Has the teaching and research productivity of Spanish Public Universities improved since the introduction of the LOU? Evidence from the bootstrap technique

¿Ha mejorado la productividad docente e investigadora de las Universidades Públicas españolas desde la aprobación de la LOU?: Evidencia a partir del *bootstrap*

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Yolanda Fernández-Santos
Almudena Martínez-Campillo
Universidad de León. Facultad de Ciencias Económicas y Empresariales. Departamento de Dirección y Economía de la Empresa. León. España.

Abstract

In the framework of the European Higher Education Area, the Organic Law on Universities 6/2001 (LOU) established a management model based on the need for Spanish universities to become more efficient and productive in their various activities. However, there have been no studies analysing whether such objectives have been accomplished in the Spanish Public University System. This study, therefore, aims to measure the variation in productivity in Spanish Public Universities after this reform, both globally and with reference to teaching and research activities separately, and also to find out the causes of such changes. We use a sample of 39 Spanish Public Universities between 2002/03 and 2008/09 and apply both the Malmquist Productivity Index to measure changes in productivity between two periods and to find out their causes, and the bootstrap technique to determine if the observed changes in productivity are statistically significant. Our findings reveal an improvement of 13.4% in the global productivity rate since the introduction of the LOU with a significance level of 5%, although the increase in

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research productivity (48.5%) is higher than that in teaching productivity (4%). They also show the importance of technological progress in this growth in productivity. Our results therefore provide useful information for political and academic decision-makers regarding the steps that Spanish universities have followed, and should also be of use in future decisions aiming to improve teaching and research productivity.

Key words: Teaching productivity, Research productivity, Spanish Public Universities, Malmquist Productivity Index, Bootstrap.

Resumen

En el marco del Espacio Europeo de Educación Superior, la Ley Orgánica de Universidades 6/2001 (LOU) establece por primera vez un modelo de gestión basado en la necesidad de que las universidades españolas sean más eficientes and productivas en sus distintas actividades. Sin embargo, no existe ningún trabajo previo que haya analizado si, efectivamente, el Sistema Universitario Público de nuestro país ha logrado tal objetivo. Por esta razón, el presente estudio pretende medir la variación de la productividad en las Universidades Públicas españolas, tanto a nivel global como en las actividades docentes e investigadoras, desde la aprobación de dicha reforma universitaria, así como conocer las causas de los cambios productivos observados. Para ello se parte de información relativa a una muestra de 39 universidades presenciales entre los cursos académicos 2002/03 y 2008/09 a fin de aplicar tanto el Índice de Productividad de Malmquist, que permite medir el cambio de productividad entre dos periodos de tiempo y determinar sus causas, como la técnica de re-muestreo *bootstrap,* que confirma si los cambios productivos encontrados son estadísticamente significativos. Así, con un nivel de significación del 5%, nuestros hallazgos indican que la productividad global universitaria ha mejorado un 13,4% desde la implantación de la LOU, si bien el incremento de la productividad investigadora ha sido bastante superior que el de la productividad docente (un 48,5% frente a un 4%). Además, también ponen de manifiesto la importancia del progreso tecnológico en los crecimientos productivos observados. Por tanto, los resultados obtenidos proporcionan información útil para los responsables políticos and académicos a fin de conocer el camino seguido por nuestras universidades and determinar hacia donde debe encaminarse la toma de decisiones futura de cara a mejorar su productividad docente e investigadora.

Palabras clave: Productividad docente, Productividad investigadora, Universidades Públicas españolas, Índice de Productividad de Malmquist, *Bootstrap.*

Introduction

A country's Higher Education system can bring a decisive dose of competitiveness to its economy and contribute to its social and cultural progress because universities create knowledge through their research activity, pass it on through teaching and transfer it to society by supporting enterprises and producing patents (Gómez-Sancho and Mancebón, 2012). This very relevant role of universities on an economic and social level, greater competition among them and limited public funds to finance their activities have sparked interest in improving their performance (Parteka and Wolszczak-Derlacz, 2013). The creation of the European Higher Education Area (EHEA) –a project for university integration and cooperation set up at the end of the 20th century to promote European convergence among universities– has changed the scenario for universities in Europe, encouraging them to be competitive and introducing for the first time criteria of management efficiency and productivity in order to enhance their performance (Mira-Solves et ál., 2012).

Up to the 1970s, the Spanish Higher Education system was hidebound, standardised, elitist, focused on teaching and detached from the country's production and social needs (Hernández Armenteros and Pérez García, 2011). But at the end of that decade a process of change began which led to a consolidated and structured university system that was also characterised by a substantial increase in the number of students and universities, greater research activity and the aim to meet the new demands arising in Spain (Corominas and Sacristán, 2011). In this context and in order to meet the challenges of the EHEA, the Organic Law on Universities 6/2001, dated 20 December (LOU), was passed. This marked the start of a new stage in university policy after almost two decades under Organic Law 11/1983 on University Reform, dated 25 August (LRU). In particular, one of the main challenges was to improve the productivity of the Spanish Public University System in order to increase its economic and social performance. Later on, Organic Law 4/2007, dated 12 April, which amended the LOU (LOMLOU), also helped harmonise Spanish universities within the framework of the EHEA, requiring them to be more efficient and productive in their use of public resources.

Over recent years, the Spanish Public Universities have considerably increased their resources and performance, but there have been problems of productivity stemming from inefficiency in the use of inputs and

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shortcomings in the quality and international relevance of the services provided. For this reason, both the LOU and the LOMLOU introduced certain technical measures to improve their productivity: a) further re-structuring of Higher Education into three cycles – bachelor's degree, master's degree and doctorate – which required significant curricular and organisational changes as well as different teaching methods and resources, with the aim of stepping up the number of students who qualify and improving their training and employability; b) strengthening of relations between universities and business by means of research staff mobility, recognition of their right to take leave to set up technology-based enterprises, and joint R&D&I programmes between universities and businesses; c) promotion of technological innovation in both classroom and distance teaching, improving the dissemination of knowledge, and in research, promoting communication among researchers; and, finally, d) promotion of international mobility for students and teachers, as well as collaboration between Spanish and foreign universities in order to establish relations that will help create synergies.

Improved productivity in the Spanish Public University System is therefore a priority, and the various political and university authorities are interested in knowing if university activities are maximising their performance given the existing resources (Mira-Solves et ál., 2012). However, although the LOU entrusts Spanish universities, for the first time, with the task of becoming more productive in their various functions and both this Law and the LOMLOU introduced new measures to improve performance, there have been no studies analysing whether this purpose has been achieved as a result of the reforms.

This paper therefore focuses on the productive behaviour of Spanish Public Universities since the approval of the LOU. In particular, its objectives are to assess the change in productivity both globally and in the two main university activities –teaching and research– and to determine the causes of such variations, during a period that covers the four alternating academic years between 2002/03 and 2008/09, this being the year for which the latest data are publicly available at institutional level. To achieve these objectives, the Malmquist Productivity Index (MPI) is applied, using Data Envelopment Analysis (DEA) to estimate productivity change over time and its causes, as well as the bootstrap re-sampling technique to determine if the changes observed in productivity are statistically verified.

The study focuses on two basic university functions –teaching and research– for the following reasons. First, although the transfer of

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knowledge is becoming increasingly relevant, it still does not bear the great relative weight of teaching and research in the activities performed by universities (Gómez-Sancho and Mancebón, 2012). Second, there is a close relation between the outputs of research and knowledge transfer activities, which can be channelled both through contracts with enterprises and institutions and by publishing the results of research in important scientific journals so that enterprises can use them (Corominas and Sacristán, 2011).

Our research aims to enrich the literature in the field of the Economics of Education as follows. *First*, it enhances knowledge on the productivity change in the Spanish Public University System, adding new empirical evidence to the limited research carried out to date. *Second*, it analyses the change in productivity both globally and separately for teaching and research activities. Although decisions are usually taken by the institutional authorities for each type of activity, there have been practically no studies in the prior literature on the productivity change of universities that differentiate between their main functions. *Third,* this is the only study, to date, which focuses on measuring the change in teaching and research productivity in Spanish universities since adoption of the LOU. Since both this Law and the current situation of budgetary cutbacks have made improved productivity essential for the Spanish Public University System, it is of interest to ascertain whether this objective has been achieved since approval of the reform. *Four*, it uses the bootstrap technique to test the robustness of its findings. Although this is the most rigorous and powerful methodology for confirming the statistical significance of the MPI results, apart from a recent study by Parteka and Wolszczak-Derlacz (2013), it has not been applied in any studies in the field of Higher Education.

The rest of the paper is organised as follows. The second section reviews the background literature. The third describes the methodology used and the research design. The fourth presents the results, and the fifth concludes.

Background

Productivity in the High Education sector measures the link between the production of universities, mainly teaching and research, and the resources

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used to obtain this production. Even though in recent years improved productivity has become a priority, both nationally and internationally, there have been few academic contributions aiming to assess the productivity change in this sector and most studies focus above all on the global productivity of universities without distinguishing between their basic activities, by using the MPI.

Regarding the change in global productivity, a distinction can be made between studies on institutions in a single country and those that compare the institutions of several countries. The former include research in several English-speaking countries. In the United Kingdom, Glass, McKillop and O'Rouke (1998) studied 54 universities during the period 1989-1992 and showed an average reduction in global productivity of 4%; Flegg, Allen, Field, and Thurlow (2004) revealed average productive growth of 51.5% in 45 institutions from 1980/81 to 1992/93; and Johnes (2008) found a 1.1% improvement in productivity in 112 universities between 1996/97 and 2004/05. In Australia, Carrington, Coelli and Rao (2005) analysed 35 institutions and found an average productivity increase of 1.8% between 1996 and 2000. Finally, in the United States, Sav (2012) showed a slight decrease of 1.3% in productivity in 133 universities between 2005 and 2009. Within Europe, Agasisti and Dal Bianco (2009) found an average improvement in productivity of 17% in 74 Italian universities between 2001/02 and 2003/04. And a single study by Fernández-Santos, Martínez-Campillo and Fernández-Fernández (2013) measured the change in productivity of Spanish universities, finding an average increase of 8.1% in a sample of 39 institutions between 2002/03 and 2008/09.

From a cross-country approach, three studies compare the change in global productivity of universities in different countries: Agasisti and Pérez-Esparrells (2010) concluded that Italian Public universities saw a greater increase in productivity (48.2%) than Spanish ones (6%) between 2001/02 and 2004/05; Agasisti and Johnes (2009) found that Italian universities were only 0.9% ahead of English universities between 2002/03 and 2004/05; and, finally, Parteka and Wolszczak-Derlacz (2013) compared a sample of institutions from seven European countries (Austria, Germany, Italy, Poland, Switzerland and the United Kingdom) between 2001 and 2005 and, after applying the bootstrap technique to check the robustness of results using the conventional MPI, found statistically significant changes in productivity, varying between a 2% drop in Austria and a 9% increase in Switzerland.

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A review of this literature leads to the general conclusion that improved global productivity is mainly due to technological progress, while a decline is largely due to poorer technical efficiency.

Finally, to our knowledge, only three studies have analysed the change in productivity of universities, distinguishing between their main activities. Worthington and Lee (2008), taking a sample of 35 Australian universities, showed that the increase in research productivity was greater than that in teaching during the period 1998-2003 (6.3% as opposed to 2.9%), and Mahmoudi, Tabandeh and Fathi (2012), taking Iranian universities during the decade from 1999 to 2009, also concluded that the improved productivity in research was greater than that in teaching (9.5% as opposed to 3.8%). So, in both these studies, research productivity grew more than twice as much as teaching productivity, bearing in mind that improved teaching productivity was exclusively due to technological progress although the latter contributed less than the growth in technical efficiency to improving research productivity. In Spain, García-Aracil, López-Iñesta and Palomares-Montero (2009) carried out an analysis by functions, considering 42 Spanish universities between 1995/96 and 2005/06. This study concluded that the productivity of research and knowledge transfer activities saw average increases of 5.4% and 12.5% respectively, largely because of improved technical efficiency, while teaching productivity dropped by 1.5%, largely because of backward progress in technology.

Methodology and design

Malmquist Productivity Index (MPI)

The most popular approach for evaluating productivity change between two periods is the Malmquist Productivity Index (Malmquist, 1953) (MPI). Färe, Grosskopf, Norris and Zhang (1994) specifically developed this index to measure productivity change in management so that, when the MPI is greater than 1, it indicates an improvement in productivity between periods t and $t+1$, while an MPI less than 1 suggests a decline in productivity.

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To calculate the MPI, the distance function (D) introduced by Shephard (1953) has to be considered in two different time periods (t and $t+1$) with their respective technologies, which, in this case, assume constant returns to scale. However, to avoid arbitrariness in the choice of the reference technology for the two periods, we must solve four distance functions. In two of them, the observation and the production technology are defined in the same period ($D^t(x^t,y^t)$ and $(D^{t+1}(x^{t+1},y^{t+1}))$ in the others, the observation and the technology correspond to different periods, ($D^{t+1}(x^{t+1},y^{t+1})$ and $D^{t+1}(x^t,y^t)$) when x is the input vector and y is the output vector. This indicator can therefore be broken down into the product of two components (Fare et ál., 1994): the first is Technical Efficiency Change (TEC), which shows improvement or worsening in the management of available resources, and the second is Technological Change (TC), i.e., growth or decline in the technology used.

$$MPI^{t,t+1} = \frac{D^{t+1}(x^{t+1},y^{t+1})}{D^t(x^t,y^t)} \text{ x } \left[\left(\frac{D^t(x^{t+1},y^{t+1})}{D^{t+1}(x^{t+1},y^{t+1})}\right)\left(\frac{D^t(x^t,y^t)}{D^{t+1},(x^t,y^t)}\right)\right]^{1/2} = TEC \text{ x } TC \qquad (1$$

The MPI, therefore, has the following advantages (Bogetoft and Otto, 2011): a) it can be calculated without price data; b) it does not need a performance that minimizes costs or maximizes revenue; and c) it allows the productivity change to be broken down into technical efficiency change and technological change, thus making it possible to determine the causes of the productivity change.

In this paper, we use the MPI based on the DEA methodology. This methodology is a non-parametric linear programming technique which allows calculation of the relative efficiency of a set of Decision Making Units (DMUs) regarding the best practices observed, taking into account the inputs and outputs involved in the production process. More specifically, we adopt an output-oriented DEA model, which measures how much universities' outputs can be proportionately increased given an observed level of inputs. The reasons for this choice are the rigidity of university resources, which are usually established by higher-level public authorities based on predetermined criteria, as well as the difficulty of making changes in such resources, at least in the short term. This means that university administrators have little control over the inputs and, therefore, they focus more on achieving better results than on minimising the resources used (Gómez-Sancho and Mancebón, 2012).

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The bootstrap technique

An important limitation of the conventional DEA model is the sensitivity of results to data errors, to the absence of DMUs that cannot be included in the study and to the presence of outliers. Moreover, its deterministic nature means that measures of sample noise, due to missing variables, incorrect values for some variables or other discrepancies are included in the estimates.

One option to overcome these weaknesses is to use the bootstrap re-sampling technique. In particular, in this study we use the non-parametric estimator developed by Simar and Wilson (1999), which has statistical inference properties. This estimator makes it possible to evaluate the statistical significance of the productivity change values from the MPI and, therefore, to conclude if the results obtained indicate a real change in productivity or are simply sampling noise.

We use the FEAR in R statistical package (Wilson, 2008) to obtain the bootstrap results.

Population and sample

The Spanish university system today comprises 77 universities of which 50 are Public universities (approximately 65% of the total) and 27 are private. Of the Public universities, one is for distance learning (UNED) and two only run specialist postgraduate programmes (Universidad Internacional Menéndez Pelayo and Universidad Internacional de Andalucía). The target population for this study therefore comprises 47 Spanish universities. The period of study covers four alternating academic years between 2002/03 and 2008/09. These are the last years for which institutional information is available since approval of the LOU.

The need to use a full data panel to apply the MPI means that eight universities had to be eliminated from the empirical study because information was missing on some variable of interest for the whole period. We therefore ended up with a total sample of 39 Public universities (or DMUs to use the DEA terminology) for each academic year. Our sample therefore represents 83% of the population of universities considered, which amounts to an acceptable margin of error of 6.5% with a confidence level of 95%.

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Selection of variables and specification of models

The first step for measuring productivity change in the Higher Education sector is to select the input and output variables that define the process of university production. For this purpose it is essential to have available data, which has traditionally been a serious limitation in Spain. In addition, in order for the estimates to be reliable, the number of DMUs must be at least the maximum between m x s or 3 x (m+s), with m and s being the number of input and output variables, respectively (Cooper, Seiford and Tone, 2007). In this study, all the estimates meet this requirement.

In particular, our specification of inputs and outputs is the same as that given recently by Parteka and Wolszczak-Derlacz (2013). They use as inputs the number of academic staff, the total number of registered students and the amount of university revenue and, as outputs, the total number of graduate students (teaching) and the number of quality publications (research). However, in order for the selection of outputs to be comparable with that given by García-Aracil et ál. (2009) –the only prior study that has measured the productivity change of Spanish universities distinguishing between their main activities– an additional variable is added, that of R&D revenue.

The three input variables were defined as follows:

- *Academic Staff* (ACSTAFF): Total number of full-time equivalent academic staff, whatever their category, per fiscal year. This variable measures the contribution of academic staff to university education, adding the number of full-time and part-time teachers, weighting the teaching hours of the latter.
- *Registered Students* (ST): Total number of students registered per academic year, considering all university levels. Since official Master courses only started to be offered in Spain during the academic year 2006/07, at this level there are only publicaly available data for all universities for 2008/09.
- *Total Revenue* (TR): Total amount of university revenues in thousands of euros per fiscal year.

The three output variables were defined as follows:

- *Graduate Students* (GRAD): Total number of students achieving their qualification per academic year, considering all university levels.
- *Research Publicactions* (RP): Total number of scientific articles published and indexed in the ISI Web of Science per fiscal year. When

an article is written by authors from several universities, this is considered a publication for each of the institutions involved.

- ***R&D Revenue*** (R&DR): Total amount of R&D revenues received in thousands of euros-per fiscal year. This variable includes both basic research –sums from aid for research and from research projects– and applied research–sums from contracts and agreements drawn up with third parties for the provison of research, consultancy and advisory services.

Measurement of these variables is based on the bi-annual information published on the website of the Conference of Rectors of Spanish Universities-CRUE (Hernández Armenteros, 2004, 2006, 2008, 2010), except for the number of research publications, for which the source is the ISI Web of Science published by Thomson Reuters (http://apps.webofknowledge.com/). Data expressed in monetary units are deflated to constant prices for 2002, using the GDP deflator.

Table 1 summarises, for each academic year, the main descriptive statistics for the input and output variables considered in the study.

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TABLE I. Descriptive statistics: input and output variables

ACADEMIC YEAR	STATISTIC	ACSTAFF	ST	IT	EG	ART	AYID
2002-03							
	Máx.	5,102	87,460	419,915	13,810	1,995	50,905
	Mín.	370	5,992	30,614	512	43	755
	Mean	1,580	26,047	135,754	3,600	412	14,528
	Std. Dev.	1,092	18,533	92,291	2,747	405	12,019
2004-05							
	Máx.	5,077	83,590	460,854	9,938	2,157	46,612
	Mín.	413	6,073	31,466	556	76	1,752
	Mean	1,642	25,132	155,806	3,294	470	15,383
	Std. Dev.	1,089	17,627	109,213	2,190	445	11,689
2006-07							
	Máx.	5,311	78,904	471,934	9,226	2,445	62,263
	Mín.	401	5,958	31,469	599	83	2,190
	Mean	1,711	23,957	151,023	3,153	547	20,276
	Std. Dev.	1,150	16,743	101,093	2,094	503	16,249
2008-09							
	Máx.	5,346	77,515	494,628	9,816	2,924	69,042
	Mín.	400	5,862	34,307	793	96	1,928
	Mean	1,764	24,092	171,758	3,612	647	24,188
	Std. Dev.	1,170	16,557	113,342	2,274	581	18,258

n= 39 DMUs

ACSTAFF: Academic Staff; *ST*: Registered Students; *TR*: Total Revenue; *GRAD*: Graduate Students; *RP*: Research Publications; *R&DR*: R&D Revenue.

Source: Own elaboration.

Starting from our specification of inputs and outputs, three different models were built: the *Teaching* and *Research* models, in order to analyse the productivity change for each activity separately and the *General* model which considers the two university functions together in order to evaluate the change in overall productivity. While the output variables for the

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Teaching and Research models differ, some of the input variables are the same because these resources are shared by both activities.

In the Teaching model, the inputs selected are Academic Staff (ACSTAFF), Registered Students (ST) and Total Revenue (TR), and the output selected is Graduate Students (GRAD). The inputs for the Research model are Academic Staff (ACSTAFF) and Total Revenue (TR), and the outputs are Research Publications (RP) and R&D Revenue (R&DR). The General model uses all the inputs and outputs defined in this section.

Results

Discussion of results

Table II shows the original estimates after applying the conventional MPI. It shows the changes in productivity, efficiency and technology for the activities performed by the universities and for each of the periods studied.

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TABLE II. Original estimates of productivity change and its components by activity and period

	IPM	ΔET	Δt
TEACHING			
2002-03-2004-05	0,952	0,949	1,005
2004/-5-2006-07	0,973	1,064	0,914
2006-07-2008-09	1,114	1,003	1,112
2002-03-2008-09	**1,032**	**1,004**	**1,028**
RESEARCH			
2002-03-2004-05	1,048	0,980	1,078
2004-05-2006-07	1,248	1,090	1,145
2006-07-2008-09	1,099	1,049	1,049
2002-03-2008-09	**1,431**	**1,087**	**1,315**
GENERAL			
2002-03-2004-05	0,958	0,947	1,011
2004-05-2006-07	1,043	1,012	1,028
2006-07-2008-09	1,106	1,019	1,085
2002-03-2008-09	**1,112**	**0,968**	**1,147**

n= 39 DMUs.
IPM: Productivity Change; TEC: Technical Efficiency Change; TC: Technological Change
Source: Own elaboration.

Although between the initial and final sub-periods the change in teaching productivity followed an upward trend as opposed to the irregular trend in research productivity, over the total period the latter saw an average increase of 43.1% as opposed to just 3.2% for the former. These improvements in productivity indicate, respectively, that per input unit, during the 2008/09 academic year, Spanish Public universities achieved 43.1% more outputs in research and 3.2% more in teaching than in 2002/03.

If the analysis focuses on teaching activity, in line with the prior empirical studies, average growth in productivity was motivated mainly by technological progress (2.8%), because the improvement in technical efficiency was insignificant (0.4%). This technological progress reflects an important change in curricular organisation in Spanish universities after approval of the LOMLOU in 2007, with the adoption of the new structure for bachelor's and master's courses which involved an increase in the ratio of

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students qualifying over registered students. Since this effect first became apparent as from the 2006/07 academic year, it should be no surprise that in the last sub-period there was an increase in teaching productivity of 11.4% as opposed to drops of 2.7% and 4.8% in the two previous sub-periods.

The marked growth in research productivity mainly occurred between the 2004/05 and 2006/07 academic years, when it grew by 24.8% as opposed to 4.8% and 9.9% in the two remaining sub-periods. Therefore, the main improvement in research productivity took place once the Spanish universities had regained stability after adapting to the new requirements of the LOU, which introduced a number of technical measures to promote research activity. Regarding the causes of this improved productivity, and in line with previous studies, this seems to be due both to improved technical efficiency and, therefore, improved management of resources, and to technological progress, although the latter made a greater contribution (31.5% as opposed to 8.7%).

Analysis of both activities together reveals growth of 11.2% in the global productivity of Spanish universities between the 2002/03 and 2008/09 academic years, exclusively because of technological progress (14.7%).

Table III compares the original and bootstrap results of estimation of the three models between the 2002/03 and 2008/09 academic years. The bootstrap results are obtained after applying the algorithm described by Simar and Wilson (1999) indicating, in this case, the productivity changes that are statistically significant at a standard level of 5%. These results are therefore more robust and reliable than the original ones.

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TABLE III. Comparison of original and bootstrap estimates of productivity change and its components by activity (2002/03 to 2008/09)

	TEACHING		RESEARCH		GENERAL	
	Original	***Bootstrap*** (α = 5%)	**Original**	***Bootstrap*** (α = 5%)	**Original**	***Bootstrap*** (α = 5%)
Productivity Change (MPI)						
N.º DMUs with increase	22	20	38	33	26	23
% DMUs with increase (*)	56,4%	51,3%	97,4%	84,6%	67%	59%
Mean (**)	1,032	**1,040**	1,431	**1,485**	1,112	**1,134**
Technical Efficiency Change (TEC)						
N.º DMUs with increase	17	11	22	11	11	4
% DMUs with increase (*)	43,6%	28,2%	56,4%	28,2%	28,2%	10,3%
Mean (**)	1,004	**1,014**	1,087	**1,253**	0,968	**0,918**
Technological Change (TC)						
N.º DMUs with increase	24	16	39	25	29	25
% DMUs with increase (*)	61,5%	41,0%	100,0%	64,1%	74%	64%
Mean (**)	1,028	**1,064**	1,315	**1,357**	1,147	**1,206**

n = 39 DMUs.
(*) El % de DMUs with increase is calculated from a total of 39 DMUs for each academic year.
(**) The mean for the "Original" column refers to the 39 total DMUs, while for the "*Bootstrap*" column it refers to the DMUs with a statistically significant change.
Source: Own elaboration.

According to the original MPI estimates, of the 39 universities considered, 56.4% managed to increase their teaching productivity and 97.4% their research, with 67% increasing their global productivity after approval of the LOU. However, when the bootstrap re-sampling technique is applied, these percentages drop to 51.3%, 84.6% and 59%, respectively.

In addition, the bootstrap results confirm, with a 5% significance level, that the improvement in research productivity in Spanish universities is much greater than that in teaching so that, while the former increases on average by 49.5%, the latter only increases by 4%. These findings are in line with those of Worthington and Lee (2008) for Australian universities and of Mahmoudi et al. (2012) for Iranian universities, although in our study we find a greater difference between the productivity increases in research and teaching. If our results are compared with those of García-Aracil et ál.

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(2009), which is the only Spanish study on this topic, it can be concluded that productivity improved substantially after approval of the LOU in the two main university functions, because the latter study shows that, between 1995 and 2006, research productivity only increased by 5.4% whereas teaching productivity dropped by 1.5%. Regarding the causes of the productivity changes observed, the bootstrap technique corroborates that, after adoption of the reform, the improvement in teaching and research productivity in Spanish univeristies was mainly due to technological progress (6.4% and 35.7% as opposed to a technical efficiency change of 1.4% and 25.4%, respectively). These results therefore differ from those found by Worthington and Lee (2008), Mahmoudi et ál. (2012) and García-Aracil et ál. (2009), which only indicated the importance of technological change for explaining the change in teaching productivity.

Regarding global university productivity, the bootstrap technique indicates, at a significance level of 5%, an increase of 13.4% between the 2002/03 and 2008/09 academic years, exclusively because of a 20.6% increase in technology. Therefore, at a national level, our findings are in line with those of Agasisti and Pérez-Esparrells (2010) and Fernández-Santos et ál. (2013). With different specifications for inputs and outputs, they also found improved productivity in Spanish Public universities as from 2001 and, therefore, as from the adoption of the LOU. However, while in the former the increase in productivity is determined solely by the increase in efficiency, in the latter, technological progress is also fundamental. If a comparison is made with other EHEA countries, with the exception of Italy whose universities achieved a 17% improvement in productivity between 2001/02 and 2003/04 (Agasisti and Dal Bianco, 2009) or 48.2% between 2001/02 and 2004/05 (Agasisti and Pérez-Esparrells, 2010), of all the countries analysed, Spain is the one that achieved greatest growth in global university productivity as from the start of the 21st century.

Finally, Graph I shows the situation of the 39 Spanish Public universities after applying the MPI in the Teaching and Research models between 2002/03 and 2008/09, as well as the level of statistical significance of this indicator in both models.

Regarding teaching, 22 of the 39 universities showed increased productivity, with 56.4% of them improving their teaching productivity and the best being the Universidad Carlos III de Madrid (UCAR) and the Politécnica de Cartagena (UPCT). Regarding research, 38 institutions showed

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an improvement, that is, 97.4%, with the most outstanding being the Universidad Pablo de Olavide (UPO) and, to a lesser extent, the Universidad de Lleida (UDL).

If both activities are considered together, the Universidad Pablo de Olavide (UPO) is in the leading position, with productivity increases in teaching and research of 18% and 135%, respectively. On the other side of the scale is the Universidad de Las Palmas de Gran Canaria (ULPGC), with drops in both types of productivity of about 40% and 20%, respectively.

When the bootstrap re-sampling technique is applied, all the changes in productivity observed in these five universities are seen to be statistically significant at 5%.

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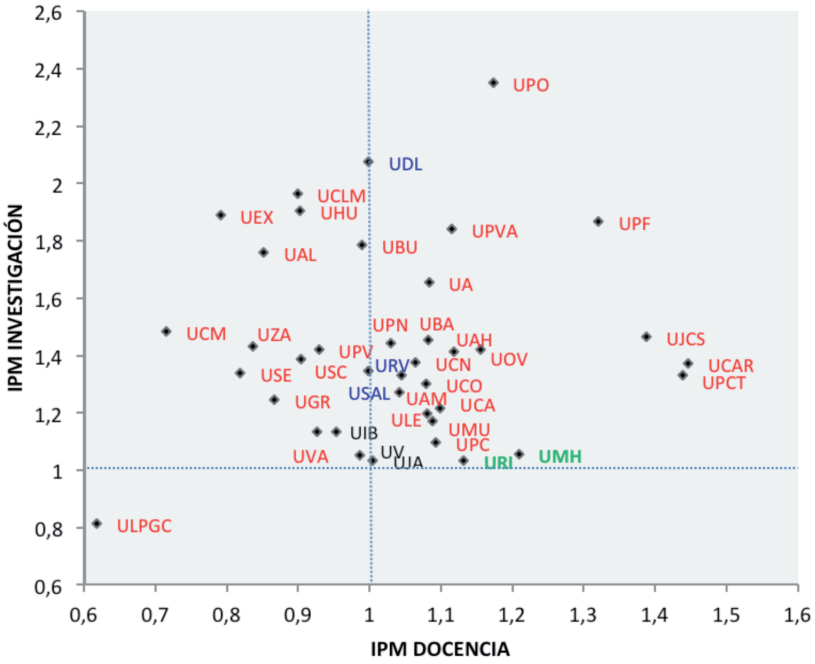
GRAPH I. Relative position of Spanish Public universities regarding productivity change in teaching and research activities (2002/03 to 2008/09)



UAL-U: Almería; UCA-U: Cádiz; UCO-U: Córdoba; UGR-U: Granada; UHU-U: Huelva; UJA-U: Jaén; UPO-U: Pablo de Olavide; USE-U: Sevilla; UZA-U: Zaragoza; UOV-U: Oviedo; UIB-U: Islas Baleares; ULPGC-U: Las Palmas de Gran Canaria; UCN-U: Cantabria; UCLM-U: Castilla-La Mancha; ubu-u: Burgos; ule-u: León; usal-u: Salamanca; uva-u: Valladolid; uba-u: Barcelona; udl-u: Lleida; upc-u: Politécnica Cataluña; UPF-U: Pompeu Fabra; URV-U: Rovira i Virgili; UA-U: Alicante; UJCS-U: Jaume I Castellón; UMH-U: Miguel Hernández; UPVA-U: Politécnica Valencia; UV-U: Valencia; UEX-U: Extremadura; USC-U: Santiago de Compostela; UAH-U: Alcalá de Henares; UAM-U: Autónoma Madrid; UCAR-U: Carlos III; UCM-U: Complutense de Madrid; UMU-U: Murcia; UPCT-U: Politécnica de Cartagena; UPN-U: Pública de Navarra; UPV-U: País Vasco; URI-U: La Rioja.

- MPI in Teaching and Research Models significant at 5%
- Only MPI in Research Model significant at 5%
- Only MPI in Teaching Model significant at 5%
- MPI in Teaching and Research Models not significant

Source: Own elaboration.

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Conclusions

The LOU established for the first time a management model based on the need for Spanish universities to be more efficient and productive in their various activities. As a result, improved teaching and research productivity became a key objective both for political decision-makers and for the administrators of Spanish educational institutions. However, there is no evidence as to whether the Spanish Public University System has actually achieved this objective since adoption of the reform.

This study therefore aims to answer the following question: *Has teaching and research productivity in Spanish Public universities improved since the LOU was adopted?* More specifically, it aims to measure the productivity change of Spanish Public universities over this period, both globally and in teaching and research separately, and to find out the causes of such changes in productivity. After applying both the conventional MPI and the bootstrap technique to information on 39 Spanish Public universities between the 2002/03 and 2008/09 academic years, two conclusions can be drawn based on statistically significant results:

1) After approval of the LOU, there were positive changes in the performance of Spanish Public universities. Their overall productivity improved by 13.4% over the period analysed, with a much higher increase in research productivity than in teaching productivity. With the same level of resources, during the 2008/09 academic year, Spanish universities obtained 48.5% more research outputs and 4% more teaching outputs than in the 2002/03 academic year.

A possible explanation for the better trend in research productivity, both nationally and internationally, could be the willingness of universities to increase their competitiveness in order to obtain a good position in the main worldwide rankings (such as The Academic Ranking of World Universities, published by the Jiao Tong University of Shanghai, The Times Higher Education Ranking, drawn up by The Times, and the Webometrics Ranking, drawn up by the Spanish Higher Council for Scientific Research -CSIC-). Within Spain, another explanation could be that Spanish Public universities adapted faster to the requirements of the LOU in research than in teaching, because both this Law and the LOMLOU emphasise the immediate promotion of research, while the new structure for official curricula was only adopted in the 2006/07 academic years for master's courses and in 2008/09 for bachelor's courses. In addition, if it is accepted

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that there is a certain trade-off between the two activities, the drop in teaching obligations for teaching staff because of the reduction in the student/teacher ratio during the period analysed (stemming from both the drop in the number of students registered, mainly for demographic reasons, and the increase in teaching staff) and the greater prestige and curricular value of research as opposed to teaching could also have intensified research activity in Spanish universities.

2) Regarding the causes of the productivity changes observed, technological progress seems to have been decisive in improving productivity in the Spanish higher education sector after adoption of the LOU. The positive trend in global productivity in Spanish universities is caused exclusively by technological progress, which contributes to a greater extent than greater technical efficiency to improving teaching and research productivity.

This technological progress reflects some changes seen in Spanish universities since approval of this reform, such as the new official curricular organisation, greater use of technological innovation, and the motivation to maximise revenue from R&D&I programmes to be adopted jointly by universities and business.

Practical implications

In the light of these findings, a number of recommendations can be made both to university authorities and political decision-makers for improving the use of the resources available for both university functions and, therefore, for enhancing the performance of the Spanish University System.

Since it would be difficult to imagine a good-quality Higher Education System with productivity problems, it should be taken into account that in this study technological progress seems to be the main factor behind the positive trend in Spanish university productivity, both globally and in teaching and research activities separately. Possible measures that could be adopted to ensure that Spanish universities continue along this path should include measures relating to technological progress. In terms of the productivity of Higher Education, such technological progress could stem from a renewed curricular structure, academic innovation, an improved process for acquiring resources and improved communication channels as well as the adoption of new university governance systems or innovative decision-making techniques.

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More specifically, the adoption of new educational tools could be vital for improving teaching productivity in Spanish universities, which is way behind research productivity and is lower than the average in the most advanced countries. It might be appropriate to draw up new models for assessing academic staff in order to obtain a rigorous diagnosis that would allow their teaching performance to be improved, to use new, active, inductive and cooperative teaching and learning techniques to encourage students to obtain better academic results or to introduce innovations that might lead to better use of university teaching resources, such as cloud computing, educational apps for mobile phones and smart campuses.

Finally, since the current legislation only covers one type of institution that must carry out both teaching and research activities to the same degree, information on the situation of each of the Spanish universities and its forward or backward progress in teaching and research productivity would be useful so that the institutional authorities can see the path followed and determine the direction of decisions to achieve a good relative position in both activities. However, the legislation has certain limitations in that, for example, some teachers are paid for research time even though they do no research, and in some universities all teachers have the same teaching load irrespective of their research performance. Therefore university productivity could be enhanced if the political decision-makers were to introduce changes allowing universities to specialise in either teaching or research, in whichever they are most productive.

Limitations and future lines of research

Although this study contributes to the field of the Economics of Education, it has certain limitations: a) it is difficult to select the input and output variables because of the shortage of data in Spain; b) it is difficult to simplify in just a few inputs the complex activities of teaching and research and to quantify outputs as these are intangible; c) inputs in the two activities overlap so, even when bootstrapping is applied, the results should be interpreted with caution; and d) the possible relations between the "before" and "after" cut-off point of the LOU and the results obtained are only provisionally acceptable hypotheses so a direct causal relationship between them cannot be established.

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For future studies it would be of interest to consider, as far as possible, more and better variables so that the study of productivity change reflects the university production process more clearly. It would also be very useful to find the determinants of the productivity changes observed, both globally and in teaching and research activities separately, by performing a second-stage analysis using DEA methodology and also performing studies on cost efficiency, in view of the current situation of budgetary cutbacks in the Higher Education sector.

Bibliography

Agasisti, T. and Dal Bianco, A. (2009). Reforming the university sector: effects on teaching efficiency–evidence from Italy. *Higher Education*, 57, 477-498.

Agasisti, T. and Johnes, G. (2009). Beyond frontiers: comparing the efficiency of Higher Education decision-making units across more than one country. *Education Economics*, 17, 59-79.

Agasisti, T. and Pérez-Esparrells, C. (2010). Comparing efficiency in a cross-country perspective: the case of Italian and Spanish universities. *Higher Education*, 59, 85-103.

Bogetoft, P. and Otto, L. (2011). *International Series in Operations Research & Management Science: Benchmarking with DEA, SFA, and R*. New York: Springer.

Carrington, R., Coelli, T. and Rao, D. P. (2005). The performance of Australian universities: conceptual issues and preliminary results. *Economic Papers*, 24, 145-163.

Cooper, W. W., Seiford, L.M. and Tone, K. (2007). *Data Envelopment Analysis*. New York: Springer.

Corominas, A. and Sacristán, V. (2011). Las encrucijadas estratégicas de la Universidad Pública Española. *Revista de Educación*, 355, 57-81.

Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. *American Economic Review*, 84. 66-83.

Fernández-Santos, Y., Martínez-Campillo, A. and Fernández-Fernández, J. M. (2013). Evaluación de la eficiencia y el cambio de productividad en

Received: 14-01-2014 Accepted: 28-10-2014

el Sistema Universitario Público español tras la implantación de la LOU, *Hacienda Pública Española*, 205, 71-98.

Flegg, A., Allen, D., Field, K. and Thurlow, T. (2004). The efficiency of British universities: a multi-period Data Envelopment Analysis. *Education Economics*, 12, 231-249.

García-Aracil, A., López-Iñesta, E. and Palomares-Montero, D. (2009). An analysis of the Spanish Public Universities missions in efficiency terms, *Investigaciones de Economía de la Educación*, 4, 293-302.

Glass, J. C., McKillop, D. G. and O'Rouke, G. (1998). A cost indirect evaluation of productivity change in UK universities. *Journal of Productivity Analysis*, 10, 153-175.

Gómez-Sancho, J. M. and Mancebón M. J. (2012). La evaluación de la eficiencia de las universidades públicas españolas: en busca de una evaluación neutral entre Áreas de conocimiento. *Presupuesto y Gasto Públic*o, 67, 43-70.

Hernández Armenteros, J. (Coord.) (2004, 2006, 2008, 2010). *La Universidad Española en Cifras.* Madrid: Conferencia de Rectores de las Universidades Españolas (CRUE). Recuperado de: http://www.crue.org

Hernández Armenteros, J. and Pérez-García, J. A. (2011). La financiación universitaria española en un horizonte de austeridad y compromiso social. En J. García and M. de Esteban (Ed.), *Nuevas Perspectivas para la Financiación and el Gobierno de las Universidades* (15-56). Madrid: Fundación Europea Sociedad and Educación.

Johnes, J. (2008). Efficiency and productivity change in the English education sector from 1996/97 to 2004/05. *The Manchester School*, 76, 653-674.

Mahmoudi, M. J., Tabandeh, R. and Fathi, B. (2012). Measuring productivity and technology changes in the Islamic Azad University in Iran. *Research Journal of Applied Sciences, Engineering and Technology*, 4, 4576-4581.

Malmquist, S. (1953). Index numbers and indifference surfaces. *Trabajos de Estadística e Investigación Operativa,* 4, 209-242.

Mira Solves, J. J., Galán Vallejo, M., Van Kemenade, E., Marzo Campos, J. C., Gilabert Mora, M., Blaya Salvador, I. and Pérez Jover, M. V. (2012). Retos para el gobierno de las universidades en el marco del EEES. *Revista de Educación,* 357, 445-465.

Parteka, A. and Wolszczak-Derlacz, J. (2013). Dynamics of productivity in Higher Education: cross-European evidence based on bootstrapped Malmquist indices. *Journal of Productivity Analysis*, 40, 67-82.

Received: 14-01-2014 Accepted: 28-10-2014

Sav, G. T. (2012). Productivity, efficiency, and managerial performance regress and gains in United States universities: a Data Envelopment Analysis. *Advances in Management & Applied Economics*, 2, 13-32.

Shephard, R., (1953). *Cost and Production Functions.* Princeton: Princeton University Press.

Simar, L. and Wilson, P. W. (1999). Estimating and bootstrapping Malmquist indices. *European Journal of Operational Research*, 115, 459-471.

Wilson, P. (2008). FEAR: a software package for frontier efficiency analysis with R. *Socio-Economic Planning Sciences*, 42, 247-254.

Worthington, A. C. and Lee, B. L. (2008). Efficiency, technology and productivity change in Australian universities, 1998-2003. *Economics of Education Review*, 27, 285-298.

Contact Address: Yolanda Fernández-Santos. Universidad de León. Facultad de Ciencias Económicas y Empresariales. Departamento de Dirección y Economía de la Empresa. Campus de Vagazana, s/n; León (24071). E-mail: yfers@unileon.es

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