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ABSTRACT: This paper links governance reforms with potential improvements in efficiency in Spanish universities. Taking the classic DEA model as our starting-point, we focus on the study of efficient units to identify the ones that present atypical behaviour (outliers) and should be removed from the analysis, and then to order the remaining institutions in terms of what is known as robust efficiency. Moreover, we use a second stage regression analysis and a three-stage adjusted values non-parametric model to analyse the influence of environmental factors on the efficiency scores obtained. Once environmental factors are taken into account, the remaining unexplained inefficiency is attributed to governance failures. Our results indicate that the observed inefficiency in Spanish public universities is mainly determined by deficient governance. Thus, there is scope for improvements in efficiency through governance reform.

JEL Codes: C14, I23, L31

Keywords: Efficiency, governance, universities.

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1. Introduction

In many countries, the organization of higher education has changed dramatically in recent years (de Boer et al, 2007). Although departing from very different situations, the governance structures adopted converge towards more market-based organizational systems. Even if there is little empirical evidence of the relationship, it is hypothesized that these new governance structures can increase levels of efficiency. In Europe, for example, higher education systems have undergone profound changes in the last decades, particularly since the late 1990s. With the Bologna Process, launched in 1999 and the Lisbon Agenda of 2000, higher education in Europe has seen the introduction of more market-type mechanisms and modern types of governance. In these reforms, public control is gradually being replaced by self-management and autonomy in the name of efficiency. Through competition and greater institutional autonomy, Higher Education Institutions (HEIs hereafter) are being asked to raise their capacity and engagement in the production and transfer of knowledge in order to satisfy their varied consumers' demands.

In Spain, the number of higher education students has increased three-fold over the past three decades, reaching one of the highest rates of university education in Europe. In this period, the number of HEIs has evolved in parallel, with the establishment of universities in all cities and major towns. This process has been accompanied by political and administrative decentralisation[1] within the framework of university reforms. The first impulse was the University Reform Act (LRU) which came into force in 1983, and focused on universities' organization and scientific modernization. The second was the Universities Act (LOU) introduced in 2001, with the aims of implementing quality assurance policies and preparing for the Spanish university system's entry into the European Higher Education Area (EHEA). Other measures envisaged in this law, such as regulations governing the functioning of universities, have been at the centre of the debate on education. The modification of the LOU in 2007 introduced changes related to rectoral elections, faculty accreditation and selection, and the coordinating bodies of university policy.

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[1] In Spain, higher education comprises universities and vocational schools. In our discussion of HEIs we will refer exclusively to universities.

In Spain’s decentralised model, governance over higher education is generally divided up between the state, the autonomous regions, local governments and educational institutions. The central government keeps control over the legal framework that guarantees the homogeneity and unity of the education system. The Ministry of Education and Science (MEC) is the central government department entrusted with exercising this legal control, whereas the autonomous regions are responsible for administering the HEIs within its territory. The government of each autonomous region has the jurisdiction to set up, authorise and oversee the running of public and private institutions, academic and administrative staff, and to build new educational facilities and renovate existing ones. The University Coordination Council (CCU) is the system’s coordinating body. It comprises all the university rectors, representatives of regional governments, and experts appointed by the central government and by parliament[2].

Higher education regulations grant autonomy to universities. Although the legal framework establishes the general rules for the organisation of public universities, the different institutions are free to define their own structure and organise their educational programmes. The autonomy granted to universities allows them to: i) draw up their own statutes; ii) choose, designate and change their governing and representative bodies; iii) draw up plans for courses, research and specific areas of study[3]; iv) issue official degrees that are valid throughout Spain, as well as university-specific certificates and degrees. Universities may introduce new official courses, provided that they have received authorisation from the autonomous region and the courses appear in the official catalogue of government-approved degrees. The current legal framework grants public universities the freedom to draw up their own budgets. Similarly, each university is free to decide how many teaching, administrative and service posts it offers (both civil service and non-civil

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[2] In addition, the central government and the autonomous regions can delegate powers to city councils in areas that are directly related to their interests. Councils do not have a common body to oversee these functions, although most do have an education department and some have set up municipal education institutes. Their functions range from providing information on the city‘s educational institutions and fostering community involvement in education (through the municipal education council) to the management and upkeep of non-university institutions.

[3] Study plans are fixed to a great extent by the Ministry, following the tradition of the national diploma.

service). Civil servants are awarded posts in accordance with the civil service legislation of the central government and the autonomous regions[4].

Reforms in the Spanish higher education sector have been less frequent and less profound than in other European countries, especially those referring to universities' external and internal governance mechanisms. The creation of the EHEA and the objectives of the Lisbon Agenda are calling for additional and deeper reforms. To be able to face these challenges, Spanish HEIs have to become more flexible, and they must do so by implementing modern governance structures. But can these governance reforms enhance HEIs' efficiency? If the answer to this question is affirmative, then governance reforms are to be welcomed. Otherwise, reforms should be oriented towards more effective goals. Although there is a growing literature analysing the effects of better governance mechanisms on private firms' efficiency, there is less evidence on public or non-profit institutions. Even though market-based reforms have been increasingly adopted by European policy makers, there is little empirical evidence that these new governance systems indeed result in efficiency gains. In this paper we aim to contribute to this literature.

In this paper we investigate to what extent governance can explain HEI inefficiency with data from Spanish public universities. We compute outlier-free efficiency scores using the superefficiency DEA procedure. In order to explain the inefficiency observed, in the second stage of the study we control for several environmental factors, separating the inefficiency attributable to non-controllable inputs (NCIs hereafter) from that attributable to governance. As a robustness check, we use two alternative methods, a second-stage regression analysis and a three-stage adjusted values non-parametric model. The paper proceeds as follows. Section 2 outlines the methodological strategy. Section 3 describes the data and the specification of inputs and outputs as well as the environmental factors considered. Section 4 presents the results and discusses our main findings. The last section concludes.

[4] The categories and salaries of the academic staff, however, are established by central government and regional laws.

2. Dealing with efficiency measurement

The DEA technique has been widely used in the technical efficiency analysis of production units, and it is especially useful as a tool to study performance in the public sector. Even though it has not frequently been used in the case of Spanish universities, there is abundant evidence for other countries. However, given the differences between the diverse higher education systems, the results cannot be compared and are difficult to extrapolate.

DEA models have a long tradition in the analysis of university efficiency evaluation, although the objectives of these studies differ. In its origins, DEA applied to higher education was used exclusively to analyse either departmental efficiency [Ahn, Arnold, Charnes and Cooper (1989), Beasley (1995), Johnes and Johnes (1995), Chen, (1997), Siegel, Waldman, and Link (1999) to mention only a few] or institutional efficiency [Ahn, Charnes and Cooper (1988), Goudriaan and de Groot (1993), Jongbloed and Vink (1994), Coelli (1996), Athanassopoulos and Shale (1997), McMillan and Datta (1998), and Avkiran (2001) among others]. More recently, the analysis of HEI efficiency is used to investigate different topics such as productivity and technological change [Worthington and Lee (2008), Ng and Li (2009)], congestion [Flegg and Allen (2007)], competition [Abbott and Doucouliagos (2009)], the establishment of minimum educational standards [Ruggiero (2007)] and comparisons of stochastic against non-stochastic methods [McMillan and Chan (2006)].

Martinez (2000) and Gimenez and Martinez (2006) applied DEA models to departments within Spanish universities. Duch (2006) and Johnes and Salas-Velasco (2007) are examples of studies analysing Spanish HEIs in general. Some specific applications use DEA to study, for instance, human resources policy at the University of Malaga [Caballero et al. (2004)] or the effects of the decentralisation of competencies in the LRU on the efficiency of regional higher education systems [Parellada and Duch (2006)]. In this paper we follow this last strand and use a DEA model to study the relationship between governance and efficiency. In so doing we want to assess whether a reform in the internal and external governance mechanisms of Spanish universities could improve their efficiency levels.

2.1 Basic features of Data Envelopment Analysis

Charnes, Cooper and Rhodes (1978) developed the DEA methodology outlining a mathematical problem whose resolution requires linear programming techniques. The authors' idea was to build an enveloping surface or efficient frontier from the available data for a set of decision-making units (DMUs hereafter); those that determine the frontier are called efficient. The starting point is to define efficiency mathematically as the quotient of the weighted sum of all outputs over the weighted sum of all inputs. This problem is defined as:

$$Max_{u,v} \quad h_0 = \frac{\sum_{r=1}^{s} u_r \cdot y_{r0}}{\sum_{i=1}^{m} v_i \cdot x_{i0}}$$

$$\text{subject to} \tag{1}$$

$$\frac{\sum_{r=1}^{s} u_r \cdot y_{rj}}{\sum_{i=1}^{m} v_i \cdot x_{ij}} \leq 1, \quad j = 1,2,...,n$$

$$u_r, v_i \geq 0 \quad r = 1,2,...,s \quad i = 1,2,...,m$$

where n units (j=1,2,…,n) are considered, each one using different quantities of the same inputs ($x_1,x_2…,x_m$) to produce the same outputs ($y_1,y_2…,y_s$). In this setting, x_{ij} represents the quantity of input i consumed by the DMU j; y_{rj} the quantity of output r produced by the unit j; x_{i0} represents the quantity of input i consumed by the DMU under evaluation; and y_{ro} the quantity of output produced by this last DMU. The coefficients u_r (r = 1,2,…,s) and v_i (i=1,2,…,m) represent the weights or input and output multipliers, respectively. In order to obtain the corresponding efficiency scores, it is necessary to solve this mathematical optimization problem for each one of the DMUs considered. The dual equivalent of this problem is known as the enveloping form and is the most used version in DEA applications:

$$Min_{u,v} \quad h_0 = \frac{\sum_{r=1}^{s} u_r \cdot y_{r0}}{\sum_{i=1}^{m} v_i \cdot x_{i0}}$$

subject to

$$h_0 \cdot x_{i0} - \sum_{j=1}^{n} x_{ij} \cdot \lambda_j \geq 0 \quad i = 1,2,...,m \tag{2}$$

$$- y_{r0} + \sum_{j=1}^{n} y_{rj} \cdot \lambda_j \geq 0 \quad r = 1,2,...,s$$

$$\lambda_j \geq 0 \quad j = 1,2,...,n$$

If the solution for the enveloping form is $h_0^* = 1$, then the unit that is being evaluated is efficient in relation to the other units according to the definition of Farrell (1957), given that it is not possible to find another unit or a linear combination of units that obtains at least the same output using less inputs. In contrast, if $h_0^* < 1$ the DMU is inefficient and the difference $(1 - h_0^*)$ will indicate the maximum proportional reduction that the unit can achieve in all its inputs keeping the same level of output (in input oriented DEA) or the maximum proportional increment of outputs that the DMU can achieve with the same level of inputs (if the DEA is output oriented).

The DEA model just described assumes that the technology satisfies the property of constant returns to scale. This means that when varying the quantity of inputs to some proportion, the quantity of output varies to the same proportion. In this case the efficiency obtained is termed Global Technical Efficiency (GTE). Banker, Charnes and Cooper (1984) modified this condition to consider variable returns to scale. Mathematically, this is obtained by imposing a convexity restriction in the formulation of problem (2) given by

$\sum_{j=1}^{n} \lambda_j = 1$. The efficiency measure obtained in this case is named Pure Technical Efficiency (PTE) and measures technical efficiency net of scale effects.

If a unit is inefficient, from the computed λ_j^* s it is possible to obtain a combination of units that works better than the DMU under evaluation. This is another advantage of the dual form, since it provides additional information on the inefficient units. For each inefficient DMU it indicates its reference units or peers. For each inefficient unit, its peers will be those DMUs which, in the solution to problem 2, satisfy the condition $\lambda_j^* > 0$ (j=1,2,…,n). Through an appropriate linear combination of these peers, an efficient (real or fictitious) unit can be obtained whose performance serves as a benchmark for the inefficient unit since it will use, as a maximum, the same proportion of inputs of the unit evaluated as inefficient and will produce at least the same quantity of outputs.

The simplest way to rank efficient units, without requiring additional computations, is to count the number of times an efficient unit serves as a peer for inefficient ones, as suggested by Torgersen et al. (1996). The argument states that the more an efficient unit appears as a peer of inefficient DMUs, the higher its efficiency level since it constitutes more frequently a reference for improvement. However, this procedure does not enable us to detect outliers.

2.2 Robust efficiency and outliers

The classic DEA methodology does not discriminate between efficient units. This implies that it is not possible to rank all the DMUs based on their computed scores. More importantly, this also implies that it is not possible to detect outliers. In this case, efficiency scores may be determined by exceptional or atypical observations meaning that inputs and/or outputs for these units are not homogeneous with respect to those of other DMUs. If one DMU acts as an outlier, it should be removed from the computation of efficiency scores in order to obtain unbiased scores.

One feature of the DEA method is that it includes the unit under evaluation in the set of restrictions. Thus, each unit can be compared with itself and if there are no units with a higher efficiency score, its index will always be equal to 1. This is also a concern in the case of outliers. This problem worsens with the number of variables considered, since in this case the comparison between units becomes more complex and the result of the self-comparison prevails.

Andersen and Petersen (1993) developed a more sophisticated system to rank efficient units giving a definition of robust efficiency (or superefficiency) and suggesting a technique that simultaneously evaluates it and detects outliers. Wilson (1993) proposed a very easy-to-implement criterion to rank efficient DMUs. Later on, Bogetoft (1995), Dula and Hickman (1997), Seiford and Zhu (1999) and Bogetoft and Hougaard (2002) refined the methodology trying to overcome some of the limitations of the original proposal.

What Andersen and Petersen (1993) proposed was a modification of the structure of the conventional mathematical DEA model excluding the unit under evaluation from the set of restrictions. The most immediate consequence of this exclusion is that the new efficiency score of each unit, $h_0^{'}$, is no longer bounded by one. Besides, with this modification the inefficient units will obtain the same score as with the conventional approach, since in their evaluation process the reference frontier to which they are compared is not modified.

2.3 The influence of NCIs on efficiency

One of the main drawbacks of the DEA methodology for evaluating efficiency is that it does not take into consideration a priori the possible effects on the results of environmental factors (variables that cannot be controlled by the DMU managers). In some cases, these factors can have a decisive influence in performance. In the literature on primary and secondary education, the influence of external factors beyond the control of schools' managers has been amply demonstrated. In a seminal contribution, Coleman et al. (1966) pioneered the analysis of the influence of NCIs in education. One of the main results of that report is the robust empiric evidence of the decisive role played by families, social environment and individual characteristics of the students (aptitude, attitude, motivation and personality among others) in the schools' efficiency. It is shown that these two factors – socioeconomic status and the students' individual training – often have more influence on a school's efficiency than the quantity of resources available to managers in their efforts to achieve it. However, in higher education the possible influence of environmental variables on efficiency has only rarely been considered, generally due to lack of appropriate data. In this paper we propose some NCIs that may be relevant in the higher education context and analyse their influence on universities' efficiency.

The techniques developed so far to evaluate the influence of NCIs can be divided in two broad groups. The first refers to one-stage models where normally the NCIs are included in the original DEA specification as additional inputs and so the computed efficiency scores already take them into account. The second approach groups several multistage methodologies, the first stage always being the computation of efficiency scores with the traditional DEA model, and the second (or subsequent) stage(s) incorporating the effects of NCIs.

2.3.1 A second stage regression analysis to capture the effects of NCIs

The second stage regression analysis is a technique developed by Ray (1988) that has been widely used when evaluating the influence of the NCI on efficiency scores. Some recent contributions are those of Chilingerian and Sherman (2004), Ray (2004), Ruggiero (2004) and Simar and Wilson (2007). The basic idea of the regression technique in the second stage is to consider that the production function of the evaluated DMUs depends on controllable and non-controllable inputs. It is assumed that this function adopts a multiplicative form:

$$T(y_r) = F(x_i, z_k) = g(x_i) \cdot h(z_k)$$

where $(y_1, y_2, ..., y_s)$ is the output vector, $(x_1, x_2, ... x_m)$ the controllable inputs vector and $(z_1, z_2, ..., z_t)$ the vector of non-controllable inputs. The function $g(\cdot)$ can be determined from standard functional forms (e.g. Cobb-Douglas), and it is supposed to be linear so that it admits variable returns to scale. The function h(·) takes values between 0 and 1 and measures the efficiency of the jth DMU:

$$h_j = h(z_{kj}) \quad j = 1,2,...,n \quad k = 1,2,...,t$$

This value is in fact the value of the efficiency score obtained with the DEA analysis. The function $h(z_k)$ defines the maximum level of attainable efficiency given a certain configuration of NCIs. But if inefficiency is due to internal unobserved factors rather than environmental ones, such as bad governance, the efficiency level achieved by the evaluated unit will be even lower to the one that would be obtained when considering NCIs only. To take this possibility into account, it is necessary to introduce a correction factor that measures the inefficiency caused by organizational factors different from traditional inputs and outputs. Thus, it is convenient to define the function h(·) as follows:

$$h_j = h(\beta_k, z_{kj}) + \varepsilon_j \quad \varepsilon_j \leq 0$$

where β_k are the parameters of an assumed linear relation and ε_j represents pure inefficiency due to deficient governance. Without this inefficiency, h_j achieves the highest value given by $h(z_{k\,j})$. Obviously, $h_j \leq h(z_{kj})$. If $h_j = h(z_{kj})$ one can conclude that there no inefficiency is attributable to governance, and that it is explained by the NCIs exclusively. Moreover, if $h_j < 1$, it is possible to calculate the deviation in efficiency due to external factors outside the control of the DMU under evaluation.

To determine the function $h(z_k)$ a linear regression is used. Here, the efficiency scores are the dependent variable and the NCIs the explanatory variables. Given that the dependent variable is censored, a Tobit estimation is required. Once the parameters (β_k) are obtained, one can compute the estimated value $\overline{h}_j$ for the jth university. The difference between this value and the one obtained with the DEA model informs us of the proportion of inefficiency attributable to governance. However, the inequality $h_j \leq h(z_{kj})$ is not always satisfied given that the estimated residuals are not always negative.

To solve this problem, Greene (1980) suggests correcting the regression constants so that all the residuals are negative and the parameters remain consistent. This correction is made by adding to all the $\overline{h}_j$'s the value of the biggest residual obtained in the regression. Proceeding in this way, one obtains a new adjusted value $\overline{\overline{h}}_j$ that will be higher than $\overline{h}_j$ except for those DMUs where the biggest residual was obtained, and in so doing estimators remain consistent. Finally, one can assign the efficiency non attributable to NCIs to the value $(\overline{\overline{h}}_j - h_j)$. If $\overline{\overline{h}}_j > 1$, then the difference $(1 - h_j)$ should be considered. It is likely that $\overline{\overline{h}}_j > 1$ in the case of the most efficient units, and so this procedure will probably underestimate their inefficiency levels.

2.3.2 A three-stage adjusted values model to consider the effects of NCIs on efficiency

As an alternative to parametric methodologies, Fried and Lowell (1994) proposed the use of a three-stage DEA model for considering NCIs in efficiency evaluation. An advantage of this technique is that it uses non-parametric methods in the whole process, reducing the bias problem of regression analysis due to the existence of statistical disturbances. The idea of these authors is to build a new efficiency score $\overline{h}_j$ free from the effects of the NCIs. This means that this new score defines the maximum level of efficiency attainable by the jth unit given a configuration of the NCIs. As in the previous methodology, the part of inefficiency attributable to deficient governance is given by the difference $(\overline{h}_j - h_j)$, where h_j is the efficiency score of the jth university obtained by applying the original DEA model. This approach seeks to find the values of h_j by repeatedly applying the DEA technique. The basic idea of the mathematical problem is that the environmental variables are the result of the existence of slacks and that these can be considered as inputs in the transformation process.

The computation strategy is as follows. Once the DEA has been applied and the efficiency scores h_j for each evaluated unit obtained, an input-oriented DEA is performed again introducing the slacks as inputs and the NCIs as outputs. The intuition behind this first stage is to determine to what extent the slacks can be minimized taking the values of the NCIs as given. Applying this procedure, for each DMU we will obtain a new score that will be termed d_0. At this stage a new frontier formed by the units that are relatively efficient is obtained. For these DMUs, the total slacks detected are due to the effect of the NCIs. For the units that are not in the frontier, the effect of the NCIs is given by its projection to the frontier.

In the second stage, the effect of the NCIs is discounted on each evaluated unit. If the unit is in the frontier in the original DEA model, it will be necessary to subtract the value of the corresponding total slack from each input and add it to each output. For the other units, it will be necessary to correct each one of their inputs and/or outputs with the value of the minimum slack obtained in the previous DEA. If for a DMU the value obtained in the first stage is d_0, then $d_0\left[(1-h_0)\cdot x_i + s_i^*\right]$ is the part of the slack of input i that could be explained by the influence of NCIs and $(1-d_0)\left[(1-h_0)\cdot x_i + s_i^*\right]$ would be the contribution of governance failures. The same reasoning applies with respect to outputs.

Once the variables of each DMU are corrected from the possible effects of NCIs, in the third stage another DEA is carried out with the corrected input and output values for each DMU. The new efficiency scores obtained, $\overline{h}_j$, define the maximum level of efficiency achievable by the j_{th} DMU given its configuration of NCIs. The difference $(\overline{h}_j - h_j)$ will indicate the inefficiency attributable to governance.

3 Data

The data consist of observations of three inputs and four outputs for 46 Spanish public universities for the academic year 2004-2005[5]. The main source of information is a report published every two years by the Conference of Rectors of Spanish Universities (CRUE, 2006). The criteria used for selecting inputs and outputs were the following: i) to choose as few indicators as possible in order to allow the DEA methodology to better discriminate between units; ii) to select inputs reflecting financial, human capital and equipment and infrastructures resources, and; iii) to choose outputs for teaching and research trying to reflect, in the former case, results linked to both teaching and graduation, and in the latter case, both basic and applied research[6].

3.1 Specification of inputs and outputs

So far, studies focusing on the efficiency of HEIs have largely neglected the issue of input and output quality. This is so because appropriate data to take into account this rather imprecise concept are lacking. Nevertheless, in this paper we make an attempt to overcome this omission in some way and try to capture input and output quality. Regarding the debate on quality in higher education, Barnett (1994) describes it as a conflict of interests among different stakeholders. As a consequence, different systems for monitoring different kinds of quality, and at different levels, have been developed. One of these is based on the elaboration of Performance Evaluation Indicators (PEIs hereafter). This approach to evaluating universities compares performance across a range of indicators (Johnes and Taylor, 1990). The advantage of using PEIs is to focus on important aspects of the higher education system. For instance, some scholars consider PEIs as signals indicating the system's performance (Spee and Bormans, 1992) or as guidelines for quality measurement (Cuttance, 1990). As Tam (2001) concludes, PEIs in the university context are helpful to analyse the relationship between the inputs they need and the outputs that institutions aim to achieve.

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[5] There are 47 public universities in Spain. However, the University of Vigo had to be excluded from the analysis due to a lack of appropriate data..

[6] Lack of data prevented us from considering variables related to the third mission.

Our first input indicator is the inverse of the student to faculty ratio. This ratio refers to the number of full time equivalent (FTE) faculty in a university with respect to the number of FTE students. This ratio is important since the more personal attention students are able to receive from their professors, the more they will become engaged in the subject matter and the better their performance will be. The lower this ratio, the more attractive a college should be in this regard. In order to have a direct relationship between inputs and outputs we take the inverse of this indicator, and construct a faculty per 100 students' ratio. In this case, the higher the ratio, the more quality is embedded in an institution's education. The second input indicator concerns administrative resources and is proxied by the inverse of the faculty to staff ratio. In this case, we construct this ratio as the quotient of FTE administrative staff over FTE faculty. The higher this ratio, the more help faculty receives in order to perform bureaucratic tasks and the more productive they can be both in teaching and doing research. The last input indicator is non-labour expenditure per student. Expenditure in goods and support services that are an integral part of the institution's primary mission of instruction, research, or public service gives an indication of the quality and abundance of such services on a per student basis. These include, among others, library expenditure, audio/visual services, academic computing support, ancillary support and academic administration.

We have chosen two outputs related to teaching activities and two more related to research. The first teaching output indicator is the academic return ratio, calculated as the quotient of graduates over drop-outs. This captures yearly relative academic return comparing a measure of academic success such as the number of students who graduate with one measure of failure, given by the number of drop-outs. In this case, values below one indicate that there are more drop-outs than graduates thus reflecting an excess of failures over successes. One complication with this ratio is that the numbers of graduates and drop-outs are heavily dependent on the duration of the different degrees; in Spain, in the academic year 2004-2005 universities offered degrees ranging from two to six years. In order to solve this issue, we compute an overall academic return ratio by institution weighting the variables by the length of each degree[7]. Our second output for teaching activities is the success rate, one of the most frequently used indicators in higher education, which relates the number of graduates in a given year over the entry cohort. In our case, and given that the length of the different degrees in Spain varies significantly, obtaining a consistent indicator turns out to be complicated. We nevertheless compute a proxy considering an average length of four years for every degree, and thus the entry cohort for any given graduate is that of four years previously. Thus, as our data for graduates correspond to the academic year 2004-2005, we use entrants to universities in the academic year 2001-2002.

Our first research output indicator is Euros per student from R&D activities. This is a very controversial indicator. Some researchers consider it to be more appropriate as an input than as an output, arguing that the revenue generated by R&D projects is used normally to finance the expansion of infrastructure and equipment for both teaching and research and is therefore more a resource than an outcome. Those who consider this indicator as an output suggest that this income stream is the most noticeable result of the applied research projects promoted by the university, and in our case we consider that this indicator reflects the effort and success in applied research and innovation. As shown in table 1, the differences observed among Spanish HEIs reveal huge variations and hence a great discriminatory power for this indicator. The second output referred to research activities is the number of JCR indexed publications per faculty member. This is also a widely-used indicator applying a standard that is well established today to reflect the quality and quantity of university research. Table 1 shows some descriptive statistics of the inputs and outputs considered.

3.2 Determination of possible NCIs

We assume three possible sources of external factors that can influence universities' efficiency results. Some descriptive statistics are shown in Table 1.

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[7] The weights are as follows: for two-year degrees 0.5, for three-year degrees 0.75, for four-year degrees 1, for five-year degrees 1.25, and finally for six-year degrees 1.5.

a) Factors that characterize institutions beyond their basic operations

This set of variables should emphasise singular and differentiating features that the institution has acquired or configured during its lifetime without being related to present conditions. We distinguish three NCIs in this group:

NCI_1: Age

The fact that a university is older than others grants the institution a degree of experience that is usually associated with the recognition of a certain prestige[8].

NCI_2: Degree specialisation

In the Spanish university system each degree taught is associated with a level of experimentation, understood as the number of laboratory practices that the student performs during the degree. The overall level of experimentation conditions investments in laboratories and specialised classrooms. To capture this characteristic, we build a specialisation coefficient defined as the average experimentation level weighted by the length of degrees.

NCI_3: Size

Another characteristic that differentiates universities is size, measured by the number of students registered in official undergraduate degrees.

b) Factors attributable to the quality of students

NCI_4: Average threshold grades of the degrees in the first quartile

In Spain, each public university establishes its annual threshold entry grade for each degree on a decimal scale, defined as the grade of the last student who is able to enter[9]. In those

[8] Since there are some universities that are secular, including the real number of years of existence of these institutions could distort the results. Besides, it is considered that the possible effect of this NCI will be the same when the years of existence surpass a certain threshold. Thus, we adopted a general value of 50 years to indicate that the possible influence of age is the same for all the universities in operation for this period or longer.

degrees where there is more supply than demand, the threshold grade is by definition 5. Since this happens in a large number of degrees, the average threshold grade will not discriminate between institutions. For this reason, we consider that a better indicator of students' quality is the average threshold grade for the first quartile of the most requested degrees in each university.

Table 1. Descriptive statistics

	Average	Median	Est. Dev.	Min	Max
(Student to faculty ratio)$^{-1}$	7.1	7.0	0.9	5.2	9.1
(Faculty to staff ratio)$^{-1}$	0.6	0.6	0.1	0.4	0.9
Non-labor expenditure/student (Euros)	973.3	914.2	343.5	470.8	2238.1
Academic return ratio	1.9	1.5	1.6	0.6	10.3
Success rate	0.7	0.7	0.1	0.4	0.9
€/student from R&D activities	150.9	110.8	109.3	35.8	468.2
JCR articles per FTE faculty	0.5	0.4	0.2	0.3	0.9
NC_1: Age	30.1	28.5	14.6	9.0	50.0
NCI_2: Degree specialisation	2.6	2.5	0.3	2.0	3.5
NCI_3: Size	23,862.7	22,067.0	15,513.7	5,843.0	72,528.0
NCI_4: Quality of students	6.5	6.6	0.7	5.0	7.5
NCI_5: Regional GDP per capita	15,314.2	15,093.9	3,418.2	9,820.2	20,374.3
NCI_6: Scholarship holders	15.8	15.8	4.4	8.0	27.1

Source: Our own data.

c) Factors attributable to the students' and region's socioeconomic conditions

Given the impossibility of measuring each student's socioeconomic and family conditions due to lack of appropriate data, we use the following more general socioeconomic indicators:

NCI_5: Regional GDP

Given that in most cases more than 80% of a university's students come from the same province, per capital regional GDP will reflect the socioeconomic conditions of these students.

[9] Only the threshold grades of students coming from high school are considered. The threshold grade for every student is computed as the weighted average of their average high school grade (60%) and the grade obtained in the university access test (40%). Places are allocated according to the threshold grades of the students demanding entry.

NCI_6: Number of MEC scholarship holders[10]

The fact that a student has a scholarship from the MEC mainly indicates a low family income. Thus, the more scholarship holders in a university, the greater the share of students from low income families and the worse the conditions in which to pursue higher education.

4. Empirical results

4.1 Efficiency scores and scale efficiency

A summary of the results obtained by applying the output-oriented DEA as explained in section two with three inputs and four outputs is shown in table 2[11]. The first column refers to the efficiency scores computed under the constant returns to scale (CRS) hypothesis. In the second column the efficiency scores under the assumption of variable returns to scale (VRS) are shown. Finally, the third column lists the main results of the ratio of constant return scores over variable returns scores, the "scale efficiency" that helps to determine whether universities are operating at an optimal scale.

Table 2. Summary of results using the classic DEA model

	CRS	VRS	Scale
Efficient units	17	23	18
Inefficient units	29	23	28
Average efficiency	0.892	0.917	0.972
Median efficiency	0.934	1.000	0.986
Standard deviation	0.131	0.128	0.038
Lowest efficiency	0.456	0.462	0.845

Source: Our own data, from results shown in table A1 in the annex.

[10] These include scholarship holders in universities located in the Basque Country and Navarre, regions with a different allocation mechanism than the rest.
[11] Table A1 in the appendix shows the results by university.

The number of efficient universities when considering constant returns to scale is 17, with an average efficiency of 89.2%. On the other hand, under the assumption of variable returns to scale, the number of efficient universities increases to 23, the average efficiency being of 91.7%. Considering that there is a wide variation in terms of the size of the institutions, it seems reasonable to consider the efficiency scores obtained under the hypothesis of variable returns to scale as more appropriate. These are the scores that will be used in what follows. With these results at hand, it is possible to argue that Spanish universities could increase their output by an average of 8.3% with the resources they are already using.

4.2 Inefficient universities: determination of peers

Inefficient units can be ordered according to the computed efficiency scores under the assumption of variable returns to scale, as shown in table A2 in the appendix. The first university in the list is the most efficient in the set of inefficient units. The remaining columns of the table present, for each inefficient unit, the peer(s) (efficient units of reference) and the weights in which each of these units is a reference for the inefficient one.

In the standard DEA model all efficient units are assigned a score of 1 and therefore cannot be differentiated. One simple way to order efficient units is to count how many times each institution appears as a peer for other universities. The ranking of efficient units obtained in this way is shown in table 3.

Table 3: Ordering of efficient universities

University	Times as peer	University	Times as peer	University	Times as peer	University	Times as peer
1: URJC	17	7: UNAVAR	6	13: UPO	2	19: UEX	1
2: UR	15	8: UGR	5	14: UPC	2	20: UMA	1
3: UV	14	9: USC	4	15: URV	2	21: UPM	1
4:UDC	9	10: UPV	3	16: UB	1	22: UAM	0
5: UZ	8	11: UVA	3	17: UCAN	1	23: ULPGC	0
6: EHU	7	12: UJAEN	2	18: UCM	1		

Note: Table A3 in the appendix shows the list of Spanish public universities and the acronyms used throughout the text.
Source: Our own data.

4.3 Outliers and robust efficiency

As explained in the methodological section, Andersen and Petersen (1993) modified the conventional DEA model to allow for robust efficiency or superefficiency. According to the value of the new index obtained with this modification in the restrictions set, a classification scheme can be implemented for the efficient units as proposed by Wilson (1993):

- If no feasible solution exists or if the computed value is very far from 1 (a difference of 25% or higher), it means that the evaluated unit is an outlier.

- For those units that obtain an efficiency score close to 1, the ranking will be established by ordering DMUs according to the measure $\left|1-h_0^{'}\right| \cdot 100$.

In line with these criteria, table 4 shows the results obtained for the 23 efficient universities under the VRS assumption. In our case, a feasible solution has been found for all the linear programming problems. Therefore, all outliers are defined as such because the solution value found lies well beyond unity (more than 25%).

Table 4: Classification of efficient universities and definition of *outliers*

Univ	h'$_0$	$\left\|1-h'_0\right\| \cdot 100$		Position	Univ	h'$_0$	$\left\|1-h'_0\right\| \cdot 100$		Position
UDC	1.202	20.2%		1	**EHU**	1.313	31.3%	Outlier	
UAM	0.971	2.9%		15	**UPC**	1.165	16.5%		2
UB	1.700	70%	Outlier		**UPM**	1.879	87.9%	Outlier	
UCAN	0.992	0.8%		16	**UPV**	1.162	16.2%		3
UCM	1.002	0.2%		18	**UNAVAR**	0.914	8.6%		11
UEX	1.102	10.2%		8	**URJC**	2.114	111.4%	Outlier	
UGR	1.301	30.1%	Outlier		**URV**	1.066	6.6%		13
UJAEN	0.896	10.4%		7	**USC**	1.120	12%		6
UR	1.093	9.3%		9	**UV**	1.141	14.1%		4
ULPGC	1.087	8.7%		10	**UVA**	1.124	12.4%		5
UMA	1.004	0.4%		17	**UZ**	0.961	3.9%		14
UPO	0.931	6.9%		12					

Note: Table A3 in the appendix shows the list of Spanish public universities and the acronyms used throughout the text.
Source: Our own data.

We find five outliers among the universities: Barcelona (UB), Granada (UGR), Basque country (EHU), Polytechnic of Madrid (UPM) and Rey Juan Carlos (URJC). The observation of the input and output values of these universities sheds some light on their peculiarities. In general, these are universities where at least one of the variables used shows an extreme value, disproportionate with respect to its other variables or with respect to the average values.

The Spearman rank correlation coefficient informs us of the level of association between the orderings obtained by both approaches. The computed value of 0.5191 with a high significance level indicates an intermediate level of correspondence between the ordering of universities with and without outliers. In the former case, outliers have been removed from the list even if they were considered in order to compute the efficiency scores.

We can now ask what the efficiency scores would be if the outliers were left out of the computation. Applying the DEA again under the hypothesis of variable returns to scale without considering outlier units, all the universities present greater efficiency indexes, as expected. The average inefficiency is now 7.2% compared to the previous 8.3%.

Obviously, universities that were already efficient in the first estimate now remain efficient, but with this procedure the number of efficient universities has increased: instead of 18 there are now 23[12]. The five universities that now appear as efficient are: Autonomous University of Barcelona (UAB), Carlos III of Madrid (UC3M), Miguel Hernández (UMH), Oviedo (UNIOVI) and Seville (US). Among these universities, the most distant scores between the initial index and the outlier-corrected index correspond to the University Carlos III of Madrid and to the University of Seville. So these two institutions are the most harmed by the presence of outliers. This result is confirmed by the figures in table 3, where the peers of these universities with more weight were in fact outliers.

4.4 NCIs and efficiency

[12] Once we drop the five outliers, the number of efficient universities falls from 23 to 18.

4.4.1 Second-stage regression analysis

The results derived by running a second-stage Tobit regression are shown in table 5. No sign changes are observed when including or excluding strongly correlated explanatory variables. Moreover, the levels of global significance (F-test) and the levels of individual significance of the coefficients are consistent, that is to say, there are no multicollinearity problems.

Table 5. Linear regression results

	Coefficient	Std. Err.	t	P>t	[95% conf. Interval]	
NCI_1	-0.0006722	0.003088	-0.22	0.83	-0.007188	0.005844
NCI_2	8.74E-02	0.124286	0.7	4.91E-01	-0.174796	0.349646
NCI_3	-3.34E-06	3.83E-06	-0.87	0.395	-0.000011	4.74E-06
NCI_4	0.1000928	0.052688	1.9	0.075	-0.011070	0.211256
NCI_5	-0.0000121	0.000014	-0.81	0.43	-0.000043	0.000019
NCI_6	-0.0006272	0.010261	-0.06	0.952	-0.022277	0.021022
Const	0.2450164	0.611646	0.4	0.694	-1.045445	1.535478

Observations: 23
Pseudo R2=-0.1833
Log likelihood = 15.863825

Source: Our own data.

The effect of NCI_4 on the index of global efficiency is highly significant – above 90%. This means that the quality of students can explain the inefficiency levels of non-efficient universities. Since the sign of the coefficient of this variable is positive, its influence on the index of efficiency is also positive. Our results indicate that the other NCIs do not affect the efficiency index significantly and, therefore, efficiency can be written exclusively as a function of NCI_4 as follows:

$$h_j = 0.2450164 + 0.052688 \cdot (NCI_4) + e_j$$

where, as explained, e_j is the part of the inefficiency not determined by the influence of the NCIs and can be attributable to governance failures.

In accordance with the procedure described in section two, $\bar{h}_j$ = 0.2450164 + 0.052688·(NCI_4) and the value of e_j will be given by the difference $(\bar{h}_j - h_j)$. Applying the correction suggested by Greene (1980) to make sure that these differences are positive, the new corrected value $\bar{\bar{h}}_j$ is obtained. In this case, the biggest positive residual (0.140) corresponds to the University of Burgos. Thus, this is the value that must be added to the regression constants to obtain the values of $\bar{\bar{h}}_j$. To simplify, table 6 presents the values of both inefficiencies expressed as percentage of total inefficiency.

The results show that in fifteen universities the whole inefficiency can be attributed to governance failures. As expected, the university that presented the biggest positive residual, the University of Burgos, is the one that benefited most from the correction suggested by Greene, and its inefficiency is fully attributable to the influence of NCI_4. Only one other university, Huelva, presents a percentage of inefficiency due to the influence of this environmental factor that was greater than that attributable to deficient governance.

Table 6. Share of inefficiency attributable to NCIs (regression results)

University	Inefficiency	% governance	% NCIs	University	Inefficiency	% governance	% NCIs
UAH	0.247	100	0	**UJI**	0.538	100	0
UA	0.245	100	0	**ULL**	0.225	100	0
UAL	0.278	78.1	21.9	**ULEON**	0.064	100	0
UAB	0.011	100	0	**UdL**	0.016	100	0
UBU	0.102	0	100	**UMH**	0.001	100	0
UCA	0.120	100	0	**UM**	0.223	100	0
UC3M	0.262	91.2	8.8	**UNIOVI**	0.024	100	0
UCLM	0.054	100	0	**UPCT**	0.229	53.3	46.7
UCO	0.085	81.2	18.8	**UPF**	0.032	100	0
UdG	0.124	99.2	0.8	**USAL**	0.073	100	0
UHU	0.198	43.4	56.6	**US**	0.204	100	0
UIB	0.441	93.4	6.6				

Source: Our own data.

4.4.2 Three-stage adjusted values model

As indicated above, the only NCI that was significant when applying the regression technique, NCI_4, is taken into account. Thus, the number of variables used in the DEA application in the second stage will be 1 + 7 = 8 (one output: NCI_4, and seven inputs: the slacks of each one of the inputs and outputs of the non-efficient universities). All universities improve their efficiency scores except the University of Oviedo. To explain this, we observe that the values of the slacks of this university, for almost every input and output, are very small and much lower than those of the rest of universities[13]. This may mean that the rounding errors are more relevant in this case. In consequence, the distribution of the aggregated slack between the part attributable to governance failures and that corresponding to the influence of the NCI is not robust. To counteract this situation, we assumed that the maximum index attainable by this university given its endowment of NCIs is the initial score obtained with the original DEA. Since the value of NCI_4 in this university is greater than the average, we will consider that this variable exercises a positive effect on its efficiency and, because of this, we attribute its whole inefficiency to governance failures.

The values of each form of inefficiency expressed in percentage terms of the total are presented in table 8. This technique assigns the whole inefficiency to governance in 17 of the 23 universities. In four universities, inefficiency due to deficient governance is higher than the influence of the environmental factors that we have considered. Only in two universities, Castilla-la Mancha and Miguel Hernández, was the inefficiency due to the influence of the NCI greater than that of bad governance.

[13] Non-radial slacks for the University of Oviedo are all equal to zero with the exception of the success rate which nonetheless is very low. Given that radial slacks are relatively low as well and inefficiency is only 2.4%, this university is very close to the efficiency frontier with null projections over the linear segments of the frontier (those parallel to the axes).

Table 7. Share of inefficiency attributable to NCI

University	Inefficiency	% governance	% NCIs	University	Inefficiency	% governance	% NCIs
UAH	0.247	100	0	**UJI**	0.538	100	0
UA	0.245	100	0	**ULL**	0.225	100	0
UAL	0.278	83.3	13.7	**ULEON**	0.064	100	0
UAB	0.011	100	0	**UdL**	0.016	100	0
UBU	0.102	88.2	11.8	**UMH**	0.001	0	100
UCA	0.120	100	0	**UM**	0.223	99.1	0.9
UC3M	0.262	100	0	**UNIOVI**	0.024	100	0
UCLM	0.054	35.2	64.8	**UPCT**	0.229	100	0
UCO	0.085	100	0	**UPF**	0.032	100	0
UdG	0.124	100	0	**USAL**	0.073	100	0
UHU	0.198	78.3	21.7	**US**	0.204	100	0
UIB	0.441	100	0				

Source: Our own data.

Our results clearly indicate that a great deal of Spanish HEIs' inefficiency is attributable to deficient governance. In this regard, there is scope for improvement in performance due to better governance mechanisms. Nevertheless, even if the reforms recently implemented all over Europe represent an effort to rectify some past "government failures"; modern market-based reforms are not free from difficulties. While governance measures usually emphasize formal structure, bodies and decision-making structures, the governance of HEIs is strongly influenced by informal networks, collegial agreements, and more process-oriented decision-making structures (Gornitzka, Kogan and Amaral 2005). Since teaching, research, and knowledge transfer rely on faculty, an important aim of governance reforms is to focus on the institutional conditions that stimulate creativity and productivity.

In the last decade, many Spanish universities have begun implementing strategic management and planning systems and have taken steps to improve quality. Many have drawn up medium-term and long-term (5-10 year) action plans based on assessments of internal operations and determining factors, as well as on the environment in which they operate. Many factors have motivated universities to adopt strategic planning measures in response to growing concerns about attracting students and funding: for example, the increasing social demand for better quality, greater complexity in teaching and research management, the need to provide value-added services to the community, and the need to extend and improve links with the economic and social environment.

We believe that the introduction of governance reforms in Spanish universities, still a matter of debate, will help to increase efficiency in research and teaching. Schubert (2009) identifies four potential sources of efficiency gains from market-based governance reforms. The first is to increase the operational flexibility of the universities, through faster decision-making and more problem-oriented processes. The second is to increase accountability by strengthening internal hierarchical elements in order to reduce the danger of moral hazard. The third source is to provide more information to managers usually by means of the introduction of internal accounting models. Finally, the fourth is to improve competencies regarding HEI strategic decisions. All these factors are likely to enhance teaching and research efficiency as they set out an overall agenda for the departments and the university as a whole.

5. Conclusions

Using a DEA model this paper has examined the relationship between governance and efficiency in Spanish universities in the academic year 2004-2005. The inputs and outputs used were defined in terms of the Performance Evaluation Indicators literature in order to take into account quality considerations that are often neglected in efficiency studies. The inputs included in the analysis were the student to faculty and the faculty to staff ratios as well as non-labour expenditure per student. In the case of outputs, we opted for two teaching outputs, academic return and success rates, and two research outputs, JCR-indexed publications per faculty and Euros per student from R&D activities. Our methodological strategy consists in computing outlier-free efficiency scores with the superefficiency procedure. In the second stage, when corrected efficiency scores are computed, we control for several environmental factors in order to explain the observed inefficiency. We use two alternative methods, a second-stage regression analysis and a three-stage adjusted values non-parametric model as a robustness check. At this stage we are able to separate the inefficiency attributable to non-controllable inputs (NCI) from that corresponding to governance.

With the standard DEA model, the number of efficient universities when considering constant returns to scale is 17, with an average efficiency of 89.2%. However, under the assumption of variable returns to scale, the number of efficient universities increases to 23, and average efficiency to 91.7%. With these results at hand, one could argue that universities could increase their output by an average of 8.3% with the inputs they are already using. In the standard DEA model efficient units cannot be differentiated, but the modified DEA model allows for the determination of outlier DMUs and the computation of robust efficiency. Our results indicate that there are five outlier universities that should be removed from the database in order to compute unbiased efficiency scores. Introducing this correction, the average inefficiency is now 7.2%, slightly lower than that obtained with the standard DEA model. When controlling for environmental factors, the results from the second stage regression analysis show that in 15 out of 23 universities the whole of the observed inefficiency can be attributed to governance failures. When using the three-stage adjusted values model, in 17 of the 23 universities this technique assigns the whole of the inefficiency to bad governance. Our results clearly indicate that a great deal of inefficiency in Spanish HEIs' is attributable to deficient governance, and highlight the scope for improvement in performance through better governance mechanisms.

In the knowledge society, universities are expected not only to teach and research, but also to actively contribute to social and economic development in a context of increased institutional global competition. This scenario differs significantly from the one that shaped administrative structures in the Spanish higher education sector in the past. Therefore, governance reform in Spanish HEIs is urgently needed. Several goals should be kept in mind in designing a new governance structure. First, the key role of universities in the creation and development of relevant social and economic values should be preserved. Second, universities should be able to compete effectively in the globalized higher education markets. Third, quality education must be provided and adapted to social needs and labor market demands. These main goals call for the following short-term objectives on the part of Spanish HEIs: i) an increase in the flexibility of decision-making mechanisms; ii) an increase in, and reinforcement of, the links between universities and society; iii) the design and execution of individualized institutional strategic planning; iv) an increase in transparency and accountability. These objectives coincide with the trends observed recently in European higher education system reforms.

Further research should try to overcome some of the limitations of this study. For instance, a key issue is the analysis of the link between governance and efficiency with direct measures of governance quality. Further, another major limitation is related to the evolution of the effects of governance on efficiency. The question of whether this has changed or not during the recent years as a consequence of current reforms in the Spanish higher education sector remains unanswered in our analysis, but certainly constitutes a research question to be addressed in the future. Even though we have adopted a novel approach to the definition of inputs and outputs, more research is needed in order to see whether the results obtained in this study are sensitive to the definition of inputs and outputs and whether the PEI approach is effective for the introduction of consideration of quality in efficiency analysis.

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Appendix

Table A1: Efficiency scores of Spanish public universities

Univ.	*Index CR*	*Index VR*	*CR/VR*	*Univ.*	*Index CR*	*Index VR*	*CR/VR*
UDC	1.000	1.000	1.000	**ULPGC**	1.000	1.000	1.000
UAH	0.723	0.753	0.961	**ULEON**	0.935	0.936	1.000
UA	0.750	0.755	0.993	**UdL**	0.846	0.984	0.859
UAL	0.696	0.722	0.965	**UMA**	1.000	1.000	1.000
UAB	0.933	0.989	0.944	**UMH**	0.981	0.999	0.982
UAM	0.971	1.000	0.971	**UM**	0.768	0.777	0.989
UB	1.000	1.000	1.000	**UNIOVI**	0.934	0.976	0.956
UBU	0.861	0.898	0.959	**UPO**	0.929	1.000	0.929
UCA	0.876	0.880	0.995	**UPV-EHU**	1.000	1.000	1.000
UCAN	0.992	1.000	0.992	**UPCT**	0.742	0.771	0.962
UC3M	0.701	0.738	0.949	**UPC**	1.000	1.000	1.000
UCLM	0.894	0.946	0.945	**UPM**	1.000	1.000	1.000
UCM	1.000	1.000	1.000	**UPV**	1.000	1.000	1.000
UCO	0.902	0.915	0.986	**UPF**	0.818	0.968	0.845
UEX	1.000	1.000	1.000	**UNAVARRA**	0.914	1.000	0.914
UdG	0.785	0.876	0.897	**URJC**	1.000	1.000	1.000
UGR	1.000	1.000	1.000	**URV**	1.000	1.000	1.000
UHU	0.774	0.802	0.964	**USAL**	0.910	0.927	0.981
UIB	0.546	0.559	0.976	**USC**	1.000	1.000	1.000
UJAEN	0.894	1.000	0.894	**US**	0.776	0.796	0.975
UJI	0.456	0.462	0.985	**UV**	1.000	1.000	1.000
ULL	0.761	0.775	0.982	**UVA**	1.000	1.000	1.000
UR	1.000	1.000	1.000	**UZ**	0.961	1.000	0.961

Table A2: Inefficient universities and information of their peers and weights

Univ.	Index (VR)	Peers *(Weight over the inefficient university)*						
24: UMH	0.999	UPC (16%)	URV (23.7%)	UCAN (2.5%)	URJC (57.9%)			
25: UAB	0.989	UPV (23.8%)	UV (14.4%)	UZ (15.3%)	UB (46.5%)			
26: UdL	0.984	UZ (44.1%)	URJC (10.7%)	UNAVARR (21.6%)	UR (23.6%)			
27: UNIOVI	0.976	UGR (33.2%)	UPO (7.8%)	UJAEN (2.3%)	UR (10.3%)	EHU (31.5%)	UDC (14.8%)	
28: UPF	0.968	UPV (13%)	UV (2.8%)	URJC (25.7%)	UNAVAR (54.6%)	UR (3.8%)		
29: UCLM	0.946	UGR (31.7%)	UPO (20%)	UR (14%)	URJC (0.4%)	UDC (34%)		
30: ULEON	0.936	UMA (7%)	UR (45.8%)	UDC (47.3%)				
31: USAL	0.927	UV (22.7%)	EHU (17.7%)	UZ (2.2%)	URJC (3.2%)	UNAVAR (11.1%)	UR (43%)	
32: UCO	0.915	USC (15.4%)	URJC (1.8%)	UZ (1.8%)	UV (55.9%)	UR (7.3%)	URV (17.8%)	
33: UBU	0.898	UV (8%)	URJC (10.7%)	UR (67.7%)	UDC (13.6%)			
34: UCA	0.880	UJAEN (4.3%)	UVA (59.3%)	EHU (7.3%)	UR (28.7%)	URJC (0.4%)		
35: UdG	0.876	UZ (41.3%)	UV (4.7%)	UR (43.6%)	URJC (7.5%)	UNAVAR (2.9%)		
36: UHU	0.802	UV (33%)	URJC (10.5%)	UR (48.8%)	UDC (7.7%)			
37: US	0.796	UV (7.6%)	UGR (76.9%)	UCM (15.6%)				
38: UM	0.777	UVA (7.2%)	UDC (30.1%)	UGR (34.8%)	UV (21.5%)	URJC (6.3%)		
39: ULL	0.775	UGR (18%)	UR (1.6%)	UEX (27.6%)	EHU (11.1%)	UVA (41.8%)		
40: UPCT	0.771	UPC (4%)	UPM (34.6%)	UPV (40.1%)	URJC (21.2%)			
41: UA	0.755	UV (32.1%)	UR (5.5%)	UDC (57%)	URJC (5.5%)			
42: UAH	0.753	URJC (2.2%)	USC (3.2%)	EHU (3.2%)	UV (28.3%)	UNAVAR (27.2%)	UZ (6.9%)	UR (29%)
43: UC3M	0.738	UNAVAR (15.6%)	EHU (37.6%)	UZ (3.7%)	URJC (43.1%)			
44: UAL	0.722	UV (38.1%)	UR (26.2%)	UDC (35.7%)				
45: UIB	0.559	UV (5.4%)	URJC (18.9%)	UR (38.1%)	EHU (28.1%)	UZ (9.5%)		
46: UJI	0.462	USC (3.1%)	UDC (17.3%)	UV (68.7%)	URJC (10.9%)			

Source: Our own data.

Table A3. Spanish public universities

UDC: Universidad de A Coruña	ULEON: Universidad de León
UAH: Universidad de Alcalá de Henares	UdL: Universitat de Lleida
UA: Universitat d'Alacant	UMA: Universidad de Málaga
UAL: Universidad de Almeria	UMH: Universitat Miguel Hernández d'Elx
UAB: Universitat Autònoma de Barcelona	UM: Universidad de Murcia
UAM: Universidad Autónoma de Madrid	UNIOVI: Universidad de Oviedo
UB: Universitat de Barcelona	UPO: Universidad Pablo de Olavide
UBU: Universidad de Burgos	UPV-EHU: Universidad del País Vasco. Euskal Herriko Unibertsitatea
UCA: Universidad de Cádiz	UPCT: Universidad Politécnica de Cartagena
UCAN: Universidad de Cantabria	UPC: Universitat Politècnica de Catalunya
UC3M: Universidad Carlos III de Madrid	UPM: Universidad Politécnica de Madrid
UCLM: Universidad de Castilla-La Mancha	UPV: Universitat Politècnica de Valencia
UCM: Universidad Complutense de Madrid	UPF: Universitat Pompeu Fabra
UCO: Universidad de Córdoba	UNAVARRA: Universidad Pública de Navarra
UEX: Universidad de Extremadura	URJC: Universidad Rey Juan Carlos
UdG: Universitat de Girona	URV: Universitat Rovira i Virgili
UGR: Universidad de Granada	USAL: Universidad de Salamanca
UHU: Universidad de Huelva	USC: Universidad de Santiago de Compostela
UIB: Universitat de les Illes Balears	US: Universidad de Sevilla
UJAEN: Universidad de Jaén	UV: Universitat de València Estudi General
UJI: Universitat Jaume I de Castelló	UVA: Universidad de Valladolid
ULL: Universidad de La Laguna	UVIGO: Universidad de Vigo
UR: Universidad de La Rioja	UZ: Universidad de Zaragoza
ULPGC: Universidad de Las Palmas de Gran Canaria	

2009

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