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MEASURING THE EFFICIENCY OF THE ITALIAN UNIVERSITY SYSTEM: THE ROLE OF MARKET STRUCTURE. A TWO STEP DEA ANALYSIS AT FACULTY-LEVEL.

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SOMMARIO

Il presente lavoro studia il ruolo della competizione, definita dalla struttura del mercato, nel fornire l'incentivo a migliorare l'efficienza tecnica dell'attività di insegnamento del sistema universitario italiano, dal 2004 al 2008.
Utilizzando la metodologia non parametrica, l'efficienza tecnica viene misurata a livello di facoltà, mentre gli studi precedenti hanno condotto l'analisi a livello di università. In tal modo, l'analisi fornisce una stima più accurata dell'efficienza ed, inoltre, consente di analizzarne dettagliatamente le determinanti.
I risultati principali suggeriscono che in mercati più concentrati, le facoltà sono meno efficienti. L'evidenza empirica è, quindi, a favore della competizione: quando le facoltà operano in un ambiente più competitivo, sono indotte a realizzare l'attività di insegnamento in maniera più efficiente.

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

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Abstract

In this paper we investigate on the role of competition, captured by the market structure, in providing incentive to improve teaching efficiency of the Italian university system, over the period 2004-2008. We measure the technical efficiency at faculty-level through the non-parametric technique, while previous studies engaged in analyses at university-level. This way we provide a more accurate measurement of efficiency and we can investigate in detail on the determinants. Our results claim that, in more concentrated market, faculties are less efficient. The evidence is in favour of competition: when faculties operate in a more competitive environment, they are induced to carry out the teaching activity in a more efficient way.

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1 Introduction

Universities are, with no doubt, the engine of the economic development of countries. One of the main goal should be to supply training activities to produce high quality students that enter rapidly into the job market.

A wide body of scientific research has flourished on universities' efficiency, its determinants and on possible related policy measures. This paper focuses, in particular, on teaching efficiency of the Italian university system over the period 2004-2008 and contributes to the existing research in two ways.

One way is to measure the efficiency of Italian university system at faculty-level, through the non-parametric technique. Previous studies engaged in analyses at university-level, whereas we take a greater level of disaggregation. This way we provide a more accurate measurement of efficiency and we can investigate in detail on the determinants.

The other way is to test the role of competition, captured by the market structure, in providing incentives to improve performance. Actually, the Italian university system has been characterised by a process of reform that, among the other things, stimulates competition for improving the efficiency and effectiveness of universities. To this aim, a share of the state fund "Fondo di Finanziamento Ordinario" (henceforth, FFO)[1], that constitutes the main source of funding for universities, is granted according to quantitative parameters[2] introduced to increase competition among universities. Therefore, it is worth to understand if competition effectively improves teaching efficiency.

The rest of the paper unfolds as follows. Section 2 provides a survey of the literature, Section 3 deals with the methodology for the efficiency measurement and the correlation analysis. Data are described in Section 4 and in Section 5 we show the empirical results. In Section 6 we show the sensitiveness analysis and, finally, in Section 7 we draw conclusions.

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.

[1]Established by the Art. 5 of Law 537/93, the FFO is autonomously managed by universities. FFO is composed by two shares: the "quota base", assigned proportionally to the FFO of previous year, and the "quota per il riequilibrio" that depends on universities' performance.

[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.

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. 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

[3] The number of students and the number of graduates of a given faculty are used as a proxy of performance, while the average number of students and number of graduates of other faculties 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.

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

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 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 stronger. 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

[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.

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

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 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 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 semms to be is affected by size: even though teaching efficiency improves when adding more staff, up to a certain size, the research efficiency is harmed.

The present study focuses on teaching efficiency of the Italian university system for the period 2004-2008 and contributes to the existing research by testing the role of competition,

[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.

captured by the market structure, in providing incentives to improve performance. We measure the efficiency of Italian university system at faculty-level, while previous studies engaged in analyses at university-level; this way we provide a more accurate measurement of efficiency and we can investigate in detail on the determinants.

3 Estimation methodology

We undertake the two-step approach for technical efficiency analysis. In the first step, we estimate the relative technical efficiency by the means of Data Envelopment Analysis (henceforth, DEA), the non-parametric method introduced by Farrell (1957) and developed by Charnes et al. (1978). DEA allows to measure 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"[12]. Combining technical efficiency and allocative efficiency provides the economic efficiency. However, data on market prices of input and output are not available for education, therefore our analysis focus on technical efficiency.

DEA is notably suitable for technical efficiency measurement in education[13] and, more in general, in the public sector. Actually, there are two methodologies for measuring technical efficiency: the parametric technique and the non-parametric technique.

The Stochastic Frontier Analysis (henceforth, SFA)[14] is the parametric technique assessing the absolute efficiency of observed organizations, under some theoretical constraints. SFA requires assumptions on the functional form of the production function and on the error term related to technical inefficiency. Conversely, DEA is the non-parametric technique that evaluates the relative efficiency of observed organizations without imposing a functional form on the input-output relationship. Within the set of Decision Making Unit (henceforth, DMUs), DEA identifies those that exhibit the best practice and constitute the efficient frontier: deviations from the efficient frontier by DMUs are the result of inefficiency. The flexibility of DEA is a valuable point when dealing with not-for-profit organizations as in case of education. Moreover, DEA manages multiple inputs and multiple outputs as the production function of education institutions require.

In the second step, we explore the determinants of performance by regressing the efficiency scores obtained by DEA on environmental variables. Timmer (1971) was among the first that

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

[13] See Worthington (2001) for a survey of frontier efficiency measurement in education.

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

applied this procedure to explain interstate variation in technical efficiency in US agriculture. Henceforth, the two-step approach has been widely applied to various sectors: among the others, by McCarty and Yaisawarng (1993) to investigate efficiency in New Jersey public school districts[15].

3.1 First step

The technical efficiency of a DMU is measured by the ratio of weighted outputs over weighted inputs. To identifies the most favourable weights of each DMU, DEA solves an optimization problem and computes the set of efficiency scores. From an output-oriented perspective, technical efficiency is reached when outputs are maximized, keeping inputs fixed; from an input-oriented perspective, technical efficiency is reached when inputs are minimized, keeping outputs fixed. By construction, technical efficiency ranges between 0 and 1. A score of 1 means that a given DMU is efficient, a score less than 1 means that a given DMU is inefficient, with lower values indicating a greater inefficiency.

For measuring technical efficiency, we apply the BCC model (i.e. the DEA model developed by Banker, Charnes and Cooper (1984)), which assumes variable return to scale (henceforth, VRS)[16]. We deem suitable the output-oriented approach to estimate technical efficiency of faculties since the endowment of academics does not vary too much in the short-run; therefore, faculties can, mainly, work on outputs. Nevertheless, we compute the efficiency scores also with the input-oriented approach in order to check the robustness of results.

Consider DMU_i, with $i = 1, ..., N$, employing z inputs to produce q outputs.

[15] 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) applied the two-step approach to assess the relative efficiency of local transport services by Italian councils and subsequently to evaluates its determinants.

[16] DEA model was initially developed by Charnes, Cooper and Rhodes (1978) and assumes constant return to scale (CRS). Banker et al (1984) relax the assumption of CRS and introduces VRS. CRS is a limiting assumption as economies of scale in university operations make returns to scale unlikely to be constant.

The output-oriented linear program is:

$$\max_{\theta,\lambda} \eta \ s.t. \tag{1}$$
$$X\lambda \leq x_i$$
$$\theta y_i - Y\lambda \leq 0$$
$$e\lambda = 1$$
$$\lambda \geq 0$$

The input-oriented linear program is:

$$\min_{\theta,\lambda} \theta \ s.t. \tag{2}$$
$$\theta x_i - X\lambda \geq 0$$
$$Y\lambda \geq y_i$$
$$e\lambda = 1$$
$$\lambda \geq 0$$

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. The solution of the above linear programs gives the set of efficiency scores.

3.2 Second step

We specify the following panel-data model to investigate on efficiency determinants:

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

where i indexes the faculties and t indexes the time that goes from 2004 to 2008. The dependent variable θ is the vector of efficiency scores that range between 0 and 1.

HHI is the Herfindahl-Hirschman Index which captures the strength of competition[17].

[17] We treat the *HHI* as exogenous. The university market structure is not likely to vary noticeably in the short run. Actually, the procedure to built up a new faculties is complex and requires time to be carried out.

We define the relevant markets by related studies, thus assembling faculties in 17 groups[18]:

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

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

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

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, faculties' fixed effects and year dummies. The Random-Effect (RE) panel data model is also used following the Mundlak (1978) approach, thus including, as further regressor, the time-average of *HHI* in order to tackle unobserved effects. In the RE model we include, additionally, faculty-group dummies, university dummies and private dummy (equal to 1 for private faculties, 0 otherwise).

4 Data

4.1 Inputs and outputs of Italian faculties

As concerns the input, we use the *number of academics* (professors plus researchers) as a proxy for human capital endowment.

As concerns the outputs, we use the *number of undergraduates* and the *number of post-graduates*. The bachelor-master structure was introduced in Italy from the academic year 2000/2001. Formerly there was a unique level of higher education studies whose degree is nowadays treated, by the Italian law, as equivalent to the master degree. Following the legislative standpoint, we aggregate pre-reform graduates and post-reform master graduates.

The Italian university system allows students to obtain the degree spending a greater number of years than those scheduled by the MIUR for each course. To account for this, we use the *On-time Graduation Index*, defined as the ratio between the legal duration of studies and the average number of years of delay (i.e. the inverse of the index of delay). Such an index favours faculties in which students carry out studies within the expected term, whereas

[18] MIUR defines the following groups of faculties, that we use as relevant markets: 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.

penalises faculties whose students take more years than the expected to complete studies, thus becoming a burden for the production process.

In light of this, we define two main DEA models. The former, standard in the literature, is composed by one input, the number of total academics, and two outputs, the number of undergraduates and the number of postgraduates. The latter adds to the outputs the *On-time Graduation Index* that captures a peculiar side of the Italian university system. 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 input stem from the databank of MIUR that considers the number of academics to the 31^{th} December of each year. Data on outputs belong from the dataset *Profilo dei Laureati* developed by *Almalaurea* providing 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.

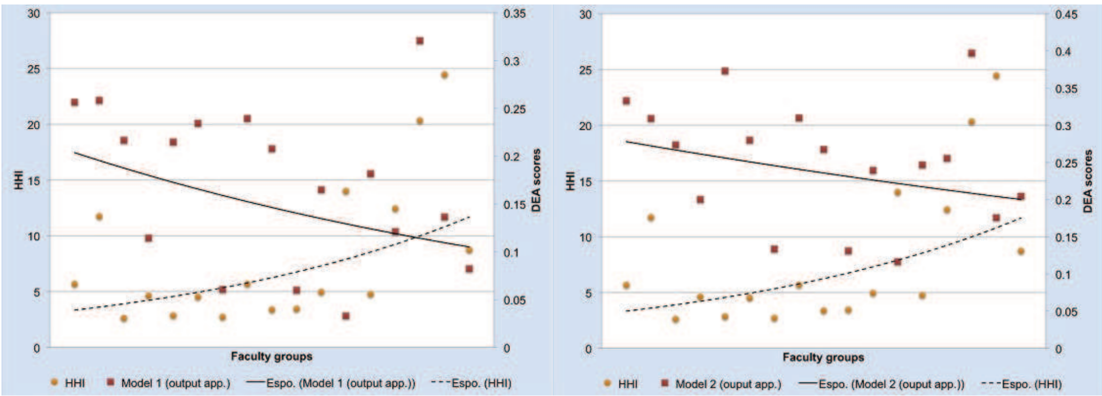
Variables	*Description*	*Obs*	*Mean*	*St. Dev.*	*Min*	*Max*
HHI	Sum of the square of market shares	1489	0.050	0.036	0.030	0.260
Faculty-level						
High-school mark	Number	1497	81.748	3.593	71.406	95.794
Upper-middle class	% students	1496	20.880	8.245	2.248	62.517
Parental education	% students (1 or 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
Teriary employment	% labour force	1497	37.967	4.416	17.058	48.596

Data on the number of students enrolled by faculties used to built up the HHI stem from the databank of MIUR[19]. Control variables at faculty-level are taken from the dataset *Profilo dei Laureati* developed by *Almalaurea*; control variables at municipality-level are taken from ISTAT "*Atlante dei comuni 2009*".

5 Results

Before discussing regressions' results, it is interesting to examine, with a graph, the relationship between technical efficiency scores and the *HHI* (see Figure 1).

Figure 1. The relationship between technical efficiency scores and the HHI.



As clearly emerges from the graph, higher values of technical efficiency are associated with lower values of HHI.

In Table 4 we show the coefficients of *HHI* estimated by the FE model and the RE models obtained using a sample of 340 faculties related to 48 universities, for the period 2004 to 2008.

[19] 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, 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.

Table 4. The role of market structure 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

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

According to our estimates, the *HHI* appears to be negative, suggesting that in more concentrated markets, Italian faculties are less efficient. Coefficients are very similar with both models and are significant in almost all the cases. The impact seems to be not significant only under the output approach when we use, as dependent variable, the efficiency scores obtained by Model 2 that considers, among the outputs, the *On-time Graduation Index*. Instead, we when employ Model 1, standard in the literature, the impact of the *HHI* is highly significant under both approaches[20]. In particular, when concentration increases by 1%, efficiency reduces by 1.11% to 1.86% under the FE model and by 1.2% to 0.20% under the RE model. Further, the R^2 is, roughly, 0.91[21].

In light of this, our results are in favour of competition: when faculties operate in a more competitive environment, they are induced to carry out the teaching activity in a more efficient way.

6 Sensitiveness analysis

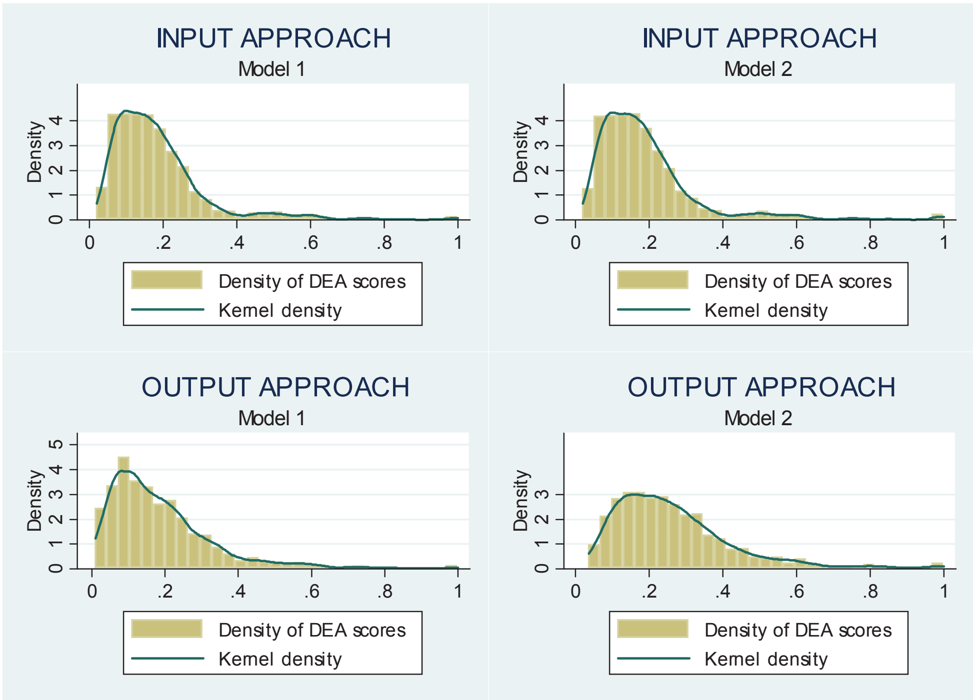
Figure 2 reports the density of efficiency scores obtained using the input and the output approach[22].

[20] This could mean that competition among faculties improves production of graduates, whereas it does not influence the duration of studies the that might be related to individual skills and motivations.

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

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

Figure 2. Density of DEA efficiency scores.



The input approach leads to similar efficiency indices scores as those obtained by the output approach. Indeed, the distributions of efficiency scores look very similar. In all cases, the distribution is right-skewed: the mass is concentrated on the left, thus having relatively few high values. This indicates the poor performance of Italian faculties. In the Table 5 we show the summary statistics of technical efficiency scores, computed also for macro-areas.

Table 5. Analysis of 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% for Model 1 and 0.66% for Model 2. Actually, the average efficiency scores are very low: Italian faculties employ too much academics to produce such a number of graduates, or, conversely, they produce too few graduates, given the number of academics employed. 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 under 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[23]. In particular, the majority of efficient DMUs lies in the North.

Moreover, it emerges a more marketed difference among private and public faculties. Private faculties seem to be definitely more efficient compared to the public counterparts[24], as shown in Table 6.

Table 6. Analysis of 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

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

[23] This finding is consistent with Agasisti and Dal Bianco (2006).
[24] This finding is consistent with Monaco (2012).

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

Models labelled 1 and 2 are the main models 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.

Focusing on the correlation between efficiency scores obtained with the input approach, models with one input (*number of academics* (*total*)), and models with two inputs (*number of professors* and *number of researchers*, appear to be highly correlated, more than 98%. Using two separate inputs instead of a unique measure of human capital endowment does not substantially adds information on the production process. Therefore, on a parsimony criterion, the models with one input are preferred.

Considering the correlations among efficiency scores obtained by the output approach, models with, simply, the *number of undergraduates* and the *number of postgraduates* appear to be correlated at 99% to models with *quality of undergraduates* and *quality of postgraduates*. Efficiency estimates are robust to the weighting with the average graduation mark.

Moreover, the correlation matrix highlights that models that account for the *On-time Graduation Index*, reported in even columns, are correlated at 80% with models that does not, reported in odd columns. Therefore, this index provides further information on the production process.

As said before, we compute the number of postgraduates by aggregating the pre-reform graduates together with post-reform master graduates. We verify that this aggregation does not influence the efficiency scores, as explained above. The bachelor-master structure introduced a number of innovations concerning the organisation of taught courses. Therefore, we define further models (labelled by b) by 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 Model 1 and Model 1b, Model 2 and Model

$2b$, are around 96% for the efficiency scores estimated with the output approach and 92% for the efficiency scores estimated with 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, we prefer models in which number of pre-reform postgraduates and the number of post-reform postgraduates are aggregated.

7 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. We measure the technical efficiency focusing on teaching activity through the non-parametric technique, using a sample of 340 faculties related to 48 universities, for the period 2004 to 2008.

Our main results claim that in more concentrated markets, Italian faculties are less efficient, thus providing evidence in favour of competition: when faculties operate in a more competitive environment, they are induced to carry out the teaching activity in a more efficient way.

Further results indicate, on average, 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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A 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)	(1b)	(2b)	(1)	(2)	(1b)	(2b)
OUTPUT APPROACH	(1)	1							
	(2)	0.882	1						
	(1b)	0.964	0.823	1					
	(2b)	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		
	(1b)	0.618	0.510	0.639	0.589	0.929	0.864	1	
	(2b)	0.657	0.612	0.675	0.673	0.867	0.922	0.938	1