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The impact of the economic crisis on the (in)efficiency of public Higher Education Institutions in Southern Europe: the case of Spanish universities

Abstract

The evaluation of university efficiency in Europe began timidly when the European Higher Education Area (EHEA) was created. However, this issue is currently becoming increasingly important in Southern European countries, where the limitation of public funding following the economic crisis in 2008 has put greater pressure on their public universities to achieve excellence and improve competitiveness. In this context, the goals of this paper are: first, to measure the relative technical (in)efficiency of Spanish public Higher Education Institutions in the period 2002-03 to 2012-13, comparing the situation before and during the last economic crisis; and, second, to analyze the determinants of university (in)efficiency and, especially, the direct impact of the crisis. After applying the two-stage double bootstrap DEA methodology, the results show that Spanish public universities have become more efficient during the crisis than before it. In fact, the regression analysis confirms that the "crisis" variable has had a statistically significant positive impact on university efficiency. We also find that age has favorably influenced how these institutions utilize their resources to produce teaching and research outputs, but technical specialization has had a negative effect. Moreover, the regional location of public universities has been also a crucial determinant of their efficiency level. Our findings are therefore relevant for political and academic decision-makers in order to know if public universities have been adequately managed in the crisis period and to identify factors that could improve their efficiency, and hence to help them to enhance their international competitiveness in the future.

Keywords: Public Higher Education Institutions; Spanish universities; (in)efficiency, economic crisis, Southern Europe; two-stage double bootstrap DEA

1. Introduction

In Europe, the Bologna Declaration signed in 1999, which promoted the European Higher Education Area (EHEA), introduced for the first time the efficiency criterion in university management to improve the performance of Higher Education Institutions (HEIs) in order to make the European university system more competitive internationally (Huisman and Van der Wende 2004; Agasisti and Haelermans 2016; Wolszczak-Derlacz 2017).

Within Spain, evaluation of university efficiency first became relevant with the *Organic Law on Universities 6/2001, dated 20 December* (*LOU*), subsequently amended by the *Reform of the Organic Law on Universities 4/2007, dated 12 April* (*RLOU*), both of which aimed to adapt the national university system to the EHEA (Fernández-Santos et al., 2013). Spanish HEIs have traditionally had serious competitiveness problems. Specifically, there have been doubts about their efficiency because, in general, the inputs used have increased more than the results achieved, and about their economic and social contribution (Ruíz et al. 2015). For this reason, the main challenges of this new regulatory framework in Spain were to achieve greater excellence in teaching and research activities of the universities and to improve their efficiency in order to increase their international competitiveness (Berbegal-Mirabent, 2018).

The economic crisis in 2008 resulted in several years of austerity measures that have impacted on all aspects of the economy and society in Europe, and particularly on its Higher Education sectors (Clarke et al. 2018). Specifically, the recent crisis has led to more drastic budget cuts in the university systems of the Southern European countries than in those of the rest of the continent, stimulating greater competition for increasingly scarce public funding and other revenues sources (Cattaneo et al. 2019; Skrbinjek et al. 2018). All this has put additional pressure on HEIs to increase their performance from the available resources, so that in recent years the improvement of their efficiency has become one of the main goals of Higher Education systems in Southern Europe (Agasisti et al., 2016; Barra et al. 2018), and more specifically of the Spanish university system (Ruíz et al. 2015).

Obviously, this efficiency objective is particularly important for the subsector consisting of public HEIs, namely those that are established and mainly financed by the government, especially in an austerity context that requires them to be more productive in the utilization of public resources and to have an unavoidable duty to render accounts to society of the actions of a public service (Carrington et al. 2018). Specifically, knowledge of the level of efficiency achieved by public universities and of the variables that can affect it is very useful for both political and institutional decision-makers because it can be used as an indirect evaluation of the use of public funding in teaching and research activities, allowing them to understand how efficient these institutions are, to adopt measures to improve their management, and to promote those factors that will lead to a higher level of university efficiency (Molin et al. 2017).

Research on the efficiency of public HEIs is therefore becoming increasingly important internationally (De Witte and López-Torres 2017). However, there are not many studies on this topic both in Southern Europe in general and in Spain in particular, despite the weaknesses of their Higher Education systems and that the vast majority of their universities are publicly financed (Ruíz et al. 2015; Barra et al., 2018). In this context, our paper aims to achieve two goals: first, to assess the relative technical (in)efficiency of Spanish public universities during the period between the 2002-03 and 2012-13 academic years in order to compare the levels achieved before and during the last economic crisis; and, second, to identify the factors behind their (in)efficiency, placing special emphasis on the possible impact of the crisis. In order to achieve these goals, we apply the two-stage double bootstrap Data Envelopment Analysis (DEA) methodology since recent studies advice the analysis of efficiency in the context of public Education with bootstrapping techniques (Agasisti and Zoido, 2019).

This study contributes to the literature for the following reasons. *First*, since the evaluation of university efficiency is one of the most important concerns of political and academic decision-makers in Southern Europe, this study provides new data on the efficiency of its public HEIs, adding empirical evidence to the limited research carried out to date. In particular, this study focuses on Spain, which is a good study reference for Southern European countries because the characteristics of its Higher Education system and the impact of the crisis on it resonate with those of Italy, Portugal and Greece (Skrbinjek et al. 2018). Given that both the new legal context and the budgetary restrictions following the 2008 economic crisis have required Spanish public HEIs to reach reasonable levels of technical efficiency, it is interesting to study if they have really achieved this goal in an increasingly competitive environment. *Second*, our study covers a fairly long period and, with a longitudinal approach, it compares for the first time university efficiency in Spain in two sub-periods: pre-crisis and crisis. The latter is of great importance for Southern European countries due to the adverse effects of recent crisis for their economies in general and for public Higher Education systems in particular, which are less developed than those in the rest of Europe. However, to our knowledge, only Agasisti and Wolszczak-Derlacz (2016) have compared the efficiency of Italian publics HEIs before and during the crisis. *Third*, our study analyzes the main determinants of efficiency in public HEIs and, especially, the direct impact of the last economic crisis. Although knowing the factors that might improve the efficiency of public universities is especially relevant for managing them and for making them more competitive in the current scenario of globalization of Higher Education, to date, there are few studies on this topic in both Europe and Spain. Moreover, to our knowledge, only the recent study by Lehmann et al. (2018) has examined the direct impact of the "crisis" variable on university

efficiency in Germany and Italy. *Fourth*, from a methodological perspective, our study applies the two-stage double bootstrap DEA methodology, which allow us to reach more robust and generalizable results than the methods traditionally used in this area of research.

The remainder of the paper is structured as follows. Section 2 gives an overview on Higher Education systems in Southern Europe in general and on the Spanish university system in particular. Then, section 3 reviews the empirical background. The research design is described in Section 4, and Section 5 presents the results of the data analysis. Finally, Section 6 draws the main conclusions and implications.

2. Public Higher Education systems in Southern Europe: an overview

All Southern European countries (Portugal, Italy, Greece and Spain) have shared similar attributes regarding their public university systems, which have been weaker than those in Northern and Central Europe for decades, and they are still developing today due to they have not rapidly adapted to the global context of Higher Education and the changes it entails (Skrbinjek et al. 2018). In particular, their main weaknesses have traditionally been the following (EUA, 2014; Cattaneo et al. 2019): (a) the lack of competition among HEIs increasing the role of government in funding them; (b) poor teaching and research performance, since the public funds each university receives are based on input measures (for example, number of students) without any reliable evaluation of their outputs; (c) the underfunding by government; (d) an excessive control by government implying low levels of financial and organizational autonomy for HEIs, and limited strategic capacity; (e) the problems of inbreeding, lack of meritocracy, nepotism, etc. that may be related to poorly qualified staffs; and (f) the mismatch between Higher Education and labour market requirements.

The recent economic crisis has amplified the chronic crisis of public Higher Education systems in Southern Europe because these countries have been hit by the crisis harder than other European countries, and the negative impact of austerity policies on their university sectors has been more severe due to they were poorly equipped to adapt to the new environment of shrinking resources (Clarke et al. 2018). Specifically, in Greece, the external interference of international creditors represented by a troika forced the dismissal of thousands of university professors and researchers, and a contingency budget that eliminated most of the elementary services of public universities. In Italy, Portugal and Spain, the radical cuts in Higher Education budgets have jeopardized their basic functioning in last years. On average, a decrease by more than 10% in the public expenditure on Higher Education, as a percentage of Gross Domestic Product (GDP), can be perceived in Southern European countries between 2008 and 2013 (EUA, 2014).

The limitation of public funding following the crisis together with the challenges of globalization, demographic change and technological innovation have placed even greater emphasis on increasing the quality of public Higher Education systems in Southern Europe. In a scenario like this, one of the main concerns of governments and the universities themselves has been the need to achieve a more efficient management of public resources to guarantee the sustainability of these institutions, which has led to the national university systems have been characterized by policy interventions aimed at stimulating competition among HEIs (Agasisti et al., 2016; Barra et al., 2018). Despite this, there are hardly any previous studies that have analyzed the impact of the 2008 crisis on university efficiency in Southern European countries. Our study addresses this issue by focusing on the Spanish Higher Education system.

2.1. The Spanish case

Up to the 1970s, the Higher Education sector in Spain was homogeneous, elitist, focused on teaching and detached from the country's needs. But, during the following decade, a number of factors brought an important process of change to the Spanish university system (Hernández Armenteros and Pérez García 2011): (a) the rise in the population; (b) economic growth; (c) a more qualified workforce motivated by growing unemployment; (d) private profitability of university studies for graduates in terms of higher remuneration; (e) the rise in compulsory schooling; (f) the increase in public investment in Higher Education; and (g) the creation of new universities. This situation facilitated access to university education, boosting the number of students in Higher Education. In addition, research activity was also stepped up and new competencies, such as the transfer of knowledge to society, were attributed to universities. Thus, legislative reform became necessary.

In the 1980s, the *Organic Law 11/1983, dated 25 August, on University Reform* (*LRU*), was passed, triggering political and administrative decentralization of Higher Education from the central government to the regions. Since then, the financing and management of Spanish universities depends on the policies and strategies adopted by regional governments, which have full authority to decide the level of public direct funding, the tuition fees that residents in the regions should pay, if they set up additional regional R&D funding strategies, etc.

After the Bologna Declaration in 1999, which lays the foundations for the creation of the EHEA, the Spanish Higher Education system had to adapt to European requirements. The two last legislative reforms, *LOU* in 2001 and, later, *RLOU* in 2007, created a new legal context aiming to improve the performance in the Spanish university system

(Berbegal-Mirabent, 2018). Shortcomings in the quality and international relevance of the educational services provided by public HEIs in Spain and their inadequate management of the resources available had traditionally given rise to problems regarding their efficiency and international competitiveness. In general, the university resources used had increased more than the teaching and research outputs generated, and there had been doubts about the economic and social contribution of public Spanish universities because the return on the investments made over many years had been limited by the inefficiencies of the institutions themselves and by the characteristics of the country's production fabric (Ruíz et al. 2015). In this context, both the *LOU* and the *RLOU* introduced certain technical measures aimed at promoting university efficiency (Fernández-Santos et al., 2013): (a) restructuring of Higher Education into three cycles – bachelor's degree, master's degree and doctorate – to endorse the role of students and improve their training and employability; (b) introduction of a new promotion and accreditation system for academic staff based on reliable evaluations of teaching and research activities; (c) improvement of relations between universities and firms; and, finally, (d) promotion of international mobility of students and academic/administrative staffs, as well as collaboration between Spanish and foreign universities.

However, several difficulties arose in the execution of these measures, coinciding with the decline in government spending on Higher Education that occurred after 2008 as a consequence of the crisis. On the basis that the bulk of the income of Spanish public universities is the block grant assigned by their respective regional governments (80% approximately), their funding as a percentage of GDP decreased by 16.2% between 2008 and 2013 (EUA, 2014). More specifically, expenditure per university student as a proportion GDP per capita dropped by 15% in Spain. This reduction in public funding, together with the greater concern for increasing the Higher Education performance, led to the implementation of pro-competitive policies in the Spanish university sector – for example, the growing link between government economic support and outstanding results, or the stricter requirements from the public quality assurance agencies for both the evaluation of research activity and the promotion of teaching staff – , which has resulted in greater competition among HEIs. All this have exerted even more pressure on public Spanish universities to achieve excellence and improve international competitiveness, so that knowledge of the evolution of their efficiency, comparing the situation before and during the crisis, has become a matter of increasing importance for political and university authorities, as well as for society in general.

During the period between the implantation of the LOU in 2002 and the end of the last economic crisis in 2013, the Spanish Higher Education system was comprised of 77 HEIs of which 50 were public universities (approximately 65% of the total). Of the public HEIs, 47 were campus-based institutions, one was for distance learning, and the other two only taught specialist postgraduate programmes. In Spain, public and private universities are embedded within the same regulatory framework, which assigns them the same basic activities – teaching and research –. However, public universities are constrained by greater regulation and control mechanisms than private universities. These differences regarding autonomy with their different nature entail distinct internal organisational structures for the development of the same activities, that is, different managerial procedures for consumption of the same inputs to produce the same outputs (De la Torre et al., 2017).

3. Literature review

3.1. Evaluation of university efficiency in Europe

The efficiency of an organization can be analyzed from two different points of view (Farrell, 1957): *technical efficiency*, which refers to the best possible relation between the amounts of inputs used and of outputs obtained, and *allocative efficiency*, which refers to whether the best possible combination of inputs is being used at current market prices. The concept that best adapts to evaluate whether public universities are performing efficiently is that of technical efficiency (which ranges from 0% -fully inefficient- to 100% -fully efficient-) because it is more related to the assessment of the efficiency on the public service provision whereas the allocative efficiency is more related to market criteria (De Witte and López-Torres 2017).

Over the last few years, renowned academics in the field of the Economics of Education have considered it relevant to evaluate the efficiency of the public HEIs, especially because of the need for them to be accountable for the way the resources provided by citizens are used, and to assess the excellence of such institutions in a highly competitive environment (Agasisti and Haelermans 2016; Molin et al. 2017; Carrington et al. 2018). Empirical research on this topic is therefore becoming increasingly important at an international level in recent years (De Witte and López-Torres 2017).

Within Europe, country-specific research has been mainly focused on the United Kingdom. While some prior studies (Flegg et al., 2004; Johnes, 2006; Thanassoulis et al., 2011; Johnes, 2014) showed good values for average technical efficiency in British public universities in some academic year before the last crisis (around 90%), the recent study by Papadimitriou and Johnes (2018) found that their mean efficiency decreased over a 17-year period (between 1996-97 and 2012-13 academic years), obtaining a value close to 70% during the crisis period.

In Southern Europe, there has been limited research on the technical efficiency of public HEIs, which has been mostly carried out in Italy and Spain. Among the country-specific studies for Italy, Agasisti and Dal Bianco (2006) considered a sample from 58 HEIs in the 2002-2003 academic year, showing an acceptable average efficiency value (85%). More recently, both Agasisti et al. (2016) and Barra et al. (2018) examined 53 universities over the 4-year period 2008-2011 and found that Italian public HEIs increased their efficiency as the crisis progressed, obtaining mean scores of around 89%. For Spain, De la Torre et al. (2017) compared the efficiency of 47 public HEIs in the 2009-10 and 2013-14 academic years, showing an increase of 70% to 79%. With a longitudinal approach, Fernández-Santos et al. (2013) evaluated 39 universities over a 7-year period (between the 2002-03 and 2008-09 academic years), obtaining an average level of efficiency of 86.1%, whereas Berbegal-Mirabent et al. (2013) reported a mean value of 88.4% in a sample of 44 institutions over a 3-year period (between the 2006-07 and 2008-09 academic years).

Finally, previous research has also evaluated the efficiency of European public HEIs from a cross-country perspective: first, the study by Agasisti and Pérez-Esparrells (2010) compared the university efficiency levels in two Southern European countries, Italy and Spain, in the 2000-01 and 2004-05 academic years, finding that the efficiency of Italian and Spanish HEIs was similar in 2000-01, while the former were more efficient than the latter in 2004-05. Second, other studies compared the efficiency of publics HEIs in a Southern European country, Italy, to that of universities in other European countries such as the United Kingdom (Agasisti and Johnes, 2009), Germany (Agasisti and Pohl, 2012), and Netherlands (Agasisti and Halermans, 2016), before the recent crisis. All of them found that Italian institutions underperformed their European counterparts. Third, only one study compared the efficiency of Italian publics HEIs to that of institutions in another European country –Poland– before and during the crisis (Agasisti and Wolszczak-Derlacz, 2016). The findings showed that, on average, Italian universities turned out to be less efficient than Polish ones over the whole period 2001-11. Moreover, the public HEIs of both countries improved their average efficiency during the crisis period compared to the previous academic years. Lastly, two studies assessed university efficiency in several European countries. While Wolszczak-Derlacz and Parteka (2011) focused on seven European countries (only Italy from Southern Europe) in the period 2001-05, finding that, on average, Swiss universities were the most efficient, Wolszczak-Derlacz (2017) examined a sample of HEIs from ten European countries (Italy and Spain from Southern Europe) during the whole period 2000-10, showing that, on average, English and Polish universities performed more efficiently than those from the rest of Europe.

3.2. Determinants of university efficiency in Europe

Taking the main studies that explain the efficiency of European Higher Education institutions as a reference (Wolszczak-Derlacz and Parteka 2011; Agasisti and Pohl 2012; Agasisti and Wolszczak-Derlacz 2016; Agasisti et al., 2016; Wolszczak-Derlacz 2017), five possible determinants of university efficiency can be singled out:

- *Size:* In theory, the largest universities tend to be more efficient because they can benefit from economies of scale so it is easier for them to improve the inputs used and/or the outputs generated in their activities. However, big universities are also slower and less flexible in organisational terms, which may lead to less efficient management. In this regard, prior evidence shows that the size of HEIs has a positive and significant influence on their levels of efficiency (Wolszczak-Derlacz and Parteka 2011; Agasisti and Wolszczak-Derlacz 2016; Wolszczak-Derlacz 2017).

- *Age:* The experience, know-how and lower operating costs associated with a mature institution, and the privileges brought by the reputation of older universities may help to improve their efficiency. However, younger universities may benefit from greater flexibility, adapting better to changes in law and their environment, and may also have more modern structures enabling them to manage their resources better. The studies by Wolszczak-Derlacz and Parteka (2011) and Wolszczak-Derlacz (2017) find that older HEIs are more efficient.

- *Specialization in technical fields:* Teaching and research specialization in universities can be viewed as a differentiation strategy that seeks to position their activities in a unique or different way than generalist competitors, implying also that they only have to invest in resources that are specific to the services they offer, all of which may increase their efficiency. However, the higher costs of providing such specialized services may lead to less efficient management. Specifically, the empirical evidence shows that university specialization of a technical nature has a negative and significant effect on efficiency (Wolszczak-Derlacz 2017).

- *Medicine and/or Pharmacy degrees:* Offering these degrees brings prestige to universities because they tend to attract the best students and professors, which may have a positive effect on university efficiency through an increase of teaching and research outputs. However, these universities need more human, physical and financial resources than those that do not teach such degrees, what it may lead to less efficient management. Empirically, while Agasisti and Pohl (2012) find that when these degrees are offered, this has a negative and significant effect on efficiency, Wolszczak-Derlacz and Parteka (2011) find a positive effect. More recently,

Wolszczak-Derlacz (2017) conclude that the existence of such degrees is associated with higher levels of university efficiency in Europe.

- *Regional location:* The heterogeneity existing among the different regions of a country – especially in terms of government policies, regulation, and macroeconomic conditions – might also help explain the differences in efficiency of their public universities. Several empirical studies have shown that there is a regional effect, suggesting that the efficiency of the universities varies depending on their geographical location within a specific country (Agasisti and Pohl 2012; Agasisti and Wolszczak-Derlacz 2016; Agasisti et al., 2016; Wolszczak-Derlacz 2017).

Finally, given that the 2008 economic crisis has led to a reduction in public expenditure on Higher Education in all Southern European countries, it is also interesting to analyze its possible impact on the efficiency of public universities in this geographical area:

- *Crisis:* On the one hand, the decline in government spending on Higher Education could make it difficult for public HEIs to carry out their teaching and research activities because, in general, public funding is their main source of revenue, so their level of efficiency would be reduced. On the other hand, in an austerity scenario like this, the governments of the countries could react by setting up initiatives to increase teaching and research outputs through pressure on competitive resources, thus improving university efficiency (Clarke et al., 2018). From the empirical point of view, Lehmann et al. (2018) conclude that the last crisis has had a positive impact on university efficiency in Italy, but the opposite effect in Germany.

4. Research design

4.1. Methods

We apply the two-stage double bootstrap DEA methodology, Algorithm 2, proposed by Simar and Wilson (2007). In the first stage, efficiency scores are calculated combining the DEA model with the bootstrap procedure. In the second stage, efficiency estimates are regressed on a set of exogenous variables using the truncated regression with bootstrap. This procedure is performed using FEAR® (Frontier Efficiency Analysis with R) software (Wilson, 2008).

First stage: Bootstrap DEA efficiency estimates

Efficiency is analysed by means of Data Envelopment Analysis (DEA), which is the most international accepted estimator for evaluating organisational efficiency (Lampe and Hilgers 2015). Specifically, it is a deterministic and non-parametric method based on a linear programming model that calculates the relative efficiency score of a given organization (Decision Making Unit – DMU, in this case, a public HEI) in comparison with the performance of other homogeneous organizations by constructing an efficient frontier where the best practices are situated. Therefore, an inefficient behavior is determined by the radial distance between the DMU under analysis and the boundary where the efficient entities are located.

This methodology has been applied successfully in different management contexts. We consider that it is appropriate for measuring efficiency in public HEIs for the following reasons: first, it allows employing multiple outputs and multiple inputs at the same time, regardless of the different measurement units, and this feature is particularly important for settings such as Higher Education; second, it does not need information about input or output prices, which is relevant in the field of public University, where prices are usually unknown or established by the Administration; third, each DMU is assigned a single efficiency score that allows ranking amongst the DMUs in the sample; fourth, this method provides information about the areas of improvement for each single DMU; and finally, it does not require a preconceived functional form of the production function.

The initial DEA model was developed by Charnes et al. (1978) and assumed constant returns to scale (CRS). It was based on the concept of efficiency originally proposed by Farrell (1957). Later, Banker et al. (1984) extended this to variable returns to scale (VRS). In the present study, following other researches on the efficiency of public HEIs (Johnes 2006; Agasisti and Wolszczak-Derlacz 2016; Wolszczak-Derlacz 2017), we use a DEA model under variable returns to scale (VRS) because CRS DEA model is only appropriate when all organizations operate at an optimal level of scale, and the existence of technological advances, imperfect competition, government regulation changes and budgetary constraints, as well as regulatory constraints on entry, mergers and exits may have different impacts across HEIs of different size. Additionally, given that the institutional managers cannot control the inputs, at least in the short run, we implemented an output-oriented DEA model, which tries to maximize outputs while using no more than a given inputs level. Accordingly, the conventional efficiency estimator for the DMU_i ($\hat{\delta}_i$) is obtained by solving the following linear programming problem (Eq. 1), which must be resolved *n* times, one for each DMU in the sample,

$$\hat{\delta}_i = max_{\hat{\delta}_i \lambda}\{\delta > 0 | \hat{\delta}_i y_i \leq \sum_{i=1}^{n} y_i \lambda; x_i \geq \sum_{i=1}^{n} x_i \lambda; \sum_{i=1}^{n} \lambda_i = 1; \lambda \geq 0\}; \text{ i=1, .., n DMUs} \quad (1)$$

where x_i is the vector of inputs; y_i is the vector of outputs; λ is an *n* x 1 vector of constants which represent the weights used to calculate the location of an inefficient DMU in order to become efficient; and $\hat{\delta}_i$ is the efficiency score for the *ith* DMU under the VRS assumption. Thus, each DMU is assigned an efficiency indicator between 0 and 1, so that if $\hat{\delta}_i = 1$, the DMU_i can be considered fully efficient, whereas if $\hat{\delta}_i < 1$, the DMU_i will be relatively inefficient.

However, despite its advantages, the conventional DEA model also suffers from some limitations such as high sensitivity to the presence of outliers and, above all, the absence of statistical properties due to its deterministic nature, which generates biased efficiency estimates (Bogetoft and Otto 2011). To mitigate this last drawback, as in the recent study by Agasisti and Zoido (2019), we calculated a statistically-modified version of conventional DEA scores, based on the bootstrap procedure by Simar and Wilson (2000). These authors proposed a smooth bootstrap on DEA estimates by drawing with replacement from the original estimates, which involves the generation of pseudo-data and the approximation of the unknown distribution of efficiency scores using the distribution of bootstrap values. As a result, a set of bias-corrected efficiency scores is obtained (denoted by $\hat{\tilde{\delta}}$). Nevertheless, Simar and Wilson (2000) advise that bias-corrected efficiency scores should only be used when the following ratio r_i is well above unity (Eq. 2),

$$r_i = \frac{1}{3}\left(\widehat{bias}_B^2[\hat{\delta}(x,y)]/\hat{\sigma}^2\right) \quad (2)$$

where r_i is a statistical test value, which allows us to assess whether the bias correction might increase mean square error; $\hat{\sigma}^2$ is the variance of the bootstrap values; B is the number of replications and $\hat{\delta}$ is the original efficiency estimate. This issue is also considered in our empirical study, so the resulting useful efficiency indices are denoted by $\tilde{\delta}$.

Although many studies have applied the conventional DEA method to cross-sectional data in the context of public Higher Education, the most recent literature deals with panel data, which allow to obtain more reliable evidence of the management carried out by the universities, since the performance of each DMU can be analyzed over time. Therefore, following Cooper et al. (2011), we develop a dynamic DEA model and define an inter-temporal reference technology constructed by pooling the data from all years and DMUs. Specifically, this study applies a bootstraped VRS and output-oriented DEA model in which each DMU is treated as if it were a different observation in each period in order to evaluate the dynamic management of the different DMUs, to know their trend and to show the stability of the efficiency results.

Second stage: Bootstrap truncated regression

The two-stage DEA analysis is applied to examine the determinants of university efficiency. A common practice in the DEA literature in the field of Higher Education is to use different regression models, such as Ordinary Least Square (OLS) or censored (Tobit) regression, to carry out the second stage. However, these regression models were criticized by Simar and Wilson (2007, 2011), who point out that they may produce biased and inconsistent parameter estimates due to correlation and dependency problems of the efficiency scores that may violate the regression assumptions, thus invalidating the results of statistical inference. Furthermore, these authors suggest that truncated regression adjusts better to provide evidence about the potential determinants of efficiency scores. Indeed, Simar and Wilson (2011) demonstrated that the two-step bias-corrected estimator proposed by Simar and Wilson (2007) is the only known method that ensures a feasible and consistent inference on the second stage regression.

Therefore, as in some recent studies evaluating efficiency in Higher Education (Agasisti and Wolszczak-Derlacz 2016; Wolszczak-Derlacz 2017), we follow the bootstrapping truncated regression procedure included in the second stage of Algorithm 2 introduced by Simar and Wilson (2007), where the useful efficiency scores ($\tilde{\delta}_i$) yielded in the first stage of the analysis are regressed on a set of exogenous factors, specified as follows (Eq. 3):

$$\tilde{\delta}_i = \alpha + \beta z_i + \varepsilon_i, \quad i = 1, \dots, n \quad (3)$$

where α is a constant term; β is a vector of the parameters to be estimated; z_i is a vector of exogenous variables that are expected to affect the efficiency of the ith DMU (they must meet the requirement established by Simar and Wilson (2007) of not affecting universities' production processes but of being able to affect their performance); and ε_i is an error term assumed to be $N(0, \sigma_\varepsilon^2)$ distributed with right truncation at $(1 - \alpha - \beta z_i)$.

4.2. Population and sample

Our population comprises the 47 campus-based public HEIs existing in Spain between the implantation of the LOU in 2002 and the end of the last economic crisis in 2013. As data on the Spanish Higher Education system are

published every two years, the period of study covers the six alternating academic years between 2002/03 and 2012/13. The initial sample therefore consists of 282 observations or DMUs.

The presence of outliers is a serious limitation for the DEA methodology, because they may increase sample noise and distort the results. Therefore, before calculating efficiency, they must be detected and eliminated from the sample. We used the methodology devised for this purpose by Wilson (1993). After removing the three identified outliers, the resulting final sample comprises a total of 264 DMUs (44 universities x 6 academic years).

4.3. Variables

One of the critical points for measuring efficiency in HEIs using the DEA methodology is to select the input and output variables that determine their complex production function, for which data availability, which has traditionally been a restriction in Spain, is essential. We follow the studies by Wolszczak-Derlacz and Parteka (2011) and Wolszczak-Derlacz (2017) who, covering the two main activities of public universities – teaching and research – consider three inputs and two outputs.

The input variables refer to the main human and financial resources used by public HEIs to achieve their outputs:

- *Students (ST)*: Total number of students enrolled in official teaching, at all university levels (bachelor's degree, master's degree and doctorate), in one academic year.
- *Academic staff (AS):* Total number of teaching and research staff in one academic year.
- *Total revenues (TR):* Total amount of university revenues, in thousands of euros, in one year. These data are deflated at constant prices for 2002 by using the GDP deflator (www.bde.es).

The output variables refer to the universities' main teaching and research results generated from their resources:

- *Graduates (GRAD)*: Total number of graduates from official teaching, at all university levels (bachelor's degree, master's degree and doctorate), in one academic year.
- *Publications (PUB):* Total number of scientific articles published and indexed in the ISI *Web of Science*, edited by Clarivate Analytics, in one year. An article published by several authors from different universities is considered a publication for each of the institutions involved.

Regarding the efficiency determinants, the five exogenous variables considered to explain university efficiency are measured as follows (Wolszczak-Derlacz, 2017):

- *Size (SIZE):* The number of academic degrees offered by universities (with logarithmic transformation for the statistical analysis).
- *Age (AGE):* The number of years since the creation of universities (with logarithmic transformation for the statistical analysis).
- *Specialization in technical fields (TECH):* A dummy variable taking the value of 1 in those universities with a teaching and research specialization of a technical nature, and 0 otherwise.
- *Medicine and/or Pharmacy degrees (M&P):* A dummy variable taking the value of 1 when universities offer degrees in Medicine and/or Pharmacy, and 0 otherwise.
- *Regional location (REG):* In geographic terms, Spain is divided into 17 Autonomous Communities (regions), with different regional governments financing and managing public universities, and with different macroeconomic characteristics. This study takes into account the universities´ location within Spain by including 16 regional dummy variables.

Finally, since the main goal of the study is to analyze the possible impact of the 2008 crisis on the efficiency of Spanish public universities, the following additional explanatory variable was considered:

- *Crisis* (*CRISIS*): A dummy variable that takes the value of 1 in the three academic years corresponding to the crisis period (2008-09, 2010-11 and 2012-13), and 0 otherwise (2002-03, 2004-05 and 2006-07).

To build these variables, information is taken from the websites of the Council of Rectors of Spanish Universities (CRUE) (www.crue.org), of the Ministry of Education, Culture and Sports (www.mecd.gob.es), of the

National Statistics Institute of Spain (www.ine.es), and of each of the universities analyzed, as well as from the *Web of Science* (www.webofknowledge.com).

Table 1 shows the main descriptive statistics of the input and output variables and of those that measure the determinants of efficiency. Analysis of the variance inflation factor (VIF) of the latter shows that all the values are below 5, indicating that there are no multicollinearity problems (Hair et al. 2010).

Table 1. Descriptive statistics

n = 264 observations	Mean	SD	Minimum	Maximum
Input variables				
ST	22842.94	13360.03	4419	67175
AS	1786.44	978.30	419	4472
TR	168706.10	107394.07	30613.54	609789.85
Output variables				
GRAD	3478.49	2012.93	512	10103
PUB	584.53	449.38	45	2269
Efficiency determinants				
SIZE	46.90	20.47	11	113
AGE	132.48	218.80	4	794
TECH	0.20	0.40	0	1
M&P	0.57	0.49	0	1
CRISIS	0.50	0.50	0	1

ST: Enrolled students (total number); AS: Academic staff (total number); TR: Total revenue (in Euros thousands); GRAD: Graduates (total number); PUB: High-quality publications (total number); SIZE: Academic degrees (total number); AGE: Age of university (number of years); TECH: Specialization in technical fields (dummy: 1 yes/0 = no); M&P: Universities with Medicine and/or Pharmacy degrees (dummy: 1 = yes/0 = no); CRISIS: Crisis (dummy: 1 = academic years 2008-09, 2010-11 and 2012-13).

5. Results

5.1. First stage: University efficiency scores

In the first stage of the methodology proposed by Simar and Wilson (2007), the DEA model was applied together with the bootstrap technique (with 2.000 repetitions and a confidence level of 95%) to estimate the values of relative technical efficiency in Spanish public HEIs from a complete data panel made up of 264 observations.

Table 2 shows mean and standard deviation values of the original($\hat{\delta}$), bias-corrected ($\hat{\hat{\delta}}$) and useful($\tilde{\delta}$) efficiency indices, for both the overall period (2002-03 to 2012-13) and each sub-period: pre-crisis (2002-03 to 2006-07) and crisis (2008-09 to 2012-13). It also shows the number and percentage of fully efficient DMUs in each case. The values considered to interpret the results are those referring to useful efficiency ($\tilde{\delta}$).

The estimates show that the mean value of university efficiency for the overall period was 58.38% – slightly above 50%, which is the minimum tolerable value for estimates of technical efficiency (Cooper et al. 2011). This means that in order to reach maximum efficiency ($\tilde{\delta} = 1$), on average, Spanish public universities would have had to increase their teaching and research outputs by 41.62% from the resources available. Only 5 of the 264 observations (2.27%) were totally efficient when useful efficiency was considered ($\tilde{\delta} = 1$).

Analysis by sub-periods points to a considerable increase of 13.74 percentage points in the average efficiency of Spanish public universities during the crisis in comparison with the previous academic years. While in the pre-crisis period a value of 51.51% was reached, it rose to 65.25% in the crisis period. Moreover, only one observation was totally efficient ($\tilde{\delta} = 1$) before the crisis and increased to four during it. This means that, in spite of budgetary restrictions and the consequent reduction in some university inputs, public HEIs in Spain generated higher levels of teaching and research outputs during the last economic crisis than before it. Specifically, according to our data, the number of graduates increased on average by 29.2% between the two sub-periods, while high-quality publications rose by 63.7%.

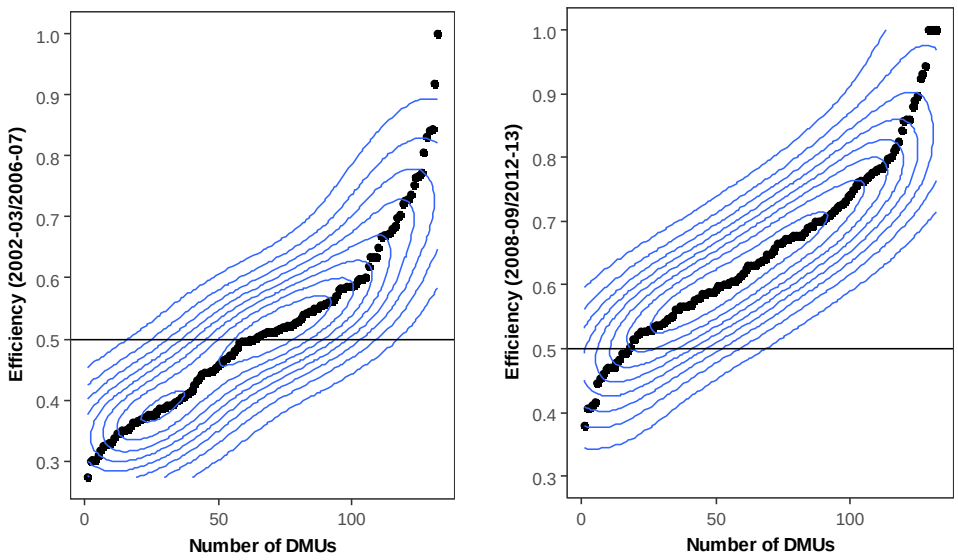
Table 2. University efficiency estimates

Period	Original efficiency ($\widehat{\delta}$)	Corrected efficiency ($\widehat{\widehat{\delta}}$)	Useful efficiency ($\tilde{\delta}$)
Total period: 2002-03/2012-13 (n = 264 DMUs)			
Mean	0.6446	0.5685	**0.5838**
SD	0.1702	0.1438	**0.1562**
Fully efficient DMUs	16	0	**5**
Fully efficient DMUs (%)	6.06%	0.00%	**2.27%**
Pre-crisis period: 2002-03/2006-07 (n = 132 DMUs)			
Mean	0.5656	0.5016	**0.5151**
SD	0.1457	0.1273	**0.1427**
Fully efficient DMUs	3	0	**1**
Fully efficient DMUs (%)	1.14%	0.00%	**0.38%**
Crisis period: 2008-09/2012-13 (n = 132 DMUs)			
Mean	0.7236	0.6354	**0.6525**
SD	0.1561	0.1277	**0.1381**
Fully efficient DMUs	13	0	**4**
Fully efficient DMUs (%)	4.92%	0.00%	**1.52%**

Note: The percentage (%) is based on the 264 DMUs in the sample.

Figure 1 depicts the position of the 132 DMUs analyzed in each sub-period (pre-crisis and crisis) in comparison with the estimates of useful efficiency, arranged from lower to higher values. As it shows, 47.73% of the observations (63 out of 132) show efficiency below 50% before the crisis ($\tilde{\delta} < 0.5$), and are therefore considered technically inefficient, while during the crisis the percentage of inefficient DMUs dropped considerably, to about 12.88% (17 out of 132).

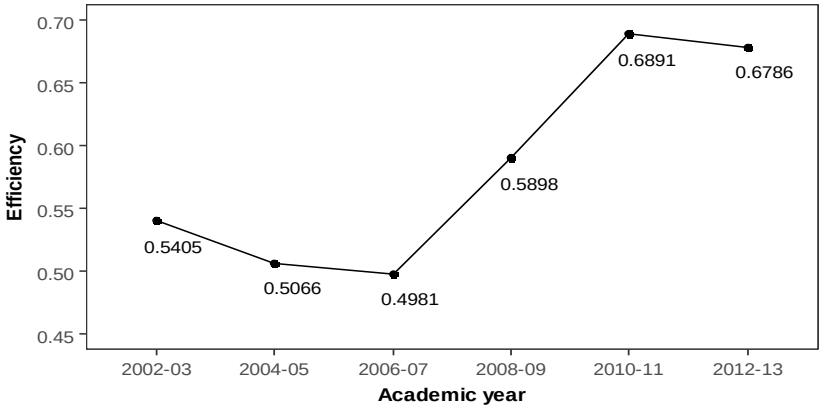
Fig 1. DMUs sorted by efficiency (pre-crisis and crisis periods)



Source: Drawn up by the authors.

Figure 2 shows the evolution of average efficiency in Spanish public universities over the six alternate academic years between the implantation of the LOU in 2002 and the end of the last economic crisis in 2013. After a continuous drop in levels of efficiency during the three academic years corresponding to the pre-crisis period – from 54.05% in 2002-03 to 49.81% in 2006-07 – because of the weaknesses of the Higher Education system in Spain, during the 2008-09 year, a strong and constant growth began, reaching maximum efficiency of 68.91% in 2010-12 and then becoming stable at about 68% in 2012-13. Therefore, although the economic crisis had begun, the levels of university efficiency showed a clear recovery after the 2008-09 academic year, that is, after both the first steps towards adaptation of the Spanish university system to the EHEA and the implementation of the first austerity measures by government.

Fig. 2. Variation in university efficiency by academic year



Source: Drawn up by the authors.

5.2. Second stage: Determinants of university efficiency

Table 3 presents the results obtained after applying bootstrap truncated regression (with 2,000 repetitions and a confidence level of 95%), corresponding to the second stage of the Simar and Wilson (2007) estimator.

Table 3. Determinants of university efficiency

Variables	β coefficients	Bootstrap standard error
Constant (α)	0.3724***	0.9426
SIZE	-0.0109	0.0289
AGE	0.0471***	0.0087
TECH	-0.0665**	0.0149
M&P	0.0250	0.0143
REG	Yes[a]	
CRISIS	0.1192***	0.0136
Sigma	0.0926***	0.0049
Log likelihood	250.2286	
Wald χ2 (21)	444.19***	
n = 264 observations	*Bootstrap repetitions* = 2,000	*α* = 95%

SIZE: Academic degrees (total number); AGE: Age of university (number of years); TECH: Specialization in technical fields (dummy: 1 yes/0 = no); M&P: Universities with Medicine and/or Pharmacy degrees (dummy: 1 = yes/0 = no); REG: Regional location (16 regional dummy variables); CRISIS: Crisis (dummy: 1 = academic years 2008-09, 2010-11 and 2012-13).

[a] Six of the 16 regional dummy variables are statistically significant at the 0.05 level.

*** p< 0.01; ** p<0.05

Regarding the determinants of efficiency in Spanish public universities, we find that the age of these institutions (*AGE*) has a positive and statistically significant impact (p< 0.01), indicating that the experience, maturity and reputation gained over the years benefits them in the form of better resource management, thus increasing their efficiency. Conversely, technical specialization of teaching and research (*TECH*) has a negative and statistically significant effect on university efficiency (p< 0.05). This shows that, even if their differentiation strategy brings them competitive advantages over their generalist counterparts, specialized HEIs achieve less efficient management, possibly because of the greater costs involved in providing such specific services. In addition, the regional location of Spanish universities (*REG*) is also an important determinant of their efficiency such that those territories with governments more active in setting up policies to increase teaching and research results in an austerity context, and/or with a greater degree of economic and technological development (for example, Madrid, Catalonia and the Basque Country) have a statistically significant positive impact on university efficiency, and vice versa.

Finally, the results show that, in comparison with the pre-crisis period, the stage corresponding to the last economic crisis (CRISIS) had a direct, positive and statistically significant impact on university efficiency in Spain (p<

0.01). Although the crisis led to a reduction in government funding for the Spanish Higher Education system, public universities performed more efficiently in this period, given that their outputs were increased through greater competition for increasingly scarce public funding and other revenues sources.

6. Conclusions

This study aimed to achieve two goals: first, to evaluate the relative technical (in)efficiency of Spanish public universities between the 2002-03 and 2012-13 academic years, comparing the situation before and during the last economic crisis; and, second, to analyze the determinants of university (in)efficiency, with a special emphasis on the possible impact of the crisis. We can draw some interesting conclusions from our findings, which should be contextualized in the geographical area of Southern Europe, whose Higher Education systems are weaker and less developed than those in the rest of Europe and therefore most affected by the austerity measures derived from the crisis.

First, in the overall period, the Spanish public HEIs showed considerable technical inefficiency, generating on average 41.62% less than the maximum level of university outputs that might be expected if they had used their human and financial resources better. It can therefore be concluded that during this period there was a clear sub-optimal allocation of university inputs, to the detriment of teaching and research outcomes. By sub-periods, the high average inefficiency in the pre-crisis period (48.49%) points to important weaknesses in the Higher Education system in Spain at that time, most of which stemmed from poor adaptation to an increasingly competitive and globalized context. After adoption of the LOU in 2001 and, especially, of the RLOU in 2007, both of which aimed to adapt the Spanish university sector to the EHEA, HEIs were restructured to boost their efficiency and competitiveness. The beginning of these legal reforms and the consequent greater need for resources coincided with the start of the last economic crisis, which led to serious cutbacks in public spending on Higher Education in Spain. We can conclude that despite these restrictions and the consequent decrease in the main university inputs, Spanish public HEIs were able to obtain higher levels of outputs during the crisis than before, thus improving their efficiency (their average inefficiency dropped to 34.75%). Specifically, the growth in the number of graduates and high-quality publications seems to have been motivated by policy interventions that stimulated competition among universities, as well as by the general wish among universities themselves to excel in the world's main scientific rankings. Our findings, therefore, coincide with those found for Italian public HEIs, which also improved their average efficiency in the crisis period compared to the pre-crisis period (Agasisti and Wolszczak-Derlacz, 2016). In addition, according to the studies by De la Torre et al. (2017) and Berbegal-Mirabent et al. (2018) for Spanish public HEIs and by Agasisti et al. (2016) and Barra et al. (2018) for Italian institutions, our findings also show a marked improvement in university efficiency as the crisis period progressed. All these studies therefore provide a clue towards the expansion of pro-competitive policies in the public Higher Education sector during a period of budget constraint, suggesting that when market forces operate, there are benefits for university efficiency. Consequently, it could be inferred that the public university systems in Southern European countries met the goal of improving their efficiency during the last crisis, achieving a better adjustment of inputs to teaching and research outputs, in the face of greater competitive pressure due to the need to adapt to the EHEA in an austerity context.

Second, we can conclude that the oldest public HEIs were the most efficient, which means that they were able to take advantage of their greater experience and reputation to better manage their resources when producing their educational services. This result is therefore in line with the findings of Wolszczak-Derlacz and Parteka (2011) and Wolszczak-Derlacz (2017) for a sample of European public universities. In contrast, despite the competitive advantages of technical universities compared to their generalist counterparts, the high costs involved in their specialized activities led to lower efficiency, thus corroborating the results of Wolszczak-Derlacz (2017). In addition, our findings reveal that variables related to regional aspects can also explain the efficiency level of Spanish public HEIs. The different strategies to deal with the crisis that regional governments have adopted when managing and financing public universities, and the presence of specific regional characteristics have played a key role, suggesting that efficiency differences may also be due to the fact that public universities are somewhat embedded in their corresponding regional context. Prior studies have also shown that this regional effect exists (Agasisti and Pohl 2012; Agasisti and Wolszczak-Derlacz 2016; Agasisti et al., 2016; Wolszczak-Derlacz 2017).

Finally, our study also provides the first results on whether, and how, the last economic crisis influenced the efficiency of public HEIs in Spain. Specifically, this stage of uncertainty exerted a significant positive influence on university efficiency. In a scenario of declining public spending on Higher Education, this better performance of Spanish HEIs during the crisis period was stimulated mainly by some measures taken by national and regional governments to increase university outputs through greater pressure on competitive resources, which seem to have encouraged universities to be more efficient in the use of existing inputs to increase their competitiveness. Our result is therefore in line with that of Lehmann et al. (2018) from a sample of Italian public HEIs, but contrasts with that observed by them for German universities. Consequently, despite the fact that the recent crisis led to drastic budgetary restrictions in university systems in Southern Europe, we can conclude that it also led to a more efficient management of the production processes of their public HEIs.

This paper points out important implications for policymakers and university managers in Southern European countries, which have undergone similar shocks due to the 2008 crisis. For political decision-makers, our results suggest that, in an adverse external situation requiring budgetary cuts, it is particularly important that the public university systems are characterized by policy interventions that encourage competition among HEIs in order to improve their efficiency. Specifically, in an austerity context, policymakers can either risk worsening the functioning of existing production processes in public universities by reducing their teaching and research outputs since public funding is their main source of revenue, or they can try to incentivize public HEIs to change their processes to generate more outputs – for example, by supporting excellence, innovation, internationalization, and institutional cooperation, and/or by setting up result-based incentive programs to allocate public funding to universities or for hiring policies–. In addition, the findings also suggest that the implementation of the same policy to enhance universities' performance in different territories, without proper adaptation to the specific characteristics of each region, may not contribute to improving university efficiency. In short, political will is required to replace Higher Education systems that are costly and inefficient with others that offer high added value and competitiveness, the latter being an essential requirement for the necessary change of the production model in Southern Europe in general, and in Spain in particular.

For university managers, the findings obtained suggest that they need to understand that, although public HEIs fall under the aegis of the government, their management largely depends on them. Although the low flexibility of public universities limits the definition of institutional strategies, academic decision-makers should try to improve their strategic behavior – for example, by working towards greater autonomy, promoting inter-university competition, fostering meritocracy among students and staffs, changing their decision-making processes or modernizing their information, organization and management models – in order to reduce their considerable technical inefficiency and raise the quality of Higher Education. Therefore, our results should spark a debate among the political decision-makers, university managers and society in Southern Europe on whether, how and why efficiency should play a key role in the public university sector.

This study does not come without limitations. The generalizability of our results is limited since our sampling is restricted with regards to institutions (public universities), geography (a Southern European country, Spain) and time period (before and during the recent crisis). Moreover, this study focuses on the short term effect of the crisis on university efficiency and it does not reflect the time-lag between inputs and outputs in the Higher Education production process. Other limitation is the choice and measurement of input and output variables because of the complexity of quantifying university performance and the shortage of data at institutional level in Southern European countries. Our findings should therefore be interpreted with caution, particularly outside this geographical area. Future research might carry out a cross-country analysis to find out the effect of the last crisis on university efficiency in different kinds of Higher Education systems across the world. In addition, it could be also interesting to examine the long term effect of the crisis on university efficiency due to time is needed for teaching and research outputs levels to reflect the input cut downs. Finally, the output variables could be improved, referring to the quality of teaching and research. If we assume that, in spite of the difficulty inherent in quantifying university efficiency, quality is a multifaceted and much-debated topic, a study on the relation between quantity and quality, especially with a view to defining future university funding, could be of great practical use worldwide.

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