \ldots, x_J) \in R_+^J$ units of inputs. An empirical envelop surface containing all production possibilities is built. Decision making units or DMUs (in our case, universities) laying on this surface are efficient, whereas observations that do not are deemed as inefficient. Once a DMU (i) is identified as inefficient, it is possible to determine the input-output combination that allows to create a hypothetical university ($i*$) that is on the efficiency production frontier and will be the efficient reference set for the DMU under analysis (i).

DEA requires the specification of how the function of the production frontier is characterised. This gives place to two possible formulations depending on the assumption made about returns to scale: constant returns to scale (CRS) or variable returns to scale (VRS). For the purpose of this study, we assume the latter approach, which allows the estimation of distances to the production frontier while controlling for the size of the benchmarks (Cooper et al., 2007). We also assume a strong disposability of inputs and outputs when modelling DEA technology (T). This constraint imposes that a larger quantity of inputs can be used to produce the same quantities of outputs, or fewer outputs can be produced from a certain level of inputs. Finally, a last restriction concerning input or output orientation must be chosen. The difference between the two specifications consists of the ability of each DMU to control input or output quantities. Given the specific characteristics of universities, we opted to use an output orientation as the budget tends to be fixed, and universities are asked to maximise the output given a set of resources (Tone & Sahoo, 2003).

In coherence with the aforementioned considerations, the linear program to correctly model the technology and compute the efficiency score for each university is shown in Equation [1]. The maximisation of d^i in equation [1] implies the production of the highest level of outputs (y) possible given the resources available (x). The term d^i represents the efficiency score obtained for each DMU. For efficient universities $d^i = 1$, whereas values greater that 1 indicate the degree of inefficiency of the distance function. In order to correct the estimated efficiencies from the sampling bias, this study applies bootstrap techniques (with 2,000 replications) on the efficiency scores obtained (Simar & Wilson, 1998).

$$
\begin{aligned}
T\left(x^{i'}, y^{i'}\right) = & \max \delta^{i} \\
\text{subject to } & \sum_{i=1}^{N} \lambda^{i} y_m^{i} \geq \delta^{i} y_m^{i'} && , m = 1, \ldots, M \\
& \sum_{i=1}^{N} \lambda^{i} x_j^{i} \leq x_j^{i'} && , j = 1, \ldots, J \\
& \sum_{i=1}^{N} \lambda^{i} = 1 \\
& \lambda^{i} \geq 0 && , i = 1, \ldots, N
\end{aligned} \qquad [1]
$$

Because universities operate in different countries, have different production opportunities and pursue different strategies, the technology sets (feasible input-output combinations) might differ among universities. Such differences should be taken into account when analysing how efficient universities are. Previous studies (Worthington & Lee, 2008; McMillan & Chan, 2006; Glass et al., 1995) have addressed this issue by estimating separate production frontiers for different groups of universities. Typically, after estimating a production frontier for a group of DMUs, a second stage follows measuring the relative performance of units within that group (McMillan & Chan, 2006). Nevertheless, it might also be relevant to compare the performance of DMUs across different groups; yet, this approach is only feasible if the frontiers of the different groups are identical.

Acknowledging the heterogeneity of European universities and aiming at comparing them with appropriate peers, we overcome the above limitation by using meta-frontier analysis, an approach that has been proved to effectively capture the impact of heterogeneity (Battese et al., 2004) and that has already been applied to study other higher education systems (Yaisawarng & Ng, 2014). For this purpose, we follow the procedure described in O'Donnell et al. (2008). First, we measure the technical efficiency ($TE(x,y)$) of each DMU relative to a common meta-frontier (DEA-MF). Aware of the existence of sub-technologies – due to the universities' strategic choices regarding international positioning and scope – we use the division of universities obtained in the first step: world-class, flagship and regional universities. In other words, the meta-frontier is not built for considering differences across countries (as usually done in previous research, but which is not the point of this research) but to investigate structural differences in the production process realized by institutions that have a different strategic orientation. We argue that each group (K) has a specific technologically feasible input-output combination in the meta-technology set originating restricted technology sets; therefore, resources, regulatory framework and other environmental constraints should be group-specific. Accordingly, technical efficiency scores with respect to the group-k frontier ($TE^{k}(x,y)$) are then calculated (DEA-K). Note that the meta-frontier envelops the group frontiers. Lastly, we compute the meta-technology ratio for group-k universities as defined in Equation [2]:

$$MTR^k(x,y) = \frac{TE(x,y)}{TE^k(x,y)} \qquad [2]$$

This expression can be in turn rewritten as in Equation [3] showing how the technical efficiency with reference to the meta-frontier can be decomposed into two components: a first component accounting for the distance from an input–output point to the group frontier, and a second component indicating the distance between the group frontier and the meta-frontier.

$$TE(x,y) = TE^k(x,y) \times MTR^k(x,y) \qquad [3]$$

Although DEA approach provides information on how inefficient units can improve their production process and become more efficient, finding the institutional and environmental factors – generally uncontrollable – beyond those considered in the DEA is a complex task as there are just many determinants in the system level that condition the way HEIs perform. Aiming at explaining differences in universities' performance arising from exogenous variables, in a second-stage analysis we ran a truncated regression model using the bootstrapped DEA scores obtained in the first stage as the dependent variable, implementing the so-called "double bootstrap" approach. More specifically we run four models: Model 1 using the DEA-MF scores, and Models 2 to 4 using the DEA-K scores. Defining these four models, it is possible to examine potential differences in the determinants of efficiency scores due to the group universities belong to. Following Simar and Wilson (2007, 2011), the highly skewed and truncated distribution of the DEA scores makes an analysis based on a truncated regression the most appropriated one. Standard errors of coefficients are again estimated by bootstrapping technique (2,000 replications) following the double-bootstrap methodology. Operating this way, errors are more consistent compared to those estimated by the standard maximum likelihood method.

3.3. Variables' selection

Our model assumes that universities use one input (resources) to produce five outputs. The reasoning behind the inclusion of only one input is the high correlation between financial and human resources metrics. Similar to Veiderpass and McKelevey (2016) our input is a proxy of current expenditures and capital. Specifically, we use the budget of the university. Aiming at correctly assessing the overall performance of universities, outputs relate to the three missions: teaching, research and third mission (in this case, intended as knowledge transfer). Specifically, two proxies to measure the educational output are considered based on the targeted students. That is, we use both the number of students enrolled in undergraduate (ISCED 6 level) and graduate programs (ISCED 7 level) – the number of students is intended to capture the overall teaching activity realised by universities and not only their results (graduates), as discussed by Avkiran (2001). Research activities are proxied using the number of publications in the ISI Web of Science. Typically, this indicator has the highest weight in ranking systems (Aguillo et al., 2010) as well as in the researchers' evaluation processes for promotion purposes (Lafuente & Berbegal-Mirabent, 2018). Accordingly, we assume this metric to capture what the society is expecting from the research mission. With respect to the knowledge transfer dimension, similar to previous studies (de la Torre et al., 2016a; Wolszczak-Derlacz, 2017) we use two variables: patents and third-party income (the latter being also a possible proxy for measuring applied research). While the former – patents – denote how active a university is in creating/developing cutting-edge discoveries with the potential of being commercialised (due to its practical application), the latter – third party funding – indicates how close does a university collaborate with the industry. Variables referring to monetary values (i.e., budget and third-party funding) were converted from national currency units into Euro PPS. This way it is possible to account for cross-country differences in price level and the purchasing power of the money that universities dispose of. Table 2 shows the descriptive statistics for the variables of interest.

[Table 2] around here

As for the second stage analysis, the rationale for the selection of the exogenous (contextual) variables – those that are neither inputs nor outputs but still shape universities' performance – is as follows, and is inspired by the existent literature about HE efficiency (Johnes, 2004; De Witte & Lopez-Torres, 2017). First, we considered the academic spread of the university. As in Widiputera et al. (2017), this variable captures the degrees offered and the nature of the research engaged. According to the ETER dataset this indicator is computed as a Herfindahl index and can be expressed as $\frac{1}{n^2} \times \sum_{1}^{11} n_j^2$, where n_j^2 is the number of students or graduates in field j (differentiating among 11 fields) and n is the total number of students or graduates for that level. An index of 1 indicates that all students are in the same field.

Second, we also include in the analysis one variable that captures the institutional experience: university age. Old universities can have both a halo and a Mathew effect based on historic interactions of expertise and prestige (Gueno, 1998; Merton 1998). Said differently, old universities may have established a working environment and a certain way of doing things that can have a positive influence over their capacity to congregate outstanding researchers and attracting talented students.

Third, similar to Daghbashyan et al. (2016) we introduce the ratio of academic staff relative to non-academic staff. The personnel included in this latter category are responsible for providing administrative support for the proper performance of academic functions (e.g. records management, schedules, students' enrolment), assisting academics in research commercialisation processes, and preserving the proper operations and maintenance of the facilities. A high ratio would indicate that the workforce mainly comprises academics, signalling that the university has a solid mass of scholars. Yet, the absence of non-academic staff might involve academics performing other tasks (e.g. administrative) which should be ideally executed by administrative staff and thus, prevent them to invest their time in their core functions (teaching, research and knowledge transfer) (de la Torre et al., 2016b).

A fourth variable refers to the presence of a university hospital. The findings from previous studies are inconclusive. While some authors found that the existence of a university hospital is linked to superior research quality (e.g. Bonaccorsi & Secondi, 2017), some others found that average increase in efficiency is higher among universities without a university hospital (e.g. de la Torre et al., 2017).

Fifth, we also introduce two variables linked to the university's profile: the legal status and the presence of multiple campuses. The inclusion of these two variables—thanks to the ETER dataset—constitutes a novelty with respect to previous studies which—due to data unavailability—were unable to control for these effects.

Lastly, we included a set of dummy variables to rule out the potential effect of time trends (year 2013 was excluded as the base year) and country effects (UK as the reference country).

The descriptive statistics of all exogenous variables are shown in Table 3.

[Table 3] around here

4. Results

4.1. Grouping of universities

Acknowledging that universities' performance might be influenced by strategic decisions, following the process described in section §3.2, we suggest a three-group classification: flagship, regional and world class universities. Table 4 presents the main descriptive statistics for each group, which highlight similarities and differences.

[Table 4] around here

Starting with the first ones and following the traditional definition of what a flagship university is, universities in this group are land-grant institutions (only 7.2% are private ones) with have a strong research profile (as shown by the number of publications, patents and income from third party funding). They are also broad in scope (including studies in different disciplines) and more than half of them have a university hospital. They are also characterised by a large disposal of inputs (including human resources—academic and non-academic staff—and large budgets) and for their big size (number of students); however, the international dimension (when looking at the number of international students and academic staff) is still to be developed. At this point it is also worth signalling that these universities have the lowest ratio of students per academic staff, meaning that such universities seem to have a more personalised training process, as class groups might be smaller, and therefore, record more useful interactions amongst students and with professors. This approach is in accordance with one of the postulates of Bologna's framework, where the enhancement of individualised learning processes is promoted. As shown in Figure 1, the country with the highest number of universities within this group is Germany. Italy and Sweden also have some, but these countries are best represented in group 2.

[Figure 1] around here

Regional universities are those that tend to respond to the local territory in which they are located. This strategy typically implies a multisite strategy, meaning that universities have often campuses in different locations (26% of the universities in this group have more than one campus). However, the number of students enrolled is relatively low, as they are mainly serving regional communities and consequently, the number of foreign students and staff is also low. Yet, the number of students per academic staff is high (doubling the average ratio of flagship universities in undergraduate programs). These universities are also characterised by a shortage of resources, and the outputs they are obtaining are therefore low, compared to the average ones of the other groups. In fact, it seems that the strategy followed by these universities is that of trying to address all the three missions (teaching, research and technology transfer) at the same intensity. Yet, they are not capable of doing an efficient transformation of inputs into outputs.

Lastly, universities in the third group can be conceived as world class institutions. UK concentrates the highest number of universities within this group, followed by Germany, Switzerland and Belgium, which however lag far behind. These universities are good at transforming the financial resources (budget) into outputs. As Salmi (2009) points out, this might be due to their capacity to select the best students and attract the most qualified professors and researchers. Certainly, the proportion of international students and foreign academic staff is the highest. In terms of research, universities in this group show the highest number of publications. Also, they report a quite high amount of funding attracted from third parties, just slightly lower of that obtained by those in the first one (flagship).

4.2. Efficiency analysis

Results from the efficiency analysis are reported in Tables 5 (by country and year) and 6 (by group and year). The lower (higher) the technical efficiency score relative to the meta-frontier, the larger (smaller) the meta-technology gap ratio (DEA-MTR) – the technology gap between the group-K (DEA-K) frontier and the meta-frontier (DEA-MF). It is important to underline here that no technological change is assumed to occur during the period under consideration – otherwise, this should be explicitly modelled for example through a Malmquist Index. Therefore, the hypothesis of no technological change seems reasonable, given that the empirical analysis covers only three years, a very short time frame for structural changes in academic productivity at institution level.

[Table 5] around here

[Table 6] around here

Without accounting for heterogeneity (DEA-MF), universities from the sample have an average efficiency of 0.5708, being UK the country exhibiting the highest average scores of its universities (0.6542), followed by Belgium (0.6142) and Sweden (0.5916). On the contrary, universities in Switzerland (0.4041), Portugal (0.4672) and Germany (0.4676) are the less efficient ones, on average. Yet, when universities are compared with appropriate peers, as shown in Table 6, it can be concluded that efficiency scores are higher (DEA-K is higher than DEA-MF), confirming the initial intuition that technology differs across groups of universities. The Wilcoxon signed rank test (z=-23.099, p-value<0.000) further confirms that DEA-K and DEA-MF scores are statistically different from each other per year and group. Likewise, the average DEA-MTR scores for the three groups are also found to be statistically different (p-values < 0.000).

The overreaching conclusion is that regional universities produce outputs under conditions that are more restrictive compared to world-class and flagship universities (average DEA-MTR = 0.7007), that is, universities within this group could, at best, produce only 70% of the output that could be produced using the meta-frontier—that is, the unrestricted meta-technology (and the same inputs). Said differently, within the own group universities are performing reasonably well (average DEA-K=0.7007), yet, relative to an across-groups benchmark (DEA-MF) infrastructural constraints prevent universities from this group to produce more efficiently. Conversely, the average DEA-MTR for world-class universities is the highest (0.9483), suggesting that the group frontier for these universities is the closest to the meta-frontier, while flagship universities exhibit an intermediate value (0.7774). These results may relate to the fact that regional universities are smaller and have less access to the technology.

Coming to the group efficiency – the technical efficiency measured against the group frontier (DEA-K) – regional universities are found to be the best performing (0.7007), yet the average values from the three groups are pretty similar (0.6692 and 0.6651 for world-class and flagship universities, respectively). During the year 2011, world-class universities performed best relative to its group frontier with an average group efficiency score of 0.7090, yet, they experienced a downtrend in subsequent years (0.6729 in 2012 and 0.6275 in 2013). At this point it is also remarkable that variability in efficiency within this group is the highest (0.1735). Conversely, flagship and regional universities show a quite steady DEA-K score over time with small fluctuations.

Table 7 shows the results of the truncated regression on the bias-corrected efficiency scores. Four models are presented. Model 1 uses the DEA-MF scores, whereas Models 2 (world-class universities), 3 (flagship universities) and 4 (regional universities) are group-specific. The results in Model 1 indicate that inefficiency is somehow related to high academic diversity. This effect is also observed in world-class and regional universities. Although some authors argue that if specialisation is too strong an institution may not be able to pick up potential new developments that fall in the intersection of different discipline (Moed et al., 2011; Daraio et al., 2015b), our findings are aligned with those of Berbegal-Mirabent (2018) and Curi et al. (2012) who found that subject specialisation helps improving efficiency. Again, world-class and regional universities also share this feature. Another key finding is that public universities tend to be less efficient than private ones. This result also holds for flagship and regional universities, while there is no effect on world-class universities. The age of the university is also found to be relevant, suggesting that seniority is somehow linked to the development of appropriate policies, managerial capabilities and processes that facilitate the work done by university workers (Wolszczak-Derlacz, 2017). Lastly, in Models 1, 2 and 3 the proportion of academic staff relative to non-academic staff is significant and negative, indicating that although non-academic staff might be helpful in providing specific support tasks such as administrative or service-oriented activities, their skills rather than a large labour force is what really matters. On the contrary, a large pool of academic staffs is desirable. Nevertheless, in regional universities this effect is just the opposite, revealing that the workforce should be balanced in order to improve efficiency.

[Table 7] around here

We also find that inefficiency is not explained by country-specific unobservable factors. The only exceptions are universities from Belgium (Model 2), Switzerland (Models 1, 2 and 3) and Denmark (Model 4), which are found to be more likely to be less efficient compared to others in the sample. Lastly, it is also worth mentioning that universities seem to become less efficient over time (as shown in Models 1, 2 and 4), although the short available panel data available suggests caution in interpreting this result.

5. Discussion

In an increasingly global and competitive landscape universities are adopting different strategies to address their objective function, allocate resources and remain attractive to prospective students and researchers. It is therefore not surprising that how efficiently universities perform has become a relevant topic. In this study, we tackle this issue by exploring how universities' performance is influenced by strategic choices. The work is particularly innovative because it assumes an international perspective, so analysing how strategies vary within and between countries in Europe.

We found that UK and Belgium institutions are the ones performing the best, whereas Swiss and Portuguese institutions show the lowest efficiency scores. Universities in Sweden, Italy and Lithuania and Denmark are in-between. We also observed that UK universities concentrate the majority of world-class universities from our sample. Universities in Belgium and Switzerland also fit best within this group. Italian and Portuguese universities are more regionally-oriented, while more than half of the German and Lithuanian universities respond to the flagship definition. At this point it is worth mentioning that some universities at the margin have moved to different groups from one year to another, yet, these moves are limited (only occur in 10% of the universities in the sample) and universities show a quite stable behaviour over time.

Our second research question, about the main universities' characteristics associated with their efficiency, has been answered by means of a truncated regression model. Specifically, we found that main sources of inefficiency relate to having a diversified academic portfolio – contrary to specialisation –, not having a university hospital – which seems to indicate that some disciplines are more likely to perform more efficiently than others – and a low proportion of academic/non-academic staff. Also, young and public universities seem to manage their resources less efficiently.

As an extension to our baseline analysis, it is worth questioning if there is any relationship between efficiency scores and universities' positioning in league tables. Given that most of the well-known rankings limit their scope to the top 500 institutions, for the purpose of this work we relied on the SCImago Institutions Rankings (SIR), which covers 5,637 academic and research-related institutions worldwide. Institutions are ranked using a composite indicator that captures the performance in three main domains: research (50%), innovation (30%) and societal impact (20%). From our 761 observations, information is available in 663 instances (87.21% of our sample); therefore, this ranking is suitable. We calculate the Pearson pairwise correlation index between our efficiency scores and the indicator used by SIR. Results are reported in Table 8 (see Appendix 5 for a graphical representation through scatterplots). It is important to note that we are using the efficiency scores relative to the meta-frontier (DEA-MF) given that in global rankings universities are compared all together. Our findings reveal a positive and significant relationship between efficiency scores and a better positioning in the ranking. This holds true for both flagship and world-class universities (except in 2011), however, it does not apply to regional universities. These results confirm that our classification scheme of universities (world-class, flagship and regional) is sound and consistent with how universities behave in terms of strategic positioning.

[Table 8] around here

Lastly, to answer our third research question, we have investigated how universities perform when they are compared with institutions with a similar strategic profile. A meta-frontier analysis has been conducted, obtaining efficiency scores relative to a common production frontier (DEA-MF) but also to a group frontier (DEA-K). Distribution of efficiency scores by countries and groups is shown in Appendixes 1 to 4. From this analysis we conclude that when the global benchmark is used, world-class universities are, on average, more efficient, followed by flagship and regional. Additional tests further confirm that average scores between groups are indeed different. These results corroborate our initial intuition that universities are heterogeneous, and that these differences should be acknowledged when analysing their performance. More precisely, our results give support to the argument that it is more suitable to compare universities that share strategic choices although these being located in different countries, instead of assuming a common technology and production process.

6. Concluding remarks

Using a cross-country approach we have examined differences in European HEIs' efficiency due to the strategic positioning and national patterns across different European countries. Based on our estimates, the average university efficiency score in the eight countries under analysis is 0.5708, indicating ample room for efficiency improvements. In this perspective, the recommendations from European Commission and national governments for continuing research of efficiency gains seem opportune: improving productivity must remain a policy priority for European academic institutions.

As for the strategic choices made by universities when defining their positioning we characterised three main groups, according to their internationalization and scope: world-class, flagship and regional. Regional universities are found to be the less efficient ones. Increasingly, regions are competing for attracting talent and retain investments, asking for both knowledge capital and financial resources. Yet, our results raise important questions about the functioning of such institutions. It is not enough for universities to define their role and missions locally, but they also should find sustainable ways to perform efficiently. Future studies should be conducted in order to shed new lights on the social and economic impact of this type of HEIs.

A different behaviour is observed in world-class and flagship universities, which are found to place emphasis on the research and third mission and which result to be substantially more efficient. At the teaching dimension, both types of universities are characterised for being large, however, the international scope is markedly different, with world-class universities attracting a substantially higher proportion of foreign students and academic staff. It is the first time that strategic positioning is considered a key lens for empirically analysing the performance of universities; however, given the growing strategic behaviour of universities (Whitley, 2008), the interplay between strategic choices and efficiency in operations should be carefully investigated. In this research, we started considering this aspect by allowing the technology of production to be different across different types of HEIs, modelled by means of a meta-frontier approach.

The current paper is focused on a relatively short time horizon. The findings presented have a strong internal validity for the three years considered (2011-2013) but cannot be assumed to remain valid in longer periods of time. A natural extension of this work is to follow the performance of universities in the medium/long run (between 5 and 10 years) to analyse whether different strategic choices assure higher or lower efficiency over time. In other words, the strategic positioning can exert less or more persistent effects on efficiency of academic activities, and this information can be used for supporting decision-making processes at strategic and operational level.

Although we believe that this study provides important and useful insights to the analysis of universities, being the first to consider strategic positioning in the international perspective, the main shortcoming of the analysis refers to data constraints and the subsequent limited ability to capture structural differences across groups. While in the theoretical models, variables seem to be relatively easy to be measured, their transformation and practical implementation is constrained by the availability of appropriate information. Future institutional efforts should be dedicated to enriching the number and types of variables collected for describing the universities' activities – for example, spin-offs, third-mission initiatives in social science, impact of academic publications, employability of graduates. This work illustrates how beneficial can be integrating different data sources (in this case, ETER and PATSTAT) for getting a wider picture of the universities' performance.

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Tables and Figures

Table 1. Descriptive statistics of the universities included in the sample by country.

Country	# HEIs	Legal status		Average age	Average academic diversity
		Public	Private		
Belgium (BE)	5	3	2	178.11	0.2489
Switzerland (CH)	10	10	0	164.96	0.3111
Germany (DE)	68	66	2	211.20	0.2350
Italy (IT)	57	52	5	218.45	0.2586
Lithuania (LT)	10	10	0	104.30	0.3990
Portugal (PT)	10	10	0	114.70	0.2170
Sweden (SE)	28	25	3	82.000	0.3120
United Kingdom (UK)	119	0	119	135.23	0.2160
Total	307	176	131	163.52	0.2403

Note: Average age is calculated as the average years since foundation of the universities in the sample per country. Average academic diversity is computed using the Herfindalh index. The higher the number the lower the diversity of studies.

Table 2. Descriptive statistics for input and output variables of the DEA model (by country and year)

Country	Budget		ISCED6		ISCED7		Papers		Patents		Third party		N
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	
BE	**115,054.62**	**82.568,75**	**10,420.56**	**8,313.02**	**7,433.00**	**6,580.39**	**3,396.22**	**2,610.87**	**17.44**	**25.58**	**2,662.99**	**3,920.53**	**9**
2011	120,834.13	85.690,87	9,942.80	7,723.46	6,887.20	5,749.02	3,549.60	2,685.10	26.60	32.32	2,208.01	3,458.94	5
2013	107,830.23	90.908,94	11,017.75	10,192.73	8,115.25	8,383.63	3,204.50	2,911.45	6.00	6.16	3,231.71	4,925.39	4
CH	**198,913.03**	**133.872,83**	**5,544.39**	**2,701.80**	**3,226.79**	**1,524.09**	**2,208.00**	**1,742.52**	**5.25**	**8.07**	**69,950.86**	**47,695.72**	**28**
2011	213,509.44	157.427,84	5,948.60	3,468.90	3,390.50	1,832.50	2,299.10	1,843.65	8.40	11.17	69,066.66	46,349.03	10
2012	188,025.65	124.390,06	5,308.00	2,306.40	3,012.56	1,352.78	2,099.33	1,746.71	5.11	6.75	69,939.77	50,400.88	9
2013	193,582.16	129.230,54	5,331.67	2,337.03	3,259.11	1,464.76	2,215.44	1,830.04	1.89	2.98	70,944.38	52,140.47	9
DE	**217,836.69**	**134.855,18**	**8,836.22**	**4,768.08**	**2,897.38**	**1,752.21**	**2,069.57**	**1,684.80**	**5.38**	**7.19**	**80,742.63**	**62,208.50**	**195**
2011	219,298.56	138.982,82	8,267.48	4,259.46	2,233.98	1,258.57	2,014.63	1,609.36	7.15	8.54	76,380.58	57,736.26	65
2012	216,929.57	136.858,23	8,670.02	4,786.92	2,852.86	1,640.29	2,038.91	1,718.40	6.23	7.45	80,441.34	64,454.11	65
2013	217,281.95	130.676,50	9,571.17	5,191.48	3,605.29	2,018.45	2,155.17	1,746.40	2.75	4.15	85,405.98	64,817.54	65
IT	**142,669.63**	**109.250,75**	**15,050.46**	**10,573.52**	**4,775.91**	**3,893.76**	**1,453.15**	**1,444.34**	**0.89**	**1.96**	**19,271.38**	**23,953.49**	**108**
2012	142,939.64	106.171,98	14,433.13	9,923.50	4,459.35	3,544.39	1,259.43	1,141.41	1.33	2.58	19,170.57	25,244.36	54
2013	142,399.62	113.243,18	15,667.80	11,245.24	5,092.46	4,223.96	1,646.87	1,682.95	0.44	0.84	19,372.19	22,826.88	54
LT	**98,821.03**	**94.295,71**	**5,955.50**	**3,594.93**	**1,866.50**	**1,724.39**	**282.60**	**319.43**	**0.10**	**0.32**	**84,736.11**	**84,447.19**	**10**
2013	98,821.03	94.295,71	5,955.50	3,594.93	1,866.50	1,724.39	282.60	319.43	0.10	0.32	84,736.11	84,447.19	10
PT	**70,046.34**	**47.927,83**	**6,581.70**	**2,831.79**	**2,015.70**	**1,267.40**	**1,327.20**	**1,810.40**	**0.70**	**1.57**	**5,259.29**	**3,170.29**	**10**
2011	70,046.34	47.927,83	6,581.70	2,831.79	2,015.70	1,267.40	1,327.20	1,810.40	0.70	1.57	5,259.29	3,170.29	10
SE	**114,859.52**	**99.618,13**	**9,814.75**	**6,941.60**	**2,628.88**	**2,634.84**	**1,225.71**	**1,672.21**	**0.09**	**0.35**	**55,776.55**	**63,984.47**	**56**
2011	112,748.11	97.277,15	9,000.00	6,254.47	3,248.86	3,153.95	1,171.14	1,609.49	0.11	0.42	53,568.92	61,759.56	28
2012	116,970.93	103.648,44	10,629.50	7,593.49	2,008.89	1,843.17	1,280.29	1,760.55	0.07	0.26	57,984.18	67,196.02	28
UK	**71,920.01**	**51.673,12**	**10,566.41**	**4,990.23**	**3,300.13**	**1,843.13**	**1,259.71**	**1,723.00**	**1.26**	**2.99**	**40,511.13**	**60,058.95**	**345**
2011	82,093.14	52.440,22	10,429.87	5,180.15	3,412.58	1,978.81	1,219.59	1,716.66	1.81	4.12	39,932.32	59,791.10	118
2012	70,053.85	51.923,36	10,464.39	4,966.20	3,186.57	1,719.72	1,246.12	1,728.83	1.65	2.73	40,730.44	62,977.53	115
2013	63,118.04	49.148,92	10,815.00	4,844.36	3,298.26	1,826.61	1,315.92	1,737.65	0.29	0.81	40,895.77	57,762.91	112

Note: Budget and third party funding are expressed in thousand euros. ISCED 6 and ISCED 7 indicate the average number of students enrolled in ISCED 6 and ISCED 7 levels. Papers and patents are computed as the average number of publications in ISI Web of Science journals and patents listed in the PATSTAT database, respectively.

Table 3. Descriptive statistics of main variables.

Variable	Definition	Mean	St. Dev.	Min.	Max.
Academic diversity	Educational spread calculated as a Herfindahl index	0.2403	0.1627	0.12	1
Age	Years of the university since foundation	163.5164	173.6987	5	930
Ratio academic/ non-academic staff	Share of academics relative to non-academic staff	0.5148	0.1026	0.2086	0.8045
Hospital	Presence of a university hospital (1=yes, 0=no)	0.3180	0.4660	0	1
Status[5]	Legal status of the university (0=public, 1=private or private government dependent)	0.4809	0.5000	0	1
Multisite	Indicates whether the university has more than one campus (0=no, 1=multisite)	0.2273	0.4194	0	1

[5] The distinction between private and public universities is the same used in other works that rely on the ETER dataset (see: Bonaccorsi & Secondi, 2017; Lepori et al., 2015; Daraio et al. 2011).

Table 4. Group characterization (average values).

Variables	Flagship	Regional	World class	Total
Third party funding*/academic staff	48.382	13.709	31.423	31.961
Share of international undergraduate students	0.062	0.048	0.210	0.132
Share of international graduate students	0.119	0.085	0.382	0.241
Share of international academic staff	0.120	0.056	0.241	0.165
Budget*	222,168.800	80,600.570	97,868.170	127,849.000
Undergraduate students/academic staff	6.063	13.880	10.846	10.240
Graduate students/academic staff	1.997	3.379	3.573	3.097
Publications (WOS)/academic staff	0.983	0.786	0.993	0.942
Patents granted/academic staff	0.00175	0.00045	0.00127	0.00121
Academic staff	2,101.541	774.388	1,301.309	1,398.169
Non-academic staff	2,370.313	561.313	1,370.370	1,456.564
Ratio academic/non-academic staff	0.514	0.582	0.484	0.515
Efficiency score	0.522	0.492	0.634	0.571
Status	0.072	0.227	0.825	0.481
Hospital	0.519	0.227	0.249	0.318
Multisite	0.096	0.256	0.286	0.227
Academic diversity	0.242	0.231	0.243	0.240
#HEIs	208	176	377	761

Note: Amounts expressed in thousand euros.

Table 5. Average efficiency scores by country and type of DEA estimate.

	2011			2012			2013			Average		
Country	**DEA-MF**	**DEA-K**	**DEA-MTR**	**DEA-MF**	**DEA-K**	**DEA-MTR**	**DEA-MF**	**DEA-K**	**DEA-MTR**	**DEA-MF**	**DEA-K**	**DEA-MTR**
BE	0.6325	0.6881	0.9149	-	-	-	0.5914	0.7120	0.8229	0.6142	0.6987	0.8740
CH	0.4111	0.4711	0.9015	0.4237	0.4506	0.9479	0.3766	0.4057	0.9446	0.4041	0.4435	0.9303
DE	0.4543	0.6428	0.7161	0.4874	0.6316	0.7743	0.4610	0.6306	0.7341	0.4676	0.6350	0.7415
IT	-	-	-	0.5425	0.7168	0.7464	0.5268	0.7087	0.7275	0.5346	0.7128	0.7369
LT	-	-	-	-	-	-	0.5141	0.6600	0.7763	0.5141	0.6600	0.7763
PT	0.4672	0.6668	0.6975	-	-	-	-	-	-	0.4672	0.6668	0.6975
SE	0.5995	0.7485	0.8068	0.5837	0.7207	0.8052	-	-	-	0.5916	0.7346	0.8060
UK	0.6810	0.7299	0.9320	0.6720	0.6959	0.9655	0.6078	0.6596	0.9244	0.6542	0.6958	0.9407
Average	**0.5873**	**0.6936**	**0.8461**	**0.5845**	**0.67906**	**0.8588**	**0.5409**	**0.6545**	**0.8271**	**0.5708**	**0.6754**	**0.8443**

Note: **MF** contains the DEA estimates of the technical efficiency relative to the meta-frontier. The meta-frontier is built by considering the three groups of universities by strategic positioning: world-class, flagship and regional. Similarly, **K** does so for the DEA estimates of the technical efficiency relative to the group-k frontier. Finally, **MTR** contains the DEA estimates of the meta-technology ratio.

Table 6. Average efficiency scores by group and type of DEA estimate.

	2011			2012			2013			Average		
Country	**DEA-MF**	**DEA-K**	**DEA-MTR**	**DEA-MF**	**DEA-K**	**DEA-MTR**	**DEA-MF**	**DEA-K**	**DEA-MTR**	**DEA-MF**	**DEA-K**	**DEA-MTR**
World_class	0.6625	0.7090	0.9346	0.6498	0.6729	0.9660	0.5917	0.6275	0.9428	0.6344	0.6692	0.9483
Flagship	0.4961	0.6665	0.7426	0.5491	0.6690	0.8108	0.5204	0.6599	0.7762	0.5225	0.6651	0.7774
Regional	0.5274	0.6924	0.7703	0.4972	0.7011	0.7046	0.4540	0.7074	0.6349	0.4918	0.7007	0.7007
Average	**0.5873**	**0.6936**	**0.8461**	**0.5845**	**0.6791**	**0.8588**	**0.5409**	**0.6545**	**0.8271**	**0.5708**	**0.6754**	**0.8443**

Note: **MF** contains the DEA estimates of the technical efficiency relative to the meta-frontier. The meta-frontier is built by considering the three groups of universities by strategic positioning: world-class, flagship and regional. Similarly, **K** does so for the DEA estimates of the technical efficiency relative to the group-k frontier. Finally, **MTR** contains the DEA estimates of the meta-technology ratio.

Table 7. Parameter estimates of the truncated regression models explaining HEIs inefficiency.

Variables	Model 1: All universities			Model 2: World-class universities			Model 3: Flagship universities			Model 4: Regional universities		
	Coefficient	95% Confidence Interval		Coefficient	95% Confidence Interval		Coefficient	95% Confidence Interval		Coefficient	95% Confidence Interval	
		LB	UB		LB	UB		LB	UB		LB	UB
Academic diversity	0.1118^{**} (0.0497)	-0.2940	-0.0992	0.2737^{***} (0.0470)	0.1816	0.3657	-0.1115 (0.0741)	-0.2568	0.0337	0.2273^{*} (0.1380)	-0.0431	0.4977
Age (log)	-0.0144^{**} (0.0071)	-0.0089	0.0128	-0.0097 (0.1088)	-0.0310	0.0116	-0.0137 (0.0095)	-0.0322	0.0048	0.0026 (0.0138)	-0.0244	0.0296
Ratio academic/ non-academic staff	-0.1598^{***} (0.0444)	-0.1020	0.0749	-0.3665^{***} (0.0719)	-0.5075	-0.2255	-0.2527^{***} (0.0734)	-0.3965	-0.1088	0.2656^{**} (0.1235)	0.0235	0.5076
Hospital	-0.0868^{***} (0.0165)	-0.0430	0.0165	-0.0896^{***} (0.0194)	-0.1276	-0.0515	-0.1066^{***} (0.0370)	-0.1791	-0.0341	-0.0407 (0.0458)	-0.1304	0.0491
Status	-0.1825^{***} (0.0456)	-0.3808	-0.1196	-0.0254 (0.0771)	-0.1766	0.1258	-0.1611^{*} (0.0901)	-0.3377	0.0156	-0.1884^{*} (0.1042)	-0.3926	0.0158
Multisite	0.0052 (0.0162)	-0.0018	0.0471	-0.0004 (0.0171)	-0.0340	0.0332	-0.0321 (0.0520)	-0.1339	0.0698	0.0192 (0.0275)	-0.0347	0.0731
Belgium	0.0350 (0.0544)	-0.2398	0.0247	0.2101^{***} (0.0650)	0.0826	0.3376	-	-	-	-	-	-
Switzerland	0.1537^{***} (0.0557)	-0.1875	0.1061	0.3849^{***} (0.0887)	0.2112	0.5587	0.2457^{**} (0.1131)	0.0239	0.4674	-	-	-
Germany	0.0501 (0.0477)	-0.1739	0.1054	0.0770 (0.0814)	-0.0825	0.2366	0.1925^{*} (0.1098)	-0.0228	0.4078	-0.0121 (0.1185)	-0.2443	0.2202
Italy	0.0173 (0.0469)	-0.1744	0.0968	-0.2061 (0.1455)	-0.4912	0.0790	0.0643 (0.1032)	-0.1380	0.2666	-0.1478 (0.1201)	-0.3831	0.0876
Lithuania	-0.0936 (0.0792)	-0.3736	-0.0367	-	-	-	0.0472 (0.1235)	-0.1949	0.2892	0.0493 (0.1406)	-0.2264	0.3250
Portugal	0.0295 (0.0784)	-0.2593	0.0793	-	-	-	-	-	-	-0.0748 (0.1235)	-0.3167	0.1672
Sweden	-0.0567 (0.0498)	-0.2793	-0.0079	-0.0827 (0.1638)	-0.4038	0.2385	0.0960 (0.1101)	-0.1198	0.3117	-0.2075 (0.1206)	-0.4439	0.0288
Year 2011	-0.0527^{***} (0.0153)	-0.0809	-0.0307	-0.1036^{***} (0.0201)	-0.1430	-0.0642	-0.0019 (0.0266)	-0.0540	0.0502	-0.0580^{*} (0.0334)	-0.1235	0.0075
Year 2012	-0.0506^{***} (0.0159)	-0.0759	-0.0260	-0.0808^{***} (0.0203)	-0.1206	-0.0411	-0.0187 (0.0273)	-0.0722	0.0348	-0.0250 (0.0303)	-0.0844	0.0344
Constant	1.4871^{***} (0.0608)	2.8027	3.3720	1.1384 (0.1037)	0.9352	1.3416	1.3181 (0.1202)	1.0824	1.5537	1.7703 (0.1615)	1.4538	2.0869
Sigma	0.1615^{***} (0.0041)	0.1535	0.1694	0.1455^{***} (0.0048)	0.1360	0.1550	0.1398^{***} (0.0073)	0.1256	0.1540	0.1490^{***} (0.0073)	0.1348	0.1633
Wald χ^2 (degrees of freedom)	318.99^{***} (15)			167.60^{***} (13)			103.31^{***} (13)			128.36^{***} (13)		
Log pseudolikelihood	339.2745			212.3688			117.7974			86.7827		
Observations	761			377			208			176		

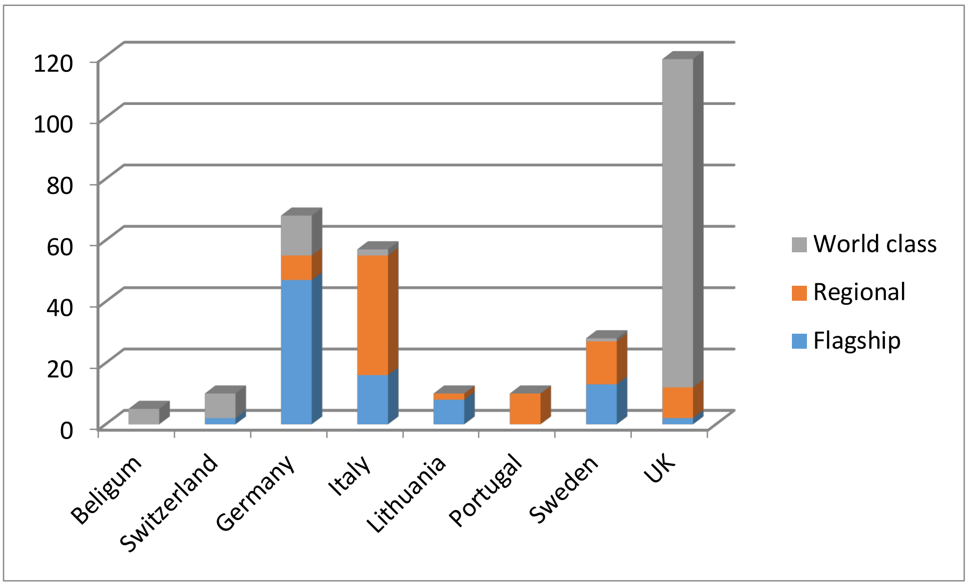
Note: Bootstrapped standard errors are presented in brackets. *, **, *** indicate significance at the 10%, 5%, 1%, respectively. Confidence intervals obtained from 2000 bootstrapping iterations. Reference year 2013. Reference country UK. LB stands for lower bound and UB does so for upper bound.

Table 8. Correlation between efficiency scores and positioning in rankings.

Ranking	Efficiency scores (DEA-MF)		
	World-class	Flagship	Regional
SRI 2011	-0.1500 (0.1362)	-0.2127 (0.0942)	0.0950 (0.5929)
SRI 2012	-0.2239 (0.0166)	-0.3296 (0.0057)	0.0979 (0.4813)
SRI 2013	-0.2262 (0.0155)	-0.3695 (0.0019)	-0.1941 (0.1911)

Note: Values in brackets indicate level of significance. **WC**, stands for world-class universities; **F**, for flagship; and **R**, for regional

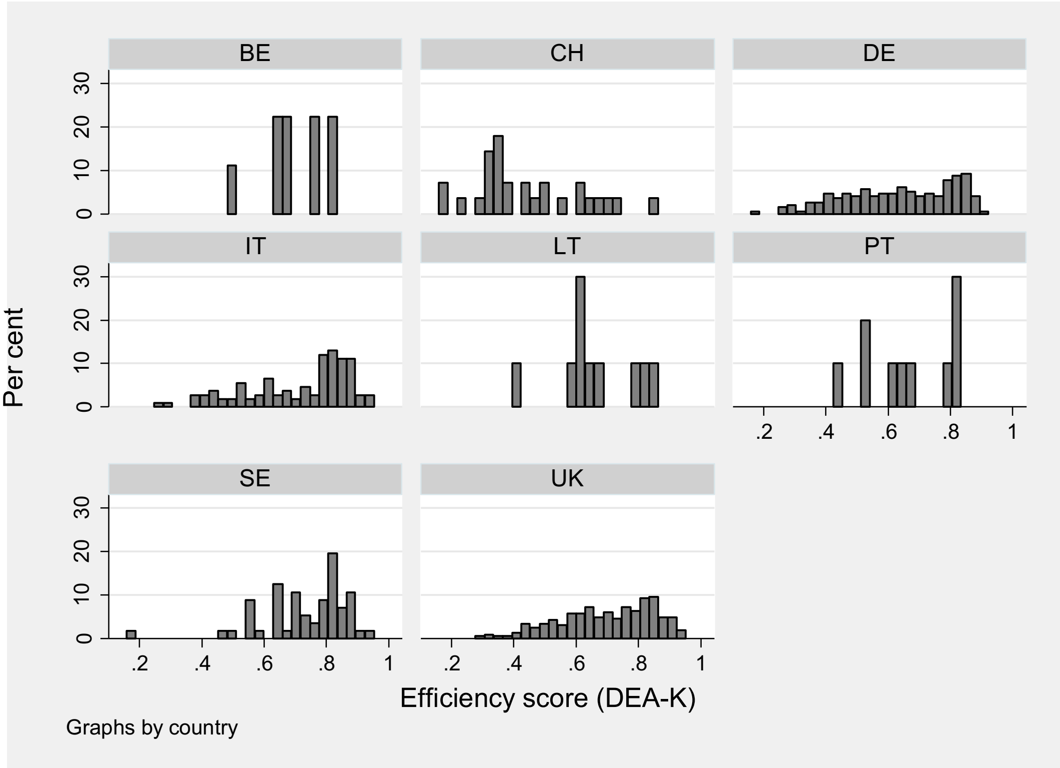
Figure 1. Countries by university type (group).



Note: 31 out of 307 universities (10%) moved to different groups from one year to another. For those universities with full data but that changed group, for the purpose of this figure we considered the group to be the one to which the university was classified during two out of the three years. For those universities with limited data (covering only two years), we considered the university to belong to the group with the most recent data. The use of different criteria does not lead to substantially different classifications.

Appendix

Appendix 1. Distribution of efficiency scores (DEA-K) per country.

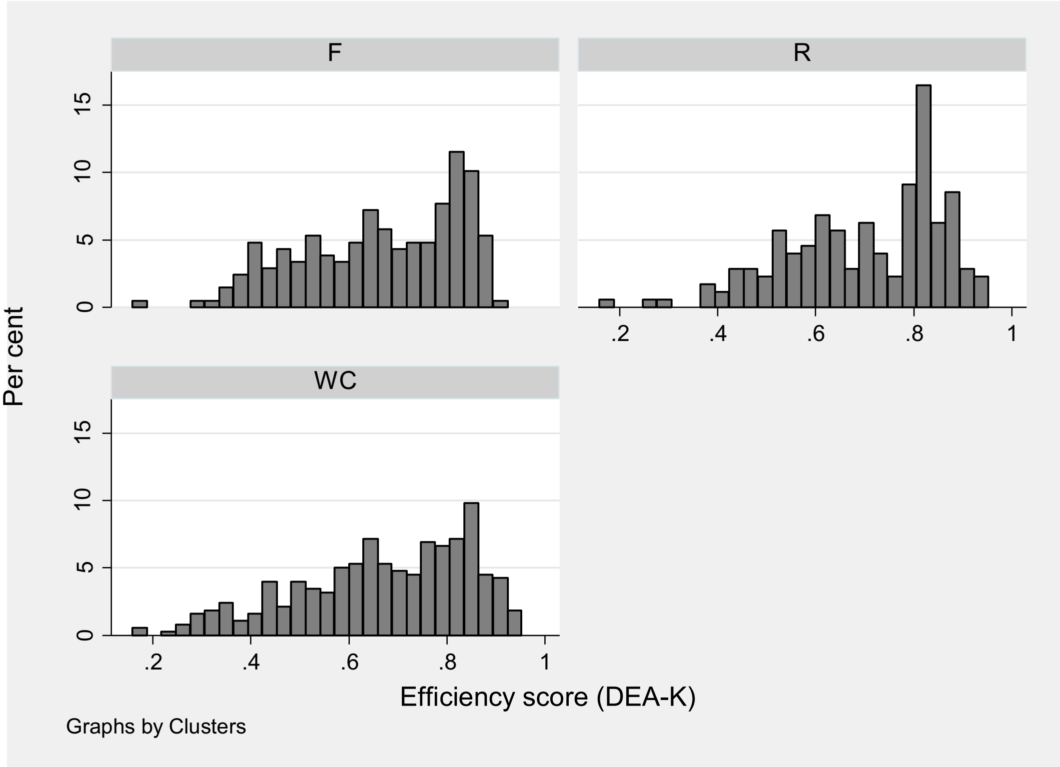


Note: **WC**, stands for world-class universities; **F**, for flagship; and **R**, for regional.

Appendix 2. Distribution of efficiency scores (DEA-MF) per country.

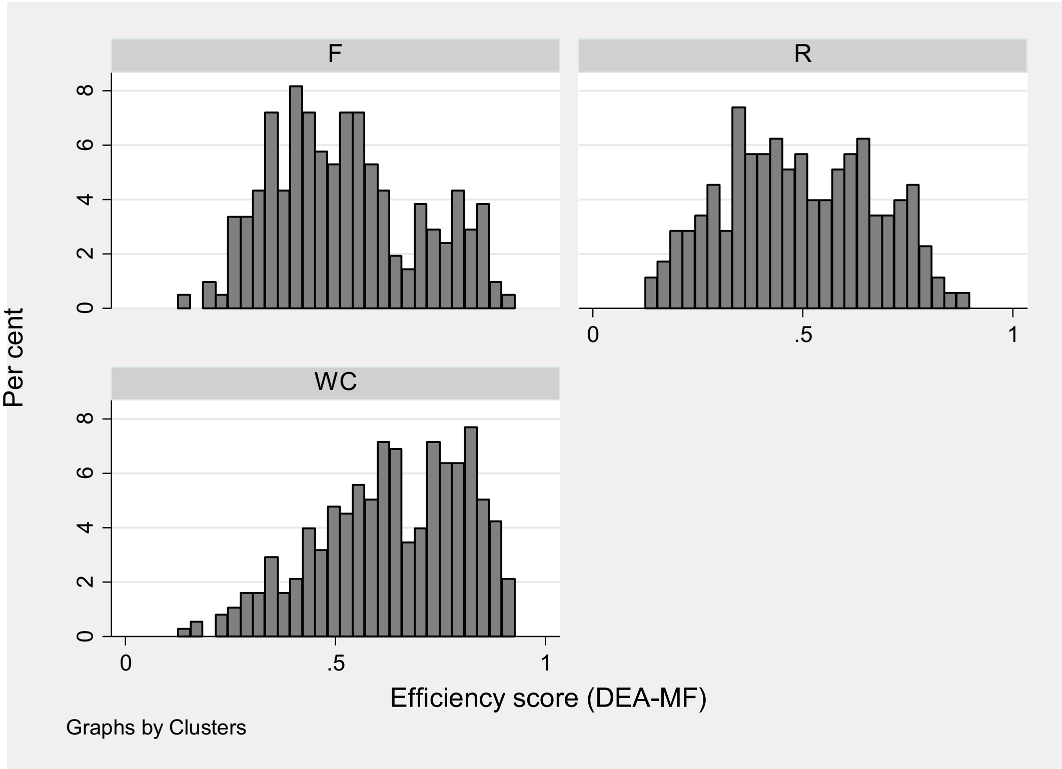
Note: **WC**, stands for world-class universities; **F**, for flagship; and **R**, for regional.

Appendix 3. Distribution of efficiency scores (DEA-K), distinguishing by groups.



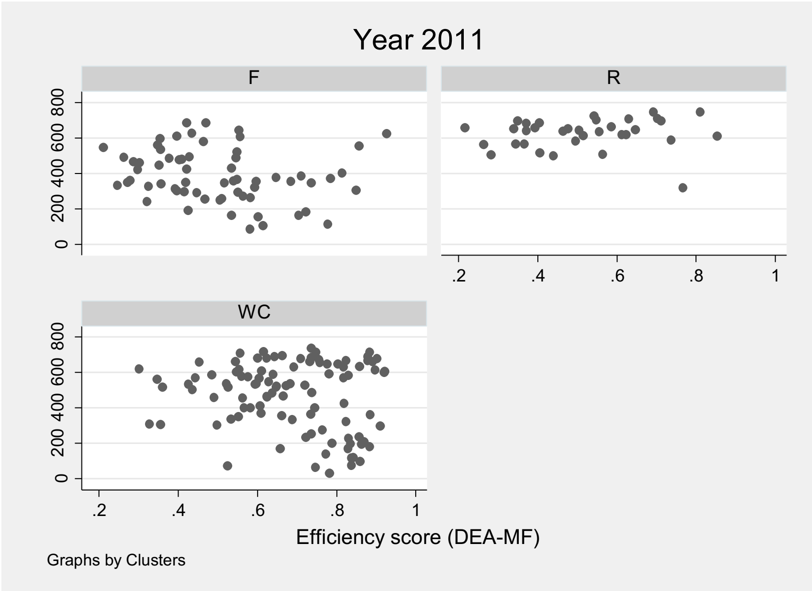
Note: **WC**, stands for world-class universities; **F**, for flagship; and **R**, for regional.

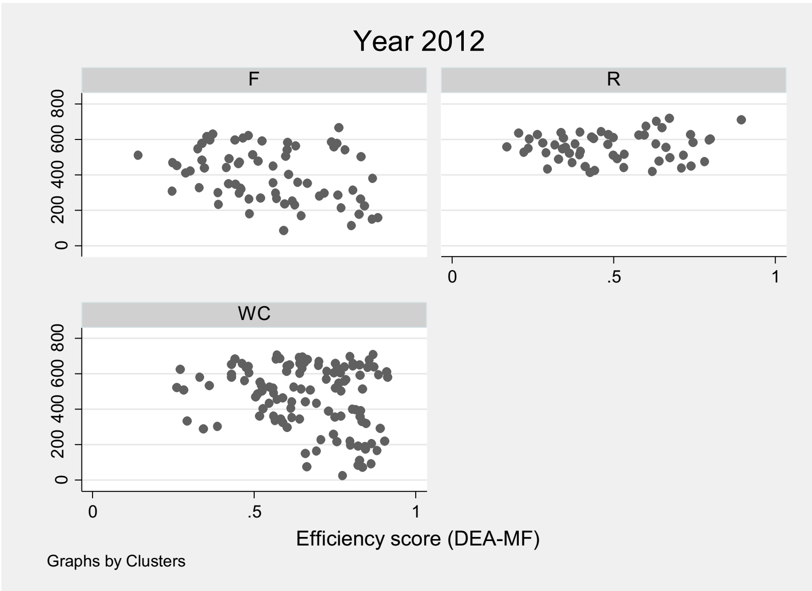
Appendix 4. Distribution of efficiency scores (DEA-MF), distinguishing by groups.

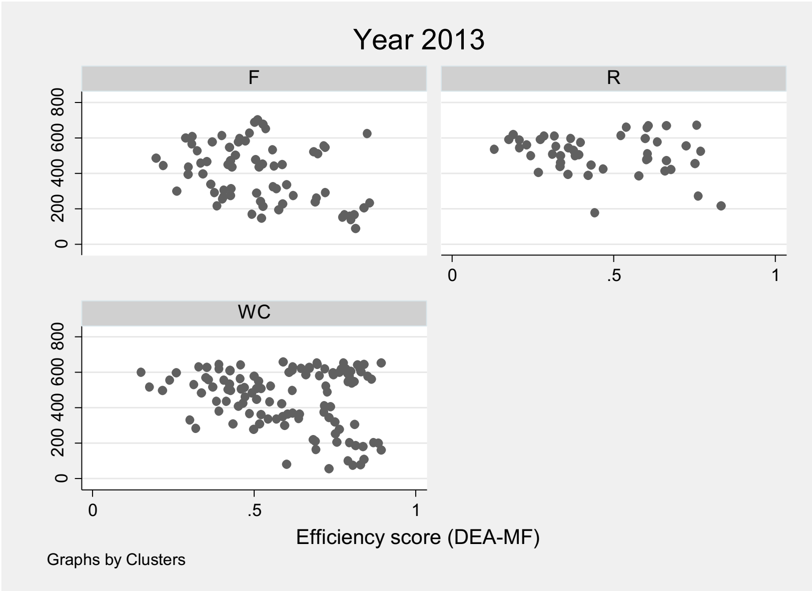


Note: **WC**, stands for world-class universities; **F**, for flagship; and **R**, for regional.

Appendix 5. Scatterplots between efficiency scores (DEA-MF) and positioning in the ranking (SIR, world ranking), by year and group.







Note: **WC**, stands for world-class universities; **F**, for flagship; and **R**, for regional. **DEA-MF** refers to the DEA estimates of the technical efficiency relative to the meta-frontier.