

## WHAT ARE WE MEASURING WHEN EVALUATING UNIVERSITIES' EFFICIENCY?

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### Abstract

Globalisation and the knowledge-based society have driven universities to an intense competition for the best professors, researchers and students. Yet, rankings and reports measuring how universities perform are available in abundance. Among these assessment tools it is worth highlighting those based on Data Envelopment Analysis (DEA), which since the 1980s have risen considerably. However, there is a lack of consensus when selecting the indicators that best represent the inputs and outputs of such institutions. Aiming to clarify how these proxies are chosen, this paper does an exhaustive review of the indicators used in DEA empirical studies in the last decade, classifying them according to their nature and use.

**Keywords:** Higher Education Institutions (HEI); efficiency; Data Envelopment Analysis (DEA); indicator; ranking

**JEL classification:** C14, I21

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### 1. Introduction

Historically, universities were considered institutions for disseminating knowledge and where scientists developed new theories. It was not until recently that they became positive vehicles for economic progress (Shattock, 2009). The contemporary university is an amalgam of teaching, research, entrepreneurial and scholastic interests capable of providing qualified graduates and researchers but also offering innovative solutions through knowledge transfer and valorisation mechanisms that enhance links with the business sector.

So exceptional has been this transformation that Higher Education Institutions (HEIs) have been identified as natural driving agents for regional development. On the one hand, policy makers are increasingly establishing regional policies on knowledge transfer activities, aiming to satisfy industry's demands for technological and scientific advances through the exploitation of the knowledge stock available at HEIs. On the other hand, academics are focusing their interests on new theories and models such as the "Mode 2" (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994), the "Triple Helix" model (Etzkowitz & Leydesdorff, 1997), or the theory on the "engaged university" (Chatterton & Goddard, 2000; Holland 2001) or illustrating how HEIs can cooperate with the innovation ecosystem they belong to.

At a European level, the Lisbon Strategy for Growth and Jobs as well as the Modernisation agenda for Universities go in this direction, aiming to make Europe the most competitive and dynamic knowledge-based economy in the world, supporting what

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is stated by the EU 2020 Strategy (European Parliament, 2000) that in a fast-changing world what makes the difference is education and research, innovation and creativity.

As literature about HEIs' commitment with society has grown significantly in the two last decades, a parallel movement asking for "quality" and "excellence" has impacted their management. Therefore, as society demands more from HEIs (Hazelkorn, 2005), their agendas have moved towards redefinition processes, looking for new formulas in an attempt to engage more efficiently within their missions (teaching, research and knowledge transfer), allocate resources and their returns, and improve their image by becoming more attractive for professors, researchers and students (Van Vught, 2009).

But perhaps the reason why the management of HEIs has become such a meaningful topic among academics and policy makers is due to the never-ending expansion of the media and the rise of the evaluative state. Yet, funding agencies want to be assured that funding is being spent in areas that are consistent with national efficiency and equity priorities, therefore, quality outcomes are important (Garlick & Langworthy, 2008). Consequently, league tables (using the British nomenclature) or rankings (in an American terminology), parametric and non-parametric approaches, composite indexes and other econometric emerged, satisfying this public demand for transparency and information.

These methodologies measure teaching, research, and third stream activities by using a wide range of indicators in pursuit of an order in which universities could be ranked according to their performance. It has just been since the turn of the century that their impact on the media and subsequent public discussions has been exceptional (Bonaccorsi & Daraio 2005), becoming a central issue for government thinking, marketing campaigns and universities' development. Yet, countries from around the world have shown, in one form or another, their interest in such procedures, developing complementary ways to assess the performance of their HEIs that have turned into potential benchmarking tools.

As expected, studies in this direction has led to a large amount of papers dealing with new ways and approaches to assess the performance of universities (Eccles, 2002; Coates, 2007; Salmi & Saroyan, 2007; García-Aracil & Palomares-Montero, 2010; Shin, Toutkoushian & Teichler, 2011), and far from converging into a unique formula, the inherent controversy of such evaluative procedures assists their diversification. Questions contributing to this debate emerge: What indicators are the best proxies for universities' resources (inputs) and results (outputs)? Are inputs linked to a specific mission? Moreover, is it possible to obtain robust measures to assess universities' performance?

In accordance with the aforementioned interrogations, and given the fact that these procedures are undoubtedly influencing the strategy of universities, there is a need to in-depth in the study of these measurement approaches (Marginson & van der Wende, 2007).

Based on the premise that universities are expected to do an efficient use of their resources (inputs) and maximize outputs, and given the exponential growth in the number of studies evaluating the performance of universities through efficiency analysis, we decided to focus our analysis on papers ranking and evaluating university's performance using the Data Envelopment Analysis (DEA) approach. In order to delimit the temporary span of this study, we only selected those papers published in journals indexed in the ISI Web of Knowledge and Scopus databases, during the first decade of the 21<sup>st</sup> century (from 2000 to 2010).

The paper is organised as follows. In the first section we briefly summarise the literature about DEA methodology and its applications in the higher education system. In

the second section we explain the methodology followed for the selection and subsequent analysis of the DEA-HEI papers reviewed. In the third section we classify the indicators found according to their uses. Finally, in the fourth section we discuss the findings. Policy implications are also suggested.

## **2. Assessing universities' performance through Data Envelopment Analysis**

### **2.1. An approach to DEA studies**

Using an econometric approach, the efficiency of an institution is determined by how its resources have been employed to obtain a particular set of objectives, that is, to achieve the combination of costs, profits, sacrifices and utilities that: 1) generates major profits from those with identical costs, 2) reduces the costs from those that produce the same level of profits, or 3) provides the best proportion between costs and benefits (Moreno, 1998). Choosing a methodology capable of measuring how efficient an organisation is has always been controversial, mainly due to the lack of a good estimation production function (Rousseau & Rousseau, 1997). First studies facing this concern can be found in Debreu (1951) and Koopmans (1951), and some years later in Farrell's (1957) work where he explicitly introduced the term "efficiency" into a firm. However, it was not until the 1970s that a huge interest around these procedures arose.

Production frontiers are traditionally estimated by non-parametric estimation techniques. One of the most popular is Data Envelopment Analysis (DEA), developed by Charnes, Cooper & Rhodes (1978). Based in linear programming, DEA consists of determining the relative performance of a set of similar operating units ("decision making units" or "DMUs"). As it is a well-known instrument for measuring efficiency, further technical explanations are not required here, as it is not the aim of this paper.<sup>1</sup>

The DEA approach is particularly suitable for modelling organisations with multiple inputs and/or outputs, and in the absence of market prices, which is hardly accomplished in stochastic frontier analysis (Ray, 2004). This is especially attractive for governments and organisations such as universities that have multiple missions and where prices are usually unknown or exogenously determined by political administrations. DEA must be primarily considered as a diagnostic tool. It does not prescribe any strategy to transform inefficient units into efficient. It provides assistance and guidance for performance improvement by facilitating the localisation of best practice performing units amongst a group of like organisations. Hence, it can help institutions achieve their full potential once weaknesses have been identified.

The first evidence of a DEA-HEI study can be found in the doctoral thesis of Rhodes (1978). Since then, applications have rapidly spread all over the world. The large amount of existing works supports its uses (Thursby & Thursby, 2002; Lee & Park, 2005). DEA-HEI studies typically carry information about how closely universities are achieving their objectives. Regardless of the chosen DMU, these studies are characterised by a wide variety of variables, trying to find the best proxies for expressing the allocation of resources (inputs) and how these are used to obtain valuable results (outputs).

DEA is suitable approach for the higher education system. However, as the precision of the estimated parameters decreases if many factors are included, the choice of a few but significant indicators is the key for an accurate applicability. The lack of a systematic

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<sup>1</sup> For further details see: Charnes et al (1978); Cooper, Seiford & Tone (2007); Ray (2004).

and uniform procedure for collecting data makes this task more difficult. The result is a complex framework from which indicators have to be carefully selected to become adequate proxies for what they are measuring, but also realistic dimensions capable of being obtained.

## **2.2 Output and input measures**

Universities are responsible for developing a wide range of activities getting multiple outputs from a set of inputs. Thus, models assessing teaching, research and third stream activities can be found in parallel with those where universities are evaluated in a combined model, mixing inputs and outputs from different missions. Universities' outputs must be understood as the results of teaching, research and third mission activities. Traditionally, frequency or quantitative indicators have been used as an easy way to account for the results achieved; however, outputs like these do not always reflect the quality, which in many cases is what really makes the difference between an outstanding institution and a conventional one. Difficulties in obtaining meaningful empirical data have led researchers to use traditional measures and simply recognise that this limitation exists. After years with this problem, there is still a lack of consensus on how to adequately account for outputs' quality and their costs.

In the inputs side, we find that indicators are usually well defined in terms of amounts or expenditures, representing the availability of resources (human, financial or equipment) from which it is possible to obtain added value results (outputs). Their management is essential for the institutions' performance, and it is precisely how they are used what denotes their efficiency. Specification of universities' inputs faces similar problems as accounting effectively for outputs, and quality considerations might also be obviated. Nevertheless, the fact is that here there is less controversy in their definition, but discussions may appear when some outputs can also be considered as inputs (i.e., number of undergraduate students, research income or research grants), depending on the aim of the study. As DEA is very sensible to specifications, the use of a variable as an input or as an output may change results substantially.

Another problem arising from inputs and outputs is the opportunity cost of obtaining the necessary data to effectively represent them, which is in many cases simply too great to be feasible. Thus, data usually comes from government statistical agencies, which are sometimes underscored by political forces (Salerno, 2004). To this extent, DEA-HEI studies depend heavily on the availability and reliability of existing data, as the majority of "willing data" is either non-existent, not publicly available or not immediately reachable. Additionally, available data tends to be aggregated (not individualised by institutions or areas of knowledge), country-specific (making cross-country comparisons difficult) and hardly registering knowledge transfer activities.

## **3. Methodology for the DEA-HEIs' article selection and analysis**

The methodology adopted for this research consists of two phases: 1) the identification and selection of those papers that were going to be included in the review, and 2) the data processing and the classification of indicators used to measure HEIs' performance. Extensive searches in the ISI Web of Knowledge and Scopus databases were conducted to capture papers with a DEA-HEI focus. Only papers published between 2000 and 2010 were included, as stated in the scope of this research. Books or book chapters, papers with full version not available or any other contribution not meeting these requirements were also excluded. Keywords used in the searches employed thesaurus terms such as "Higher

Education Institution(s)” or “HEI(s)” and “university(ies)”, crossed with the ones defining the evaluative approach: “Data Envelopment Analysis” or “DEA”, “efficiency”, “productivity”, “performance” and “ranking”. After a first round search a screening phase was conducted to ensure the suitability of the resulting papers. Papers appearing more than once were restricted to one entry, and those that did not deal simultaneously with DEA and its uses in the higher education system were also eliminated.

Using these inclusive parameters, a final sample of 45 papers reporting worldwide empirical DEA applications was obtained. Each empirical research paper was then scrutinised to capture general information about its aim and scope. Table 1 summarises these features, including the authors, the publication source and year, the country, the type and number of DMUs and the academic years tested.

Table 1. Characterisation of the DMUs and geographical areas of analysis.

| Country         | Universities | Public universities | Departments or research units | Frequency |
|-----------------|--------------|---------------------|-------------------------------|-----------|
| Australia       |              | 2                   |                               | 2         |
| Canada          |              | 1                   |                               | 1         |
| China           | 4            |                     | 1                             | 5         |
| England         | 3            |                     |                               | 3         |
| Germany         | 2            | 1                   |                               | 3         |
| Greece          | 1            |                     | 1                             | 2         |
| Helsinki        |              |                     | 1                             | 1         |
| India           |              |                     | 1                             | 1         |
| Italy           | 2            | 1                   | 1                             | 4         |
| South Africa    |              | 1                   |                               | 1         |
| Spain           |              | 1                   | 4                             | 5         |
| Spain & Italy   |              | 1                   |                               | 1         |
| Sweden          |              |                     | 1                             | 1         |
| Switzerland     | 1            |                     |                               | 1         |
| Taiwan          | 2            |                     | 1                             | 3         |
| The Netherlands |              |                     | 1                             | 1         |
| Turkey          |              | 1                   |                               | 1         |
| UK              | 5            |                     |                               | 5         |
| USA             | 1            |                     | 1                             | 2         |
| Worldwide       | 2            |                     |                               | 2         |
| <b>TOTAL</b>    | <b>23</b>    | <b>9</b>            | <b>13</b>                     | <b>45</b> |

All selected papers were also submitted to an in-depth analysis, where indicators used to measure the efficiency of HEIs were extracted and classified according to whether they were considered as inputs or outputs and to which mission they were linked. Once this information was processed, indicators were then labelled into different categories, grouping those of similar nature in the same block. This labelling process was conducted several times to reduce the number of categories.

#### 4. Results

In this section we first provide information about the geographical area and the DMUs considered. Then, for each category of indicators identified, we discuss the different ways that, according to the literature, resources (inputs) and universities' outputs (results) can be proxied.

#### 4.1. Units of analysis

Traditionally, DMUs represent individual universities from the same country/region, academic departments and research groups from the same university or departments and research groups from different HEIs that work in a similar area of knowledge. Table 1 summarises the choices adopted in the papers from our sample. As shown, evidence from 18 countries, one cross-country study (Italy and Spain) and two worldwide studies are reported. In nine of 45 cases, public HEIs are the focus of the analysis, whereas in 23 the character of the HEI is not explicit or combines public with private universities. Also, department units are chosen as DMUs (in 13 occasions).

#### 4.2 Financial measures

Measures to represent financial resources have been classified in two categories according to whether they are reflecting funding sources or operating expenditures (Table 2). Information about the treatment received (such as an input or an output), the model where they appear (general, teaching, research or third mission) and its frequency is also provided.

Table 2. Financial resources (G: global, T: teaching, R: research, KT: knowledge transfer, I:input; O:output).

| Subgroup     | Indicators                                                  | Use | Model |    |   |    | Sum | Total |
|--------------|-------------------------------------------------------------|-----|-------|----|---|----|-----|-------|
|              |                                                             |     | G     | T  | R | KT |     |       |
|              |                                                             | I   | 1     |    | 1 |    | 2   |       |
|              | Total funding                                               | O   |       |    |   |    | 0   | 2     |
|              |                                                             | I   |       | 1  |   |    | 1   |       |
| Funding      | Funding (external)                                          | O   | 1     |    |   |    | 1   | 2     |
| sources      |                                                             | I   | 3     |    | 1 |    | 4   |       |
|              | Sponsored and research grants                               | O   | 7     | 2  |   |    | 9   | 13    |
|              |                                                             | I   |       | 1  |   |    | 1   |       |
|              | Revenues from tuition and fees                              | O   | 1     |    |   |    | 1   | 2     |
|              |                                                             | I   | 9     | 4  |   |    | 13  |       |
|              | Operating costs                                             | O   |       |    |   |    | 0   | 13    |
|              |                                                             | I   | 5     | 1  |   |    | 6   |       |
|              | Operating costs, other than labour                          | O   |       |    |   |    | 0   | 6     |
|              |                                                             | I   |       |    |   |    | 0   |       |
|              | Staff expenditure                                           | O   | 4     | 1  |   |    | 5   | 5     |
|              |                                                             | I   | 1     |    | 3 | 1  | 5   |       |
| Operating    | R&D expenditures                                            | O   |       |    |   |    | 0   | 5     |
| expenditures |                                                             | I   | 1     |    |   |    | 1   |       |
|              | Teaching and research expenditures                          | O   | 1     |    |   |    | 1   | 2     |
|              |                                                             | I   | 2     |    |   |    | 2   |       |
|              | Central administration and services expenditure             | O   |       |    |   |    | 0   | 2     |
|              |                                                             | I   | 1     |    |   |    | 1   |       |
|              | Central administration and services expenditure, other than | O   |       |    |   |    | 0   | 1     |
|              |                                                             | I   | 2     |    |   |    | 2   |       |
|              | Expenditure on libraries and computer facilities            | O   |       |    |   |    | 0   | 2     |
|              |                                                             |     | 39    | 10 | 5 | 1  | 55  |       |

Funding sources include possible sources of fundraising for the day-to-day operation of HEIs. Here, funding for specific research uses is a commonly used proxy. When employed as an input, denotes the capability of HEIs to transform external funding into valuable outputs, and when used as an output explains the ability of HEIs to capture external funding, reflecting how universities are perceived by stakeholders (Fandel,

2007). Ratios of research funding per academic staff are also employed to avoid scale size effects (Glass, McCallion, McKillop, Rasaratnama & Stringer, 2006). Problems arise when considering the amount of external research funding, as it is difficult to express the quality of such funds. In this sense, specifications of the origin of funds (i.e., internal, governmental or third parties) are usually introduced as control proxies for quality (Ng & Li, 2000; Abbott & Doucouliagos, 2003). Other indicators that can be included in this category are sponsored and research grants (McMillan & Chan 2006; Abramo, d'Angelo & Pugini, 2008), and revenues from tuition and fees (Kongar, Pallis & Sobh, 2010).

On the other hand, operating expenditures refer to the costs of maintaining HEIs' activity (García-Aracil & Palomares-Montero, 2008). These operating costs, mainly used as inputs, are quite often disaggregated leaving aside staff expenditures (Katharakí & Katharakis, 2010) or central administration costs (Casu & Thanassoulis, 2006). Variables computing the differences between staff and non-staff expenditures can also be found (Warning, 2004), as well as those only considering R&D expenditures (Korhonen, Tainio & Wallenius 2001) or both teaching and research ones (Taylor & Harris, 2004). Finally, library and computer facilities are also used in an attempt to express the economic resources spent on the improvement of students and staff facilities (Johnes, 2006).

### 4.3. Human capital

Table 3 depicts how human capital resources have been characterised when it comes to assess HEIs' efficiency.

Table 3. Human resources.

| Indicators                                                 | Use | Model |    |    |    | Sum | Total |
|------------------------------------------------------------|-----|-------|----|----|----|-----|-------|
|                                                            |     | G     | T  | R  | KT |     |       |
| Faculty staff (academic + non-academic)                    | I   | 2     | 1  | 1  |    | 4   | 4     |
|                                                            | O   |       |    |    |    | 0   |       |
| Academic staff                                             | I   | 7     | 5  |    |    | 12  | 12    |
|                                                            | O   |       |    |    |    | 0   |       |
| Academic staff classified (by category or time dedication) | I   | 10    | 2  | 5  |    | 17  | 17    |
|                                                            | O   |       |    |    |    | 0   |       |
| Non academic staff                                         | I   | 9     | 3  | 1  |    | 13  | 13    |
|                                                            | O   |       |    |    |    | 0   |       |
| Academics with PhD                                         | I   |       | 1  | 1  |    | 2   | 2     |
|                                                            | O   |       |    |    |    | 0   |       |
| Academics without PhD                                      | I   |       | 1  | 1  |    | 2   | 2     |
|                                                            | O   |       |    |    |    | 0   |       |
| Visiting scholars                                          | I   |       |    |    |    | 0   | 1     |
|                                                            | O   | 1     |    |    |    | 1   |       |
| Grant workers                                              | I   |       |    | 1  |    | 1   | 2     |
|                                                            | O   | 1     |    |    |    | 1   |       |
| Female rate                                                | I   |       |    |    |    | 0   | 1     |
|                                                            | O   | 1     |    |    |    | 1   |       |
|                                                            |     | 31    | 13 | 10 | 0  | 54  |       |

Labour force is the core of any organisation. In the case of universities, it is traditionally measured by full-time equivalent or total number of faculty staff (Avkiran, 2001; Halkos, Tzermes & Kourtzidis, 2010), or by differentiating between those who are academics and those who have a more service-oriented and administrative profile (non-academic staff) (Abbott & Doucouliagos, 2003). Additionally, staff can be categorised according to its commitment and range within the university: academics with or without a PhD (Martín, 2006), visiting scholars (Chang, Wu, Ching & Tang, 2009), grant workers (Caballero, Caballero, Galache, Gómez, Molina & Torrico, 2004) and full-time or part-time (Archibald & Feldman, 2008). A female staff ratio has also been identified (Kongar et al., 2010), indicating the importance of gender studies also in this field of research.

#### 4.4. Infrastructures

Another important aspect that has to be taken into account relates to those spaces and infrastructures that support universities' activities (Table 4). These include total area (in squared meters) (Qingyun, Ya, & Keqiang, 2010), value of teaching equipment (Nan-bin & Jing, 2009), number of books in libraries (Duh & Kuo, 2006) or seats in teaching rooms, libraries and laboratories (Agasisti & Dal-Bianco, 2009). Measures of this kind are also used in studies analysing which services are better supporting teaching and research activities (Del-Palacio, Solé & Berbegal, 2011).

Table 4. Infrastructures.

| Indicators                                          | Use | Model |   |   |    | Sum | Total |
|-----------------------------------------------------|-----|-------|---|---|----|-----|-------|
|                                                     |     | G     | T | R | KT |     |       |
| Area (sqm meters)                                   | I   | 2     | 1 | 1 | 1  | 5   | 5     |
|                                                     | O   |       |   |   |    | 0   |       |
| Books in libraries                                  | I   | 1     | 1 |   |    | 2   | 2     |
|                                                     | O   |       |   |   |    | 0   |       |
| Seats in teaching rooms, libraries and laboratories | I   |       | 1 |   |    | 1   | 1     |
|                                                     | O   |       |   |   |    | 0   |       |
| Value of teaching equipment                         | I   | 1     |   |   |    | 1   | 1     |
|                                                     | O   |       |   |   |    | 0   |       |
|                                                     |     | 4     | 3 | 1 | 1  | 9   |       |

#### 4.5. Teaching measures

The definition of teaching measures has commonly reached lower agreement than research ones. Here, technical problems associated with outputs are identified, employing quantitative meaningfulness measures reflecting qualitative students' rates (perhaps more easy to quantify but less related to assessing teaching activities) instead of measuring teaching efficiency. The lack of relevant data and the unquantifiable aspects of teaching performance sometimes result in unfair evaluations. Table 5 presents the indicators referring to this teaching dimension, differentiating three categories: enrolments, students' success and teaching offer and activity. Education enrolments are usually proxied by physical headcounts of total number or full-time equivalent enrolments (Abbott & Doucouliagos, 2003; Taylor & Harris, 2004). Sometimes these enrolments are considered separately by degree level (undergraduate, postgraduate and PhD) or per area of knowledge (Johnes, Johnes, Thanassoulis, Lenton & Emrouznejad, 2005; Thanassoulis, Kortelainen, Johnes & Johnes, 2009), although they are usually computed altogether. Students' scores before entering HEIs is also an employed indicator (Celik & Ecer, 2009); however, far from representing the teaching quality it measures the excellence of the incoming students.

Table 5. Teaching measures.

| Subgroup                    | Indicators               | Use | Model |    |   |    | Sum | Total |
|-----------------------------|--------------------------|-----|-------|----|---|----|-----|-------|
|                             |                          |     | G     | T  | R | KT |     |       |
| Enrolments                  | Total students enrolled  | I   | 7     | 3  |   |    | 10  | 15    |
|                             |                          | O   | 4     | 1  |   |    | 5   |       |
|                             | Undergraduate students   | I   | 2     |    |   |    | 2   | 7     |
|                             | enrolled                 | O   | 4     | 1  |   |    | 5   |       |
|                             | Postgraduate students    | I   | 2     |    |   |    | 2   | 7     |
|                             | enrolled                 | O   | 4     | 1  |   |    | 5   |       |
|                             | PhD students enrolled    | I   | 1     |    |   |    | 1   | 3     |
|                             |                          | O   | 2     |    |   |    | 2   |       |
|                             | Entering scores          | I   | 1     | 3  |   |    | 4   | 4     |
|                             |                          | O   |       |    |   |    | 0   |       |
|                             | Total degrees awarded    | I   |       |    |   |    | 0   | 11    |
|                             |                          | O   | 8     | 3  |   |    | 11  |       |
|                             | Undergraduate degrees    | I   |       |    |   |    | 0   | 5     |
|                             | awarded                  | O   | 4     | 1  |   |    | 5   |       |
|                             | Post-graduate degrees    | I   |       |    |   |    | 0   | 4     |
|                             | awarded                  | O   | 3     | 1  |   |    | 4   |       |
| Students' success           | PhD Completions (Thesis) | I   |       |    |   |    | 0   | 8     |
|                             |                          | O   | 3     | 3  | 2 |    | 8   |       |
|                             | Adult learning degrees   | I   |       |    |   |    | 0   | 1     |
|                             | awarded                  | O   |       | 1  |   |    | 1   |       |
|                             | Graduation rate          | I   |       |    |   |    | 0   | 2     |
|                             |                          | O   | 1     | 1  |   |    | 2   |       |
|                             | Students' progress rate  | I   | 1     | 1  |   |    | 2   | 4     |
|                             |                          | O   | 1     | 1  |   |    | 2   |       |
|                             | Attrition rate           | I   | 1     |    |   |    | 1   | 1     |
|                             |                          | O   |       |    |   |    | 0   |       |
|                             | Students' retention rate | I   |       |    | 1 |    | 1   | 2     |
|                             |                          | O   |       | 1  |   |    | 1   |       |
|                             | Employment rate of       | I   | 1     |    |   |    | 1   | 3     |
|                             | graduates                | O   | 2     |    |   |    | 2   |       |
|                             | Teaching load            | I   |       | 2  |   |    | 2   | 9     |
|                             |                          | O   | 2     | 4  | 1 |    | 7   |       |
| Teaching offer and activity | Average size group       | I   |       |    |   |    | 0   | 1     |
|                             |                          | O   |       | 1  |   |    | 1   |       |
|                             | Teaching quality         | I   |       |    |   |    | 0   | 2     |
|                             |                          | O   | 1     | 1  |   |    | 2   |       |
|                             | International degrees    | I   |       |    |   |    | 0   | 1     |
|                             | offered                  | O   | 1     |    |   |    | 1   |       |
|                             | Membership in teaching   | I   |       |    |   |    | 0   | 1     |
|                             | committees               | O   | 1     |    |   |    | 1   |       |
|                             |                          |     | 57    | 30 | 4 | 0  | 91  |       |

Students' success may almost exclusively refer to teaching outputs. In this category indicators reflect the ambiguity of this concept, where data usually does not reflect teaching efficiency but students' capacities. Measures of the learning process suffer from a similar problem. Indicators such as number of degrees awarded (per levels or globally) and PhD completions are widely used (Emrouznejad & Thanassoulis, 2005) but do not satisfactorily capture the essence of teaching activity (i.e., differences in the time-lengths of students to obtain the diplomas are not computed). Measures like students' progress

rates (Avkiran, 2001) or the attrition rate (Kongar et al., 2010) can be used to better target this problem. Employment rate of graduates is a remarkable indicator (Tóth, 2008), being very significant for an HEI to have students rapidly employed. However, the difficulty in obtaining such data has led researchers to neglect it. Finally, teaching offer and activity category includes those measures related to teaching tasks. Credit hours or teaching load (Kao & Hung, 2008) are used to indicate the time academics expend on teaching tasks (limiting them from developing research activities). Average size group is considered from the students' perspective (Caballero et al., 2004). Students are supposed to have a more personalised training process if class groups are reduced, recording more useful interactions among students and with teachers. Indicators such as international degrees offered (Chang et al., 2009) or membership of academic staff in teaching committees (Kongar et al., 2010) have also been included here. Nevertheless, as noted above, quality limitations persist when using the aforementioned dimensions. "Teaching quality" variables try to fulfil this gap, including qualitative evidences of teachers' performance and students' progress (Giménez & Martínez, 2006).

#### 4.6 Research measures

The relationship between research metrics and research quality is a never-ending source of debate. The most used and robust indicators tend to use bibliometric data (Sarrico, Rosa, Teixeira & Cardoso, 2010), relatively easy to be obtained and measuring parameters such as the number of papers published in scientific journals (usually those indexed in the Science Citation Index, the Social Science Citation Index or similar). In this case, publication counts (Kao & Hung, 2008) reflect quality aspects as papers have been submitted to double-blind peer reviews and the journals where they have been published are well considered among academics. Conference proceedings (Coccia, 2008), books and book chapters (Daghbashyan, 2009) are other viable outputs, although they denote less quality than the former but are more affordable to non-academics (Table 6).

Table 6. Research measures.

| Indicators                        | Use | Model |   |    |    | Sum | Total |
|-----------------------------------|-----|-------|---|----|----|-----|-------|
|                                   |     | G     | T | R  | KT |     |       |
| Publications                      | I   | 1     | 1 |    | 1  | 3   | 18    |
|                                   | O   | 8     |   | 7  |    | 15  |       |
| Books and book chapters           | I   |       |   | 1  |    | 1   | 3     |
|                                   | O   | 1     |   | 1  |    | 2   |       |
| Conference papers and proceedings | I   |       |   |    |    | 0   | 3     |
|                                   | O   | 1     |   | 2  |    | 3   |       |
| Awards                            | I   |       |   |    |    | 0   | 1     |
|                                   | O   |       |   | 1  |    | 1   |       |
| International collaborations      | I   |       |   |    |    | 0   | 1     |
|                                   | O   | 1     |   |    |    | 1   |       |
| Index of scientific quality       | I   |       |   |    |    | 0   | 10    |
|                                   | O   | 6     | 2 | 2  |    | 10  |       |
|                                   |     | 18    | 3 | 14 | 1  | 36  |       |

Reviewed papers also employ a “scientific quality index” that includes weighted measures of different research results (both quantitative and qualitative) using a priori value judgments of the relevance of each research outcome (Daghbashyan, 2009). While some academics suggest that aggregate dimensions of this kind might be obviated for introducing biases (weightings are subjective), others argue that only a qualitative indicator like this can really reflect research quality. Other less frequent indicators identified are the number of awards received by academic staff (Ng & Li, 2000) and the number of international collaborations in research projects (capturing the internationalisation level of the research groups) (Chang et al., 2009).

#### 4.7. Knowledge transfer activities

Evaluation of third mission or knowledge transfer activities has become a core issue for the management of universities but also for regional and national governments. Although our sample reveals that few studies are specifically addressing this mission, it is possible to find some indicators clearly referring to this dimension. In fact this is a relatively recent concept, and just a few years ago universities were not considering it seriously. Notwithstanding, the real problem in measuring it lies in the lack of a formal definition of what is meant by “contribution to regional development” or “third mission”, so proxies able to measure it are even more difficult to formalise.

Table 7. Knowledge transfer measures.

| Subgroup                                 | Indicators                                     | Use | Model |   |   |    | Sum | Total |
|------------------------------------------|------------------------------------------------|-----|-------|---|---|----|-----|-------|
|                                          |                                                |     | G     | T | R | KT |     |       |
|                                          | Total income                                   | I   | 2     | 1 |   |    | 3   | 5     |
|                                          |                                                | O   | 2     |   |   |    | 2   |       |
|                                          | R&D income                                     | I   | 1     |   |   |    | 1   | 8     |
|                                          |                                                | O   | 5     | 1 | 1 |    | 7   |       |
| Research and technology transfer incomes | Income from other services rendered            | I   |       |   |   |    | 0   | 2     |
|                                          |                                                | O   | 2     |   |   |    | 2   |       |
|                                          | Research and technology contracts and projects | I   |       |   |   |    | 0   | 3     |
|                                          |                                                | O   | 1     |   | 2 |    | 3   |       |
|                                          | R&D achievements                               | I   |       |   |   |    | 0   | 1     |
|                                          |                                                | O   |       |   | 1 |    | 1   |       |
|                                          | License incomes                                | I   |       |   |   |    | 0   | 1     |
|                                          |                                                | O   |       |   |   | 1  | 1   |       |
|                                          | Patents and intellectual property              | I   |       |   |   | 1  | 1   | 2     |
| Production                               |                                                | O   |       |   | 1 |    | 1   |       |
|                                          | Invention disclosures                          | I   |       |   |   | 1  | 1   | 1     |
|                                          |                                                | O   |       |   |   |    | 0   |       |
|                                          |                                                |     | 13    | 2 | 5 | 3  | 23  |       |

Table 7 shows how dimensions regarding the third mission have been categorised. According to Montesinos, Carot, Martinez & Mora (2008), the development of the third mission entails an innovative dimension, comprising those services, products or processes that research groups transfer to society. Here, indicators are represented by the number of invention disclosures (Ken, Huang, Wu & Shiu, 2009), and the number of patents issued

or other forms of intellectual property protection (Zhu, Zeng & Ren, 2010). The exploitation of these research results tends to generate revenues that should be computed, as incomes coming from knowledge transfer activities are closely related to the quality of the HEI perceived by its stakeholders (Cohn, Sherrie, Rhine & Santos, 1989). These incomes manifest themselves in the form of research incomes (overall, from projects and/or grants, from contracts and/or other sources) (Martín, 2006) and license agreements (Ken et al., 2009). Nevertheless, problems with third mission dimensions remain on the impediments to collect appropriate data (many HEIs are still reluctant to make visible such financial results), as well as on the complexity of accepting and justifying in the public arena that public funds can be used to generate institutional benefits.

#### 4.8. Overall measures

Lastly, Table 8 depicts how the overall perception of HEIs is assessed. This dimension can be constructed by internal surveys among students, staff and managers (e.g., provosts, vice chancellors and deans) (Johnes & Yu, 2008) or by external sources such as the scores obtained in external rankings (Celik & Ecer, 2009).

Table 8. Overall perception.

| Description       | Use | Model |   |   |    | Sum | Total |
|-------------------|-----|-------|---|---|----|-----|-------|
|                   |     | G     | T | R | KT |     |       |
| External rankings | I   |       |   |   |    | 0   | 1     |
|                   | O   |       | 1 |   |    | 1   |       |
| Internal surveys  | I   |       |   |   |    | 0   | 1     |
|                   | O   |       |   | 1 |    | 1   |       |
|                   |     | 0     | 1 | 1 | 0  | 2   |       |

## 5. Discussion

In a knowledge-driven and globalised world where everyone competes with the other and society demands more transparency in the autonomous governance of public institutions, universities are trying to find an adequate balance of their three core missions assuming new roles and responsibilities. In this framework, the evaluation of HEIs has gained prominence, and a general interest in rating them through efficiency studies using a DEA approach has increased since the 1980s. DEA is a well-known non-parametric approach that fits particularly well with universities' requirements, reporting valuable information about how to improve efficiency but also enabling comparisons with universities with similar behaviours. Papers dealing with this topic can be found in abundance. However, far from converging into a unique formula, the inherent controversy of such evaluative and ranking procedures assists their diversification.

Aiming to contribute to a better understanding of the indicators and mechanisms used in the evaluation of HEIs' performance, in this paper we have undertaken an extensive literature review of DEA-HEI papers published during the last decade, providing an overview of how to proxy resources (inputs) and university's results (outputs). In order to study these proxies, we have classified the indicators identified according to their nature, and resulting in seven categories: financial resources, human capital resources, infrastructures, teaching, research, third stream measures and overall perception.

From the in-depth analysis of the papers reviewed it has been possible to observe that different structures and missions nested in regional contexts, cultures and conditions of possibility make difficult to converge in the way of assessing HEIs' performance, and in particular, their efficiency. There are just too many factors at the system level that are almost impossible to control simultaneously (Salerno, 2004). The examined papers

corroborate this fact by identifying 61 different measures, many with similar scopes but little nuances, that make cross-country comparisons even more difficult. Yet, some dimensions can be used either as inputs or as outputs. For instance, discrepancies are found in the “number of students enrolled”, which used as an input quantify how many of them have successfully completed the degree; whereas as an output denotes the quality of the university in terms of students' demand. Also, indicators expressing scientific research and knowledge transfer results are somehow difficult to be distinguished, especially research results and revenues arising from a commercialisation process. A clear example is for example the case of patents, where there is still a soft boundary whether they should be considered as an outcome of the second or the third mission.

Regarding data availability, incomplete records and non-homogenous procedures to collect information amongst different universities hinder the characterisation process of indicators to assess the performance of HEIs. Thus, measures used are usually the easiest to be obtained but not the best to express a particular asset. Consequently, the validity of the scores obtained is uncertain for questioning the suitability of the metrics employed. It is interesting to highlight that any of the studies reviewed employ the spin-off activity as an output of the third mission. This fact can be explained by several factors: the lack of an entrepreneurial culture inside the academic system; the non-existence of an appropriate rewarding system for academics involved in starting up new ventures; the novelty of considering the spin-off activity as a natural mechanism for exploiting the knowledge generated at HEIs; or the absence of a systematic register of the number of spin-offs created for all the DMUs to be included in the analysis. This trend is expected to change substantially in the forthcoming years, as universities are seriously considering spinning-off as an important function to be enhanced. Although it is extremely important to evaluate the overall performance of universities, as general models consider multitask challenges (where activities are sometimes substitutive but others complementary), an individual approach focusing on each mission independently is also needed. Here, critical issues in the ways of comparing institutions emerge: Is it fair to compare entire universities? Does really one size fit all? Only after analysing disciplines, fields or missions attaining the specific dimensions, can a global balance of HEIs make completely sense. From the literature review we have conducted, it becomes clear that the evaluation of HEIs has produced an enormous interest in both academics and policy-makers, encouraging and influencing the rationalisation of institutions and the professionalisation of services, transforming the way they liaise and collaborate with each other (Hazelkorn, 2009). This paper has demonstrated the complexity that universities entail, and that boundaries between some measures and missions are still not clear enough.

Although we are aware of the difficulty in reaching an agreement on the use of indicators, we hope this study help academics and policy makers better understand the current status of the state of the art while give assistance to the establishment of fair and reliable indicators to assess and rank universities according to their performance.

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