Measuring Teaching Efficiency of the Italian University System: the Role of Market Structure. A two step DEA analysis at faculty level.

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Provisional draft

Abstract

In this paper we explore the role of competition in providing incentives to improve teaching efficiency of the Italian university system over the period 2004 to 2008. The analysis is performed in two stages: first, we use Data Envelopment Analysis (DEA) to calculate an index of efficiency; second, a parametric approach is used to evaluate the determinants of teaching efficiency, focusing on the impact of competition. We contribute to the existing research in two ways. One way is to measure teaching efficiency of the Italian university system at faculty level; this way we provide a more accurate measurement of teaching efficiency by using the faculty-level of analysis. The other way is to explore the role of competition, captured by the market structure, in providing incentives to improve teaching efficiency. Our results are in favour of competition: when faculties operate in a more competitive environment, they are induced to carry out teaching activity in a more efficient way. However, competition does not induce faculties to grant more easily the degree to merely increase the output.

1 Introduction

Universities are, with no doubt, the engine of the economic development of countries. One of the main goal should be to supply teaching activity aiming at producing qualified students which are prepared to enter the job market.

A wide body of scientific research has flourished on university efficiency, its determinants and on related policy measures. In this paper we explore the role of competition in providing incentives to improve teaching efficiency of the Italian university system over the period 2004 to 2008. The analysis is performed in two stages: first, we use Data Envelopment Analysis (DEA) to calculate an index of efficiency; second, a parametric approach is used to evaluate the determinants of teaching efficiency, focusing on the impact of competition.

We contribute to the existing research in two ways. One way is to measure teaching efficiency of the Italian university system at faculty level, while previous studies engaged in analyses at university level. The choice of accounting for a greater level of disaggregation is motivated by the fact that each faculty supplies distinctive courses. Consider, for instance, the differences between science-related degree or humanistic-related degree. If teaching efficiency measurment is done at university level, such differences cannot be captured; therefore, we provide a more accurate measurement of teaching efficiency by using the faculty-level of analysis.

The other way is to explore the role of competition, captured by the market structure, in providing incentives to improve teaching efficiency. In the recent years, European countries have carried out reforms aiming at stimulating the yardstick competition among universities by leveraging funding. In Italy, the state fund "Fondo di Finanziamento Ordinario" (henceforth, FFO)[1] constitutes the main source of funding for universities. FFO is composed by two shares: the "quota base", assigned proportionally to the FFO of previous year, and the "quota per il riequilibrio", granted depending on quantitative parameters related to university performance[2].

In light of this, it is worthwhile to verify if competition effectively improves the efficiency of the Italian university system.

The reminder of the paper unfolds as follows. Section 2 provides a survey of the literature, Section 3 deals with the methodology to measure efficiency and to investigate its determinats. Data are described in Section 4. In Section 5 we show the results and in Section 6 the sensitiveness analysis. Finally, in Section 7 we draw conclusions.

[1]Established by the Art. 5 of Law 537/93.

[2]Defined by the Ministry of Education, University and Research (henceforth, MIUR), following the proposal of the "Comitato Nazionale per la Valutazione del Sistema Universitario" (henceforth, CNVSU), http://www.cnvsu.it/_library/downloadfile.asp?id=11146. For the period we consider, the "quota per il riequilibrio" is assigned depending on the following weights: 30% to higher education demand; 30% to teaching results; 30% to scientific research results and 10% to specific incentives.

2 Literature review

In this section we review the studies on universities' performance with attention to the role of competition in improving the level of efficiency.

Traditionally, producers take incentives to improve the efficiency in highly competitive markets than under less competitive conditions. In competitive markets only efficient firms survive, thus managers are motivated to increase their effort to avoid bankrupt. Moreover, best performers come out from neck-to-neck competition; hence, rival firms can draw on the best practice to improve their performance. One might says that these arguments do not hold for not-for-profit organizations, such as universities. Instead competition among universities takes place in several ways: universities compete to attract students, academic staff, research funding and consultancies. Such a competition can spur an efficiency gain. Actually, Agasisti (2009) empirically proves that competition among Italian universities led to an improvement in teaching performance[3].

The earliest studies on universities' efficiency develop the methodological framework to evaluate performance and provide applications to some departments of UK higher education institutions[4]. The first analysis at university-level is accomplished by Athanassopoulos and Shale (1997) which measure the efficiency of UK higher education institutions in the early nineties: few institutions have satisfactory performance. Flegg et al. (2004) illustrate that the UK system experienced a convergence process, a very important aspect since a system, as a whole, cannot produce the maximum attainable output if relative inefficiencies persist. In fact, ten years after, the analysis by Johnes (2006a) highlights the high level of efficiency across English higher education institutions. According to him, this finding is due to the competitive pressure to which higher education institutions are subjected to attract students and funds for research[5].

Further insights in favour of the role of competition in improving performance come out by matching the efficiency results of Johnes (2006a) with the number of higher education institutions within an area, thought as a proxy of competition. For instance, Greater London is the county with the greatest number of higher education institutions.

[3] The number of students and the number of graduates of a given unversity are used as a proxy of performance, while the average number of students and the average number of graduates of other universities is thought as a proxy of competitive pressure.

[4] See Johnes and Johnes (1993, 1995) and Beasley (1995).

[5] Johnes (2006b) develops an analysis at both individual and department-level on teaching efficiency in UK with the aim to distinguish the individual effect from the effect of departments on the level of degree achievement.

The 71.4% is deemed efficient and the 85.7% is above the average efficiency of the sample. After Greater London, in terms of number of higher education institutions, the Leicestershire has the 66.7% efficient institutions and the remaining are still above the sample mean. On the contrary, in counties with only one higher education institution, as those of the south-west, the efficiency level is below the sample mean[6]. A more intense catchment area competition appears to stimulate the efficiency of higher education institutions.

The research stream on higher education efficiency has spread to other countries[7]. Avkiran (2001) and Abbott and Doucouliagos (2003) measure the efficiency of Australian universities, pointing out a high level of efficiency with a room for improving performance. Afterward, Abbott and Doucouliagos (2009) shed light on the impact of competition on the efficiency of Australian and New Zealand universities. Australian universities appears to be characterised by a noteworth relationship between competition for overseas students and the level of efficiency achieved. Oppositely, New Zealand universities' efficiency is not affected by this competition. Actually, Australian universities have a greater share of overseas students with respect to New Zealand universities, being, therefore, more exposed to the global market forces.

Kemkes and Pohl (2010) evaluate the efficiency of German universities: western universities exhibit a higher level of efficiency compared to the eastern counterparts, even though eastern universities have experienced a greater improvement in efficiency. As said by the authors, a channel through which improve efficiency could be the stimulation of competition by assigning part of public funding to universities depending on their performance.

Agasisti and Dal Bianco (2006) focus on the efficiency of the Italian university system[8]: few universities are efficient, most of them lies in northern Italy[9]. The north-south gap is also proved by Monaco (2012) which notes, additionally, that private universities are more efficient than the public ones.

Provided that socioeconomic motivations hold, the north-south gap can be explained

[6] These considerations are based on the efficiency scores of pre-1992 higher education institutions.

[7] Preliminary studies on Turkish universities provide evidence on the lower efficiency of faculties of economics (Çokgezen (2009)) and on the excessive use of resources by accounting education institutions (Celik and Ecer (2009)). Tzeremes et al (2010) conduct an efficiency analysis at department-level on the University of Thessaly that highlights strong inefficiencies among departments.

[8] Preliminary studies on Italian universities measure the performance at department-level of University of Trieste and University of Venezia. See, respectively, Pesenti and Ukovich (1996a, 1996b) and Rizzi et al (1999).

[9] 66.7% of efficient universities lies in the north, 26.7% in the centre and 6.6% in the south of Italy.

also in light of the stronger catchment area competition among universities in northern Italy. Actually, prospective students who live in the north can choose among a greater number of universities. The morphology of the territory makes such universities more easily accessible within the regions and from the neighbouring regions than universities in the south; therefore competition is more effective. For instance, the Lombardy region has 13 universities, the highest number in Italy. Eight of them are included in the analysis of Agasisti and Dal Bianco (2006): the 87.5% exhibits a level of efficiency over the sample mean and the 62.5 % is totally efficient[10].

The growing internationalization of universities in Europe has increased the interest on the cross-country comparison of universities' performance. According to Agasisti and Johnes (2009), the average efficiency of Italian universities appears to be lower than the English counterparts. Despite this, Italian universities show a definite improvement of efficiency along the years, whereas English efficiency is more stable. Although these results could be related to the different economic and regulatory contexts, the greater efficiency of English higher education institutions is due to the stronger competitive pressure to which they are exposed, given the lower dependence on public funding with respect to Italian universities. Agasisti and Perez-Esparrels (2010) prove that Italian universities are more efficient than Spanish and also the improvement in efficiency is greater[11]. These findings seem to be related to the reform that introduces the bachelor-master structure in Italy and allows students to obtain the degree in less time. Instead, German universities appear to be more efficient than the Italian counterparts; nevertheless, the efficiency improvement is more rapid for Italian than German universities. Germany and Italy show the same gap between west-east and north-south universities, respectively (Agasisti and Pohl (2012)).

The European landscape is explored by Joumandy and Ris (2005) and Bonaccorsi et al (2007). Joumandy and Ris (2005) provide an efficiency comparison among universities across eight countries: British, Dutch and Austrian universities are the most efficient; Spanish, Finnish and Italian are deemed as the less efficient; French and German universities lie in between.

Bonaccorsi et al (2007) disentangle the efficiency of European universities by analysing

[10] Percentages are computed on efficiency estimates of Agasisti and Dal Bianco (2006).

[11] This analysis confirms the north-south gap in Italy pointed out by Agasisti and Dal Bianco (2006). The improvement in performance of universities of southern and central Italy together with the slowdown of universities in the northern Italy depict a process of convergence. In Spain there are no similar regional differences, however the process of convergence among regions is even more accentuated.

teaching and research efficiency conditional to universities' size. On teaching efficiency, universities exhibit, overall, increasing return to scale up to a certain size. However, separate analyses suggest differences across country. For instance, universities in Italy exhibit moderate increasing return to scale, while Spanish universities show remarkable increasing return to scale, in particular the larger ones. In UK a group of universities lies in region of strong increasing return to scale up to a certain size; beyond that size, such universities exhibit strong decreasing return to scale. According to the authors, larger universities are relative less teaching efficient because the academic staff is more devoted to research than to teaching activity. As concerns research efficiency, there is no such a trend as for teaching efficiency. Further, the overall efficiency seems to be affected by size: even though teaching efficiency improves when adding more staff, up to a certain size, the research efficiency is harmed.

This paper focuses on teaching efficiency of the Italian university system for the period 2004-2008. We engage in a two-step DEA analysis. Specifically, we contribute to the existing research in two ways.

One way is to measure the efficiency of the Italian university system at faculty-level, while previous studies realized analyses at university-level. Actually, faculties carry out different training programme. If the analysis is conducted at university-level, such differences cannot be captured. Therefore, we provide a more accurate measurement of efficiency by adopting the faculty-level of analysis.

The other way is to explore the role of competition, captured by the market structure, in providing incentives to improve faculties' performance. Unlike previous studies in education, we undertake the two step analysis that allows us account for the impact of environmental factors, as competition.

3 Estimation methodology

This section aims at detailing the estimation methodology used to measure relative teaching efficiency of the Italian university system and to assess the impact of environmental factors in affecting teaching efficiency. Specifically, we focus the role of competition in providing incentives for improving teaching performance.

The approach for efficiency analysis is the two step methodology. Timmer (1971) was among the first that applied this procedure to explain interstate variation in efficiency in US agriculture. Henceforth, the two-step methodology has been widely applied to various sectors: among the others, by McCarty and Yaisawarng (1993) to investigate efficiency in New Jersey public school districts[12].

In the first step we estimate efficiency by the means of Data Envelopment Analysis (henceforth, DEA), the non-parametric matematical programming technique introduced by Charnes et al. (1978). According to Worthington (2001), DEA is suitable for technical efficiency measurement in education. Actually, there are two methodologies for measuring efficiency: the parametric technique and the non-parametric technique. The Stochastic Frontier Analysis (henceforth, SFA)[13] is the parametric technique that evaluates efficiency under some theoretical constraints. Indeed, SFA requires assumptions on the functional form of the production function and on the error term related to technical inefficiency.

Instead DEA does not impose a functional form on the input-output relationship: within the set of comparable Decision Making Unit (henceforth, DMUs), it identifies those that exhibit the best practice and constitute the efficient frontier. Deviations from the efficient frontier are the result of inefficiency. The flexibility of DEA is a valuable point when dealing with not-for-profit organizations as education institutions. Moreover, DEA, contrary to SFA, manages multiple inputs and multiple outputs, as the production function of higher education institutions requires, thus avoiding forced output aggregation.

DEA measures either the technical efficiency or the allocative efficiency. The former "refers to the ability to avoid waste by producing as much output as input usage allows, or by using as little input as output production allows". The latter "refers to the ability to combine inputs and outputs in optimal proportions in light of prevailing prices"[14]. Combining technical efficiency and allocative efficiency provides the economic efficiency. However, data on market prices of inputs and outputs are not readily available for

[12]Worthington and Dollery (2002) compared different methods to account for the effect of environmental factors on the efficiency of 73 New South Wales local governments in Australia. Afonso and Aubyn (2006) considered a two-stage approach in relation to the health production process of OECD countries. Recently, Adam et al. (2008) used the same methodology to estimate the effect of decentralisation on the efficiency of the public sector; Bergantino and Porcelli (2011, 2012) applied the two-step approach to assess the relative efficiency of local transport services by Italian councils and subsequently to evaluates its determinants. Finally Bergantino and Musso (2011) provide an analysis of performance of a panel of Southern European ports. Following a multi-step approach, they distinguish between the role of external and internal factors to the organisation of the port in determining the relative efficiency.

[13]SFA is based on the stochastic production frontier models introduced by Aigner et al. (1977) and Meeusen and van den Broeck (1977).

[14]See Lovel (1993) pg. 12.

education, consequently our analysis focuses on technical efficiency.

Finally, the second step consists of regressing the efficiency scores emerging from the first step on environmental variables in order to explain differences in efficiency.

3.1 First step

For measuring technical efficiency, a variable returns to scale envelopment problem is solved for each i^{th} DMU in the sample (Banker, Charnes and Cooper (1984))[15]; to this end each faculty is treated as a DMU. Technical efficiency is reached when outputs are maximized, keeping inputs fixed (output-oriented approach) or when inputs are minimized, keeping outputs fixed (input-oriented approach). For this study, we deem suitable the output-oriented approach since the endowment of inputs does not vary too much in the short-run, thus faculties can mainly increase outputs to improve performace. We also compute efficiency scores under the input-oriented approach, in order to check the robustness of results.

Formally, consider DMU$_i$, with $i = 1, ..., N$, employing z inputs to produce q outputs. Under the output-oriented approach, $\eta_{i,t}$ is the solution of the following linear program:

$$\max_{\theta,\lambda} \eta \quad \textit{subject to}: \; X\lambda \leq x_i; \; \theta y_i - Y\lambda \leq 0; \; e\lambda = 1; \; \lambda \geq 0 \tag{1}$$

Under the input-oriented approach, $\theta_{i,t}$ is the solution of the following linear program:

$$\min_{\theta,\lambda} \theta \quad \textit{subject to}: \theta x_i - X\lambda \geq 0; Y\lambda \geq y_i; \; e\lambda = 1; \; \lambda \geq 0 \tag{2}$$

where x_i is the $(z \times 1)$ input vector of the i^{th} DMU; y_i is the $(q \times 1)$ output vector of the i^{th} DMU; X is the $(z \times N)$ matrix of input vector in the comparison set; Y is the $(q \times N)$ matrix of output vector in the comparison set; λ is the $(N \times 1)$ intensity vector and e is the $(N \times 1)$ unity vector.

Hence, $e_{i,t}^{O\_DEA} = \frac{1}{\eta_{i,t}}$ and $e_{i,t}^{I\_DEA} = \theta_{i,t}$ are two sets of efficiency scores for each faculty i in the year t obtained under the output and the input approach, respectively. Efficiency scores correspond to Debreau (1951) - Farrell (1957) indices of technical efficiency (i.e. the distance between a DMU and the efficiency frontier) bounded between

[15] Formerly, Charnes, Cooper and Rhodes (1978) assume constant return to scale (CRS). Banker et al (1984) relax this assumption and introduce VRS. Actually, CRS is a limiting assumption as economies of scale in university operations make returns to scale unlikely to be constant.

0 and 1, where 1 is related to faculties lying on the efficient frontier.

The linear programs are solved by using a pooled approach where only one production frontier is estimated, thus each faculties is compared also with itself in another year. In this way it is possible to use all the $N\times T$ observations.

3.2 Second step

We specify the following model to investigate efficiency determinants:

$$e_{i,t}^{DEA} = \beta_0 + \beta_1 HHI_{i,t} + \gamma_2 Control\ Variables_{i,t} + \varepsilon_{i,t} \tag{3}$$

where i identifies the faculty and t the time (2004 to 2008). The dependent variable $e_{i,t}^{DEA}$ is the vector of efficiency scores obtained from the first step. As said before, efficiency scores bounded, by construction, between 0 and 1.

HHI is the Herfindahl-Hirschman Index. We identifies the relevant markets by using the criterion adopted by MIUR to group faculties depending on related studies in order to define the *HHI*[16]:

$$HHI_{i,t} = \sum_{i=1}^{I^j} s_{i,t}^2, \forall t \tag{4}$$

where j indexes the groups of faculties ($j = 1, ..., 17$), s_i is the market share, computed as:

$$s_{i,t}^2 = \frac{Number\ of\ enrolled\ student_i}{\sum_{i=1}^{I^j} Number\ of\ enrolled\ student_i}, \forall t \tag{5}$$

We treat the *HHI* as exogenous. As a matter of fact, the university market structure is not likely to vary substantially in the short run since the procedure to built up a new faculty is bureaucratically complex and specific requirements need to be met.

Control Variables is the set of environmental variables that could influence the efficiency scores.

Taking advantage from the panel structure of the dataset, we employ the Fixed-Effect (FE) panel data model including, among the regressors, faculty fixed effects and year dummies. The Random-Effect (RE) panel data model is also used following the

[16] MIUR defines 17 groups of faculties: Agriculture; Architecture; Economics; Pharmacy; Law; Engineering; Liberal Arts; Foreign Languages; Medicine; Veterinary Medicine; Psychology; Political Science; Education; Mathematics, Physics and Natural Science; Motor Science; Statistics; Sociology.

Mundlak (1978) approach that consists of adding, as further regressor, the time-average of *HHI* in order to tackle unobserved effects. In the RE model we also include year dummies, faculty-group dummies and university dummies.

4 Data

4.1 Inputs and outputs of Italian faculties

The choice of inputs has fallen on *number of academics* (professors plus researchers) as a proxy for human capital endowment. As far as the output side, we use the *number of undergraduates* and the *number of postgraduates*. The bachelor-master structure was introduced in Italy from the academic year 2000/2001. Formerly there was a unique level of degree course which is nowadays treated, by the Italian law, as equivalent to the postgraduate degree. Following the legislative standpoint, we sum up pre-reform postgraduates and post-reform postgraduates to define the output *number of postgraduates.*

The Italian university system allows students to spend more than the years scheduled by MIUR for each course to obtain the degree. To capture this point, we define *On-time Graduation Index*, the ratio between the number of years scheduled for each degree course and the average number of years of delay. This index favours faculties in which students carry out studies within the expected term, whereas penalises faculties whose students take more years to obtain the degree, thus becoming a burden for the production process. On this account, we define two main production functions:

Production Function 1	*Production Function 2*
Input	**Input**
Number of academics	Number of academics
Outputs	**Outputs**
Number of undergraduates	Number of undergraduates
Number of postgraduates	Number of postgraduates
	On-time Graduation Index

The former, standard in the literature, is composed by one input, *number of academics*, and two outputs, *number of undergraduates* and *number of postgraduates.* The latter adds to the output side *On-time Graduation Index.* In Table 1 we provides descriptive statistics of input and outputs.

Table 1. Descriptive statistics of input and outputs.

Variables	*Obs*	*Mean*	*St. Dev.*	*Min*	*Max*
INPUT					
Number of academics	1508	119.094	125.494	6	1589
OUTPUT					
Number of undergraduates	1508	267.920	282.812	5	2423
Number of postgraduates	1508	269.805	262.166	5	2596
On-time Graduation Index	1508	1.503	1.317	0.127	16.250

Data on *number of academics* are taken from MIUR which provides information on academics as of December 31 of each year. Data on outputs belong to the dataset *Profilo dei Laureati* developed by *Almalaurea* which provides statistics at faculty-level on 48 universities listed in Table 2 (in Appendix).

4.2 Environmental variables

The list and the description of environmental variables included in the analysis are reported in Table 3.

Table 3. Descriptive statistics of environmental variables.

Variables	Description	Obs	Mean	St. Dev.	Min	Max
HHI	Sum of the square of market shares	1489	0.050	0.036	0.030	0.260
FACULTY-LEVEL						
High-school mark	Number	1497	81.748	3.593	71.406	95.794
Upper-middle class	% students	1496	20.880	8.245	2.248	62.517
Parental education	% students with at least 1 or more graduate parents	1495	15.329	4.784	1.5	37.185
MUNICIPALITY-LEVEL						
Inhabitants	Number	1497	443674.4	693657.6	1046	2724347
Inhabitants under 14	% inhabitants	1497	12.472	1.591	9.404	1.752
Inhabitants over 65	% inhabitants	1497	22.095	3.299	12.999	28.107
Local GDP	Real Euros per inhabitant	1497	21942.42	2543.861	13775.15	30756.31
Public transport demand	no. passengers	1425	179.935	155.150	6.9	763.137
Incoming outliers	no. per 1000 inhabitants	1497	615.485	100.010	0.733	3906.576
Self-employed worker	% labour force	1497	22.183	2.141	18.620	26.816
Tertiary employment	% labour force	1497	37.967	4.416	17.058	48.596

Data on number of students enrolled by each faculty used to built up the *HHI* are taken from MIUR[17]. Control variables at faculty-level are taken from the dataset *Profilo*

[17] The number of enrolled students refers to the academic year, whereas inputs and outputs and, consequently, the efficiency scores refer to the calendar year. We match the *HHI* based on the number of enrolled students in the academic year 2003/2004 with the efficiency scores of calendar year 2004,

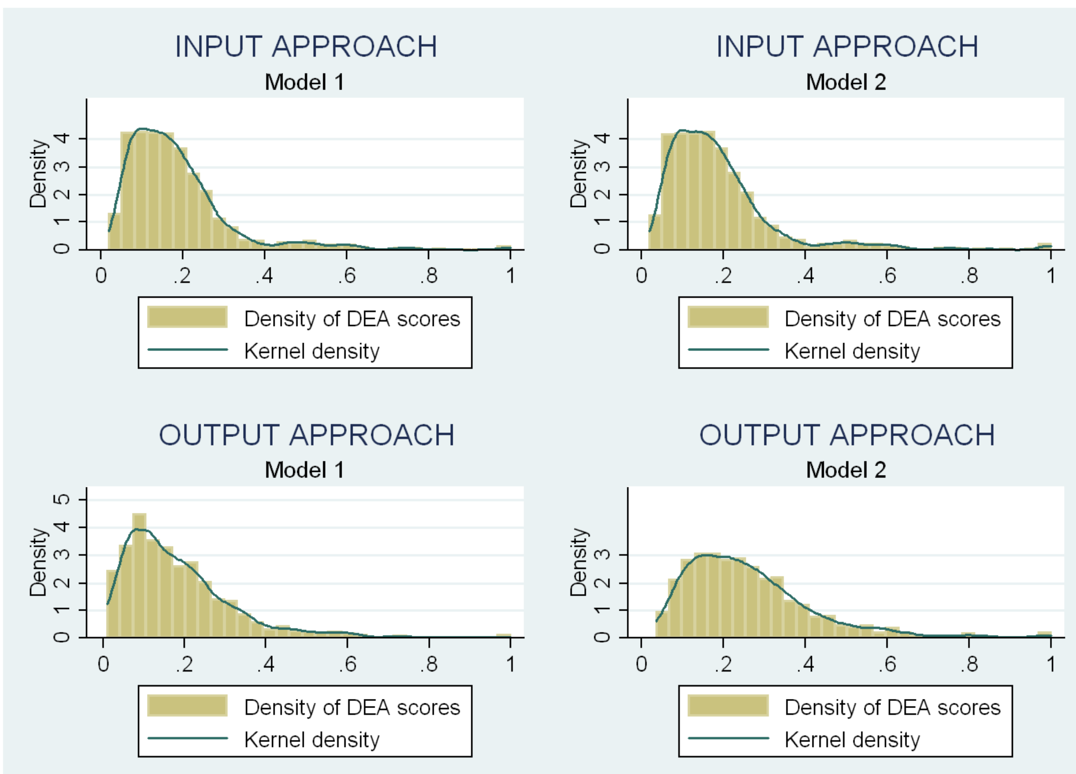
dei Laureati developed by *Almalaurea*; control variables at municipality-level are taken from ISTAT "*Atlante dei comuni 2009*".

5 Results

5.1 Analysis of efficiency scores

Figure 1 reports the density distribution of efficiency scores obtained from Production Function 1 and Production Function 2 under the output and the input approach[18].

Figure 1. Density distribution of DEA efficiency scores.



The density distributions of efficiency scores look very similar: the output approach leads to efficiency indices close to those obtained under the input approach. Density

the HHI based on the number of enrolled students in the academic year 2004/2005 with the efficiency scores of calendar year 2005, and so on.

[18] Efficiency scores were undertaken using the package Frontier Efficiency Analysis with R (FEAR) 1.15 developed by Wilson.

distributions are right-skewed: the mass is concentrated on the left, thus having relatively few high values. This indicates the poor performance of Italian faculties, as shown also in Table 5 in which we provide summary statistics of technical efficiency scores, computed also for geographical areas.

Table 4. Efficiency scores.

	OUTPUT APPROACH		INPUT APPROACH	
	(1)	(2)	(1)	(2)
ITALY				
Mean	0.193	0.270	0.180	0.192
Standard Deviation	0.152	0.168	0.137	0.145
Min	0.010	0.036	0.019	0.019
Max	1	1	1	1
DMUs	1508	1508	1508	1508
Efficient DMUs	5	10	5	10
NORTHERN ITALY				
Mean	0.201	0.304	0.197	0.204
Standard Deviation	0.162	0.181	0.144	0.159
Min	0.010	0.050	0.030	0.030
Max	1	1	1	1
DMUs	684	684	684	684
Efficient DMUs	3	7	3	7
CENTRAL ITALY				
Mean	0.228	0.284	0.192	0.196
Standard Deviation	0.169	0.171	0.158	0.165
Min	0.026	0.054	0.032	0.032
Max	1	1	1	1
DMUs	318	318	318	318
Efficient DMUs	1	2	1	2
SOUTHERN ITALY				
Mean	0.159	0.216	0.173	0.173
Standard Deviation	0.115	0.130	0.109	0.109
Min	0.013	0.036	0.019	0.019
Max	1	1	1	1
DMUs	506	506	506	506
Efficient DMUs	1	1	1	1

Our measures point out a few best practices. Technical efficient DMUs are only 0.33% according to Model 1 and 0.66% according to Model 2. Actually, the average efficiency scores are very low: Italian faculties produce too few graduates, given the number of academics employed or, conversely, they employ too much academics to produce such a number of graduates. Further, the average efficiency scores appear to be higher when computed by the output-oriented approach: about the 39.5% of faculties show a level of efficiency higher than the sample mean, whereas by the input approach, about the 37% of faculties exhibit a level of efficiency higher than the sample mean. This could indicate a greater ability of Italian faculties to produce graduates than to make a good use of inputs. Descriptive statistics on northern, central and southern Italy show that northern and central faculties are more efficient than the southern counterparts[19]. In particular, the majority of efficient DMUs lies in the North. However, our measurements show that the north-south gap is not so much pronounced as Agasisti and Dal Bianco (2006) suggest.

Moreover, a more remarkable difference is among faculties belonging to private universities and faculties belonging to public universities. The formers seem to be definitely more efficient than the latters[20], as shown in Table 5.

[19] This finding is consistent with Agasisti and Dal Bianco (2006), although our measurements show that the north-south gap is not very pronounced.

[20] This finding is consistent with Monaco (2012).

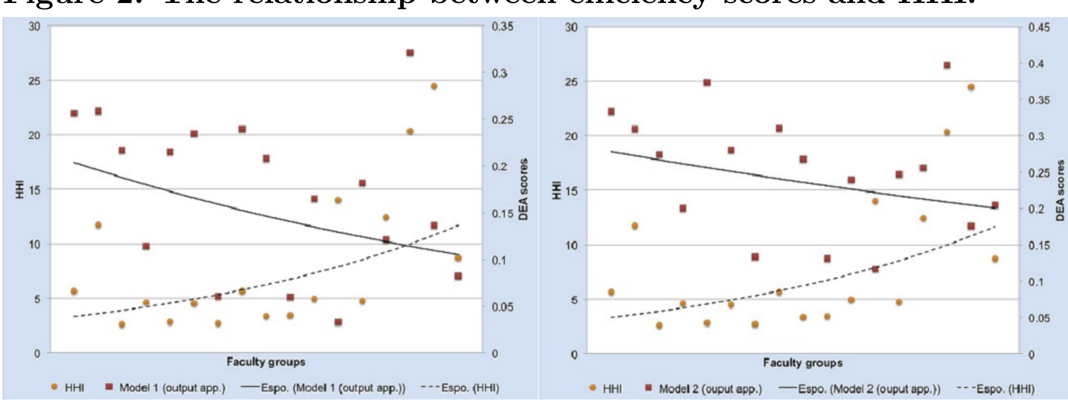
Table 5. Efficiency scores: private and public faculties.

	OUTPUT APPROACH		INPUT APPROACH	
	(1)	(2)	(1)	(2)
PRIVATE UNIVERSITIES				
Mean	0.564	0.585	0.412	0.611
Standard Deviation	0.238	0.243	0.272	0.214
Min	0.102	0.109	0.026	0.260
Max	1	1	1	1
DMUs	54	54	54	54
Efficient DMUs	3	4	3	4
PUBLIC UNIVERSITIES				
Mean	0.174	0.178	0.185	0.258
Standard Deviation	0.109	0.118	0.139	0.152
Min	0.019	0.019	0.010	0.036
Max	1	1	1	1
DMUs	1454	1454	1454	1454
Efficient DMUs	2	6	2	6

5.2 The role of market structure in improving efficiency.

Before discussing regressions' results, it is interesting to look at the relationship between technical efficiency scores and *HHI.* As clearly emerges from the Figure 2, higher values of technical efficiency are associated with lower values of *HHI.*

Figure 2. The relationship between efficiency scores and HHI.



IIn Table 6 we show the coefficient estimates of *HHI* obtained using a sample of 340 faculties related to 48 universities over 2004 to 2008.

Table 6. The role of competition in improving efficiency.

	OUTPUT APPROACH		INPUT APPROACH	
	(1)	(2)	(1)	(2)
FE	-0.0186***	-0.0017	-0.0130***	-0.0111*
	(0.0070)	(0.0075)	(0.0049)	(0.0058)
RE	-0.0202***	-0.0038	-0.0135***	-0.0121**
	(0.0069)	(0.0075)	(0.0050)	(0.0058)
Observations	1417	1417	1417	1417
Number of faculties	340	340	340	340
Control variables	yes	yes	yes	yes

(1) Dependent variable: efficiency scores obtained from Production Function 1

(2) Dependent variable: efficiency scores obtained from Production Function 2

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Cluster-robust standard errors in parentheses.

According to our estimates, the coefficient of *HHI* appears to be negative which suggests that Italian faculties are less efficient in more concentrated markets. Coefficients are very similar across models and are significant in almost all the cases. When the dependent variable is the set of efficiency scores obtained from Production Function 1, the impact of the *HHI* is highly significant. An increase in concentration by 1% reduces efficiency by 1.11% to 1.86% using the FE estimator and by 1.2% to 0.20% using the RE estimator. However, the impact of *HHI* becomes not significant when the dependent variable is the set of efficiency scores obtained under the output approach from Production Function 2, in which we add *On-time Graduation Index* to the output side. Finally, the R^2 is, roughly, 0.91[21].

Our results suggest that competition induces faculties to carry out the teaching activity in a more efficient way and improves the production of undergraduates and postgraduates. However, competition does not seem to influence the number of years that students spend to obtain the degree. Provided that the number of years needed to graduate could be related to individual skills and motivations, our findings suggest faculties are not likely to grant more easily the degree to merely increases the outputs.

[21] Computed with the Least Square Dummy Variables (LSDV) model.

6 Sensitiveness analysis

We check the sensitiveness of efficiency scores estimated by means of the aforementioned production functions to different characterizations of inputs and outputs. To this aim, we use *number of academics (professors)* and *number of academics (researchers)*, separately. Moreover, we weight *number of undergraduates* and *number of postgraduates* for the average graduation mark, thus defining *quality of undergraduates* and *quality of postgraduates*, respectively. By combining these alternative measures of inputs and outputs, we define the production functions summarized in Table 7.

Table 7. DEA models for robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INPUT								
Number of academics (total)	X	X			X	X		
Number of academics (professors)			X	X			X	X
Number of academics (researchers)			X	X			X	X
OUTPUT								
Number of undergraduates	X	X	X	X				
Number of postgraduates	X	X	X	X				
Quality of undergraduates					X	X	X	X
Quality of postgraduates					X	X	X	X
On-time Graduation Index		X		X		X		X

The main production functions labelled 1 and 2 are those whose robustness is checked by the additional specifications, labelled 3 to 8. In Table 8 (in Appendix) we show the correlation matrix of efficiency scores.

Efficiency scores obtained under the input approach are correlated at more than 98%. This means that using two separate inputs in place of a unique measure of human capital endowment does not add information on the production process; therefore, on a parsimony criterion, the production functions with one input are preferred.

Efficiency scores obtained under output approach are correlated at 99%. This suggests that efficiency estimates are robust to the weighting of outputs with the average graduation mark.

The correlation matrix highlights that production functions that account for *On-time Graduation Index* are correlated at 80% with production function that does not. The introduction of this index provides further information on the production process.

As said in Section 4, we compute the *number of postgraduates* by summing up the number of pre-reform postgraduates and the number of post-reform postgraduates. As the bachelor-master structure introduced a number of innovations concerning the organisation of taught courses, we verify that this aggregation does not influence the efficiency estimates; thus, we define further models (labelled by *b*) holding separate the number of pre-reform postgraduates from number of post-reform postgraduates. In Table 9 (in Appendix) we report the related correlation matrix: correlations among efficiency scores are around 96% for those obtained under output approach and 92% for those obtained under the input approach. The distinction among number of pre-reform postgraduates and number of post-reform postgraduates does not provide additional information on the production process; therefore, on a parsimony criterion, production functions using the sum of postgraduates are preferred.

Summary and conclusions

In this study we shed light on the role of competition in providing incentives to improve performance of the Italian university system using a sample of 340 faculties related to 48 universities, for the period 2004 to 2008. We undertake the two-step DEA methodology. In the first step, technical efficiency is computed at faculty-level; in the second step we evaluate efficiency determinants, focusing on competition.

Our evidence is in favour of competition: when faculties operate in a more competitive environment, they are induced to carry out teaching activity in a more efficient way. However, competition does not induce faculties to grant more easily the degree to increases the output.

Further results indicate, on average, the poor performance of Italian faculties. In particular, northern and central Italian faculties are more efficient compared to the southern counterparts. In addition, private faculties seem to be markedly more efficient than public faculties.

Developments for future research could be to explore the role of competition in providing incentives to improve research performance of the Italian university system. On a technical level, the bootstrap procedure developed by Simar and Wilson (1998, 2000) can be used to estimate a "bias corrected" measure of efficiency.

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Appendix

Table 2. List of universities included in the sample.

	Universities
1	Libera Università "Vita Salute S.Raffaele" MILANO
2	Libera Università degli Studi "Maria SS.Assunta" Roma
3	Libera Università di BOLZANO
4	Libera Università di lingue e comunicazione IULM-MI
5	Politecnico di TORINO
6	Seconda Università degli Studi di NAPOLI
7	Università "Cà Foscari" di VENEZIA
8	Università "Campus Bio-Medico" ROMA
9	Università "Carlo Cattaneo" - LIUC
10	Università degli Studi "G. d'Annunzio" CHIETI-PESCARA
11	Università degli Studi "Magna Graecia" di CATANZARO
12	Università degli Studi "Mediterranea" di REGGIO CALABRIA
13	Università degli Studi de L'AQUILA
14	Università degli Studi del MOLISE
15	Università degli Studi del PIEMONTE ORIENTALE
16	Università degli Studi del SALENTO
17	Università degli Studi del SANNIO di BENEVENTO
18	Università degli Studi della BASILICATA
19	Università degli Studi della TUSCIA
20	Università degli Studi di BARI "Aldo Moro"
21	Università degli Studi di BOLOGNA
22	Università degli Studi di CAGLIARI
23	Università degli Studi di CAMERINO
24	Università degli Studi di CASSINO e del LAZIO MERIDIONALE
25	Università degli Studi di CATANIA
26	Università degli Studi di FERRARA
27	Università degli Studi di FIRENZE
28	Università degli Studi di FOGGIA
29	Università degli Studi di GENOVA
30	Università degli Studi di MESSINA
31	Università degli Studi di MODENA e REGGIO EMILIA
32	Università degli Studi di PADOVA
33	Università degli Studi di PARMA
34	Università degli Studi di PERUGIA
35	Università degli Studi di Roma "Foro Italico"
36	Università degli Studi di ROMA "La Sapienza"
37	Università degli Studi di SALERNO
38	Università degli Studi di SASSARI
39	Università degli Studi di SIENA
40	Università degli Studi di TORINO
41	Università degli Studi di TRENTO
42	Università degli Studi di TRIESTE
43	Università degli Studi di UDINE
44	Università degli Studi di VERONA
45	Università degli Studi ROMA TRE
46	Università della CALABRIA
47	Università della VALLE D'AOSTA
48	Università IUAV di VENEZIA

Table 8. Correlation matrix of DEA models (I).

		OUTPUT APPROACH								INPUT APPROACH							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OUTPUT APPROACH	(1)	1															
	(2)	0.835	1														
	(3)	0.942	0.795	1													
	(4)	0.996	0.834	0.935	1												
	(5)	0.945	0.800	0.997	0.944	1											
	(6)	0.807	0.963	0.854	0.802	0.854	1										
	(7)	0.844	0.998	0.801	0.849	0.811	0.959	1									
	(8)	0.818	0.964	0.861	0.818	0.866	0.998	0.964	1								
INPUT APPROACH	(1)	0.550	0.525	0.622	0.511	0.598	0.588	0.507	0.573	1							
	(2)	0.564	0.602	0.628	0.530	0.608	0.653	0.582	0.636	0.949	1						
	(3)	0.494	0.482	0.618	0.456	0.592	0.588	0.464	0.572	0.972	0.921	1					
	(4)	0.563	0.535	0.634	0.527	0.612	0.598	0.520	0.586	0.999	0.949	0.971	1				
	(5)	0.506	0.492	0.626	0.471	0.603	0.596	0.477	0.582	0.971	0.921	0.999	0.972	1			
	(6)	0.512	0.562	0.627	0.479	0.605	0.656	0.542	0.639	0.934	0.973	0.960	0.934	0.959	1		
	(7)	0.578	0.616	0.640	0.547	0.622	0.666	0.599	0.652	0.946	0.999	0.918	0.948	0.920	0.972	1	
	(8)	0.525	0.574	0.636	0.495	0.617	0.665	0.557	0.650	0.933	0.972	0.958	0.935	0.960	0.999	0.973	1

Table 9. Correlation matrix of DEA models (II).

		OUTPUT APPROACH				INPUT APPROACH			
		(1)	(2)	(1*b*)	(2*b*)	(1)	(2)	(1*b*)	(2*b*)
OUTPUT APPROACH	(1)	1							
	(2)	0.882	1						
	(1*b*)	0.964	0.823	1					
	(2*b*)	0.886	0.963	0.894	1				
INPUT APPROACH	(1)	0.581	0.506	0.533	0.519	1			
	(2)	0.610	0.593	0.561	0.590	0.933	1		
	(1*b*)	0.618	0.510	0.639	0.589	0.929	0.864	1	
	(2*b*)	0.657	0.612	0.675	0.673	0.867	0.922	0.938	1