Hotelling competition and teaching efficiency of Italian university faculties. A semi-parametric analysis.

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Abstract

In this paper we explore the effect of competition (à la Hotelling) on teaching efficiency of the Italian university system at faculty-level, 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 teaching efficiency. Second, a parametric approach is used to evaluate the determinants of teaching efficiency, focusing on the impact of competition. 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.

Key words: teaching efficiency, competition, two step DEA analysis.

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1. Introduction

University systems provide pivotal services for the economic development of countries. Actually, universities supply teaching activity aiming at producing qualified students which are prepared to enter the job market. Moreover, universities carry out research, thus playing an important role in broadening the existing knowledge, with positive spillover effects on the entire economy. In light of this, the analysis of university efficiency, its determinants and on related policy measures is a crucial point.

In this paper we explore the role of competition in providing incentives to improve the 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 measure the efficiency; second, we evaluate the determinants of efficiency, focusing on the impact of competition, by using a parametric approach.

We contribute to the existing research in two ways. One way is to measure 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 type supplies distinctive teaching and research activity. Consider, for instance, the differences in both teaching and research between science-related or humanistic-related faculties. If efficiency is measured at university level, such differences cannot be captured; therefore, we provide a more accurate measurement of efficiency by performing the analysis at faculty-level.

The other way is to explore the role of competition in providing incentives to improve the 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, 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.[1]

[1] Agasisti (2009) empirically proves that competition among Italian universities led to an improvement in teaching performance. Specifically, the author explores the relationship between number of students (number of graduates) of a given university and the average number of students (average number of graduates) of other universities. Actually, the average number of students (average number of graduates) of other universities are thought as a proxy of competitive pressure.

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" (FFO)[2] 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.[3]

In light of this, it is worthwhile verifying 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 determinants. 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.

2. Literature review

This section aims at reviewing existing studies on university performance with attention to the role of competition in improving the level of efficiency. The earliest studies on university efficiency developed the methodological framework to evaluate performance and provide applications to some departments of UK higher education institutions (Johnes and Johnes, 1993, 1995; and Beasley, 1995). 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.[4]

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

[3] Defined by the Ministry of Education, University and Research (MIUR), following the proposal of the "Comitato Nazionale per la Valutazione del Sistema Universitario" (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.

[4] 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.

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.[5] 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.[6] 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 characterized by a noteworthy 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.

Kempkes 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:[7] few universities are efficient, most of them lies in northern Italy.[8] 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

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

[6] 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.

[7] 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).

[8] 66.7% of efficient universities lies in the north, 26.7% in the centre and 6.6% in the south of Italy.

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 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.[9]

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.[10] 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 analyzing teaching and research efficiency conditional to universities' size. On teaching efficiency,

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

[10] 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.

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.

3. Estimation methodology

We a adopt the two step semi-parametric procedure to estimate the impact of competition among faculties on their technical efficiency. 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.[11]

We treat each faculty as a decision-making unit that operates in order to minimise the level of inputs given the level of output (input approach), or alternatively, that operates in order to maximise the output given the inputs (output approach).

To explain the methodology, let consider that aggregated output of faculties is the result of the following production function:

$$y_{it} = f(x_{it}; \beta) h(z_{it}; \gamma) \exp(v_{it} + u_i) \quad i = 1, \dots, N \text{ and } t = 1, \dots, T \qquad (1)$$

[11] Among the others, McCarty and Yaisawarng (1993) use the two-step procedure to investigate efficiency in New Jersey public school districts. Worthington and Dollery (2002) compare 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) consider a two-stage approach in relation to the health production process of OECD countries. Recently, Adam et al. (2008) use the same methodology to estimate the effect of decentralization on the efficiency of the public sector. Bergantino and Porcelli (2011, 2012) apply the two-step approach to measure 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 organization of the port in determining the relative efficiency.

where N is the number of faculties, T the number of years, y_{it} is the aggregated output, x_{it} is a (L × 1) vector of inputs, z_{it} is a (M × 1) vector of environmental variables, β a vector of technology parameters and γ is the vector of environmental variables' coefficients of the. For simplicity, we assume separability between $f(.)$, which describes the technology, and $h(.)$ which represents the way in which the environmental factors affect the output.

The error term has two components, the idiosyncratic error v_{it} and the inefficiency error component u_i, which is assumed to satisfy the restriction $u_i \leq 0$ and provides a measure of "residual" efficiency that captures the distance between the actual level of output $y_{it}$and the frontier, once the influence of environmental variables is taken into account. The u_i can be assumed time invariant given that we are conducting a short term analysis.

In the first step, Data Envelopment Analysis (DEA), the non-parametric technique introduced by Charnes et al. (1978), provide a straightforward procedure to estimate the level of efficiency $e_{it} = \frac{y_{it}}{f(x_{it};\beta)}$ achieved by each faculties, which corresponds to the Debreu (1951) - Farrell (1957) index of technical efficiency, i.e. the distance between the actual level of output attained by the faculty i in the year t and the maximum output attainable, given the inputs employed in the production.

As highlighted by Worthington (2001), DEA is suitable for technical efficiency measurement in education. DEA is a non-parametric estimator of e_{it}, no assumptions about the functional form of the production function are required (the convexity of the production set is the only restriction that needs to be imposed). The flexibility of DEA is a valuable point when dealing with not-for-profit organizations as education institutions. Moreover DEA is a powerful estimator in case of multidimensional production frontier (multiple outputs), like those of university faculties.

In the second step, the impact of competition on faculties' technical efficiency is evaluated through the estimation of the following empirical model:

$$\frac{y_{it}}{f(x_{it};\beta)} = h(z_{it};\gamma)\exp(v_{it} + u_i) \qquad (2)$$

After replacing $\frac{y_{it}}{f(x_{it};\beta)}$ with e_{it}^{DEA} and assuming for simplicity a Cobb-Douglas functional form for $h(.)$ the final empirical model that can be used to estimate the impact the environmental variables is:

$$e_{it}^{DEA} = \prod_{m=1}^{M} z_{itm}^{\gamma_m} \exp(v_{it} + u_i) \quad (3)$$

where M is the number of environmental variables.

Details on the first and the second step with application to the purpose of this work are provided in the next sub-sections.

3.1 First step

In the first step, we use DEA to estimate the technical efficiency of faculties. In case of input approach, the index of efficiency $e_{it}^{DEA\_I} = \theta_{it}$, where θ_{it} is the solution of the following linear program which provides the efficiency score for the faculty *i* in period *t*:

$$\max_{\theta,\lambda} \theta \quad \text{s.t.} \quad \mathrm{X}\lambda \leq \theta \mathrm{x}_{\mathrm{it}}; \quad \mathrm{y}_{\mathrm{it}} \leq \mathrm{Y}\lambda; \quad \lambda \geq 0; \quad \mathrm{e}\lambda = 1 \quad (4)$$

In case of output approach, the index of efficiency $e_{it}^{DEA\_O} = \frac{1}{\theta_{it}}$, where θ_{it} is the solution of the following linear program which provides the efficiency score for the faculty *i* in period *t*:

$$\max_{\theta,\lambda} \theta \quad \text{s.t.} \quad \mathrm{X}\lambda \leq \mathrm{x}_{\mathrm{it}}; \quad \theta \mathrm{y}_{\mathrm{it}} \leq \mathrm{Y}\lambda; \quad \lambda \geq 0; \quad \mathrm{e}\lambda = 1 \quad (5)$$

where x_{it} is the vector of inputs of faculty *i* at time *t*, X the matrix of inputs of all N faculties over all T years, y_{it} is the vector of outputs of faculty *i* at time *t*, Y the matrix of outputs of all N faculties over all T years, λ is vector of optimal weights that identify the benchmark faculties on the frontier for each inefficient faculty, and *e* is the unity vector. The three first constraints are necessary in order to generate the frontier and the last constraint is important for imposing variable returns to scale (Banker et al., 1984).

Then e_{it}^{DEA} is the efficiency score for the faculty *i* in period *t*. It satisfies that e_{it}^{DEA} ϵ (0, 1], with a value of 1 indicating a point on the frontier, and hence a technically efficient faculty.

It is important to note that the linear program in (1) and (2) is solved by using a pooled approach where only one production frontier is estimated and each region is compared also with itself in another year. In this way it is possible to use all the N x T observations in order to minimise the upward small-sample bias that affects this nonparametric estimator of technical efficiency. [12]

For this study, the output-oriented approach should be preferred since the endowment of inputs of faculties does not vary too much in the short-run, thus faculties can mainly increase outputs to improve performance. However, in our analysis, we use both approaches to estimate indices of technical efficiency as for robustness check. The bootstrap procedure developed by Simar and Wilson (1998, 2000) is used to estimate a "bias corrected" measure of technical efficiency.

3.2 Second step

In the second step, bias corrected technical efficiency scores are regressed against the set of environmental variables, among which the regressor of interest is the proxy for competition.

The dependent variable is fractional, thus it would be appropriate to estimate the following a non-linear panel data model, derived from (3):

$$e_{it}^{DEA} = \phi\left(\sum_{m=1}^{M} \gamma_m \log z_{itm} + \delta_t + u_i\right) + v_{it} \qquad (6)$$

where $\phi(.)$ is the standard normal cumulative distribution function. The impact of competition on technical efficiency can be consistently estimated by the Bernoulli quasi-MLE estimator as proposed by Papke and Wooldrige (2008).

The competition among faculties is *à la* Hotelling. Therefore we introduce in the model the variable *DISTANCE*, computed for each faculty as the average distance from all the other faculties belonging to the same faculty-group, defined by MIUR.[13] We consider a set of other environmental variables that could influence the efficiency scores and δ_t is the set of year dummies. We introduced in the model university fixed effects and faculty-group fixed effects.

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[12] This bias produces a small measurement error in the estimated indices of technical efficiency that vanishes as the number of observations increases (Kneip et al., 1998).

[13] 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 Sciences; Motor Science; Statistics; Sociology.

4. Data

4.1 Inputs and outputs

The choice of inputs has fallen on number of academics (professors plus researchers) as a proxy for human capital endowment.

For the outputs' specification, we use the *number of undergraduates* and the *number of postgraduates*.[14] 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 the *On-time Graduation Index*, the ratio between the years scheduled for each degree course and the average 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 the following production functions:

Tab. 1. Production functions.

(1)	(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

In Table 2 we provide descriptive statistics of input and outputs.

Tab. 2. Descriptive statistics of input and outputs.

	Obs	*Mean*	*St. Dev.*	*Min*	*Max*
Input					
Number of academics	1508	119.094	125.494	6	1589
Outputs					
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

[14] 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.

Data on number of academics are taken from MIUR statistical office, which provides information on academics as of December 31 of each year. Data on teaching outputs belong to the dataset *Profilo dei Laureati* by *Almalaurea* which provides statistics at faculty-level on 48 universities listed in Table 3 (in Appendix).

4.2 Environmental variables

The list and the description of environmental variables included in the analysis are reported in Table 4.

Table 4. Descriptive statistics of environmental variables.

Variable		*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Consumer price index	Weighted average of prices of a basket of consumer goods and services	1508	0.956	0.030	0.895	1
Distance	For each faculty, the average distance from all the other faculties belonging to the same faculty-group	1508	428.020	108.953	175.429	751.184
High-school mark	Range: 60 to 100.	1508	81.738	3.589	71.406	95.794
Inhabitants	Number	1508	446293.1	696082.8	1046	2724347
Inhabitants over 65	% Inhabitants	1508	22.103	3.293	12.999	28.107
Local GDP	Real Euros per inhabitant	1508	21,956.03	2,543.691	13,775.15	30,756.31
Parents' education	% students with at least one parent holding a graduate degree	1506	15.329	4.772	1.5	37.185
Public transport demand	% inhabitants	1436	180.661	155.499	6.900	763.137
Upper-middle class	% students belonging to the upper-middle class	1507	20.912	8.235	2.248	62.517

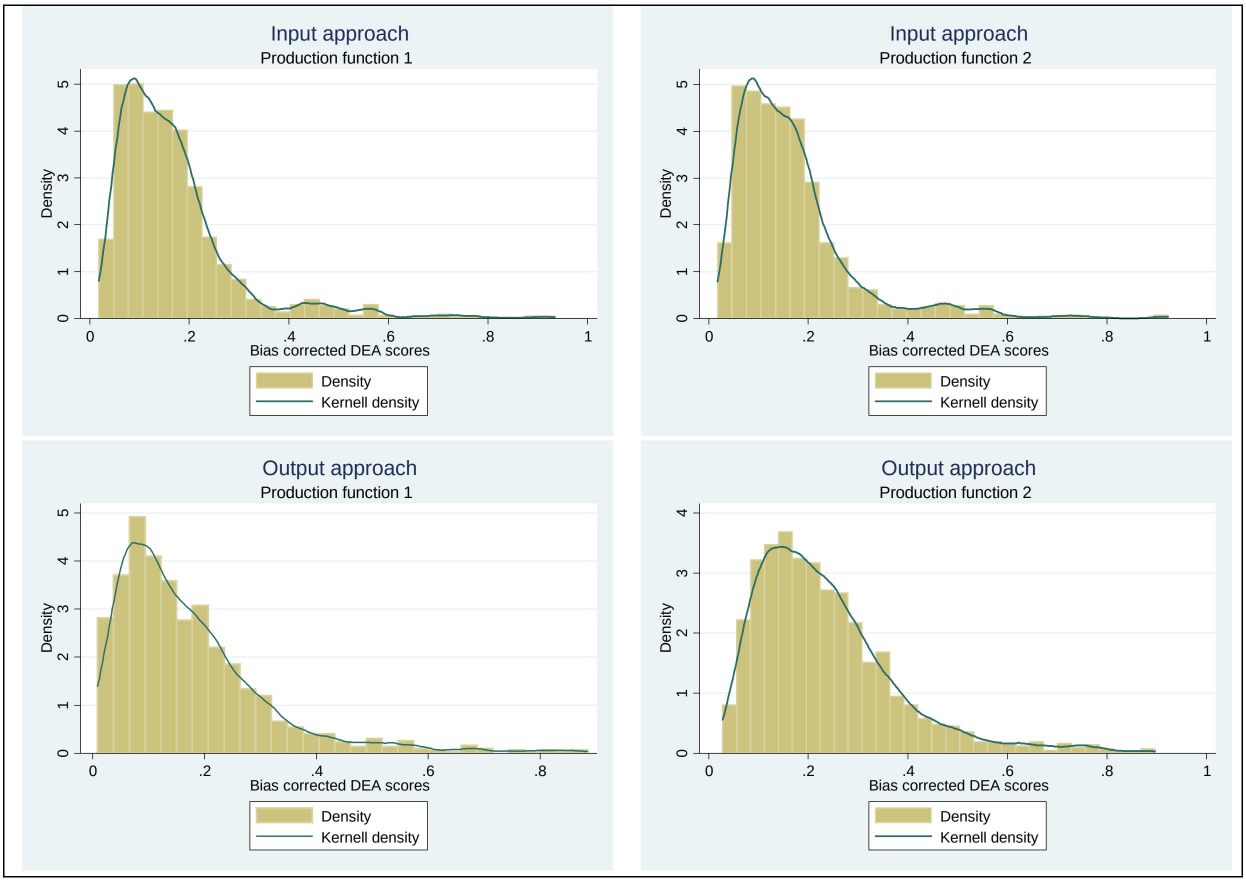
The variable *DISTANCE* is computed using data collected from *Google Map*. Control variables at faculty-level are taken from the dataset *Profilo dei Laureati* by *Almalaurea*, whilst control variables at municipality-level are taken from ISTAT "*Atlante dei comuni 2009*".

5. Results

5.1 Analysis of efficiency scores

Figure 1 reports the density distribution of bias corrected efficiency scores obtained under the input and the output approach.[15]

Fig. 1. Density distribution of bias corrected DEA teaching efficiency scores.



The density distributions of bias corrected efficiency scores look very similar across the input and the output approach. Moreover, density distributions are right-skewed, the mass of the values is concentrated on the left, showing relatively a few high values. This would indicate the poor performance of Italian university faculties. In Table 5 we provide summary statistics of technical efficiency scores obtained from each of the production function designed.

Tab. 5. Summary statistics of bias corrected teaching efficiency scores for different production function (PF)

	Variable	Obs	Mean	Std. Dev.	Min	Max
Input	*DEA scores (PF 1)*	1508	0.168	0.122	0.018	0.934
approach	*DEA scores (PF 2)*	1508	0.166	0.117	0.018	0.923
Output	*DEA scores (PF 1)*	1508	0.173	0.136	0.009	0.885
approach	*DEA scores (PF 2)*	1508	0.236	0.141	0.028	0.897

[15] Efficiency scores are computed using the package Frontier Efficiency Analysis with R (FEAR) 1.15 developed by Wilson.

The average teaching efficiency scores appear to be very low. Italian faculties seem produce too few graduates, given the number of academics employed or, conversely, they employ too much academics to produce such a number of graduates. The average teaching efficiency scores appear to be higher when computed with the output-oriented approach. This could indicate a greater ability of Italian faculties to produce graduates than to make a good use of inputs.

5.2 The effect of competition on efficiency.

In Table 6 we show the estimation results using a sample of 340 faculties related to 48 universities over the period 2004 to 2008.

Table 6. The effect of competition on teaching efficiency.

	(1)	(2)	(3)	(4)
Dependent variable:	$e_{it}^{DEA\_O\_FP1}$	$e_{it}^{DEA\_O\_FP2}$	$e_{it}^{DEA\_I\_FP1}$	$e_{it}^{DEA\_I\_FP2}$
DISTANCE	-0.0027*	-0.0026**	-0.0057***	-0.0055***
	(0.0015)	(0.0013)	(0.0012)	(0.0013)
$DISTANCE^2$	0.0000***	0.0000***	0.0000***	0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Control variables	Yes	Yes	Yes	Yes
University fixed-effect	Yes	Yes	Yes	Yes
Faculty-group fixed effect	Yes	Yes	Yes	Yes
Observations	1,435	1,435	1,435	1,435

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

$e_{it}^{DEA\_O\_FP1}$ indicates that the dependent variable is the set of efficiency scores obtained under the output approach using production function 1.

$e_{it}^{DEA\_O\_FP2}$ indicates that the dependent variable is the set of efficiency scores obtained under the output approach using production function 2.

$e_{it}^{DEA\_I\_FP1}$ indicates that the dependent variable is the set of efficiency scores obtained under the input approach using production function 1.

$e_{it}^{DEA\_I\_FP2}$ indicates that the dependent variable is the set of efficiency scores obtained under the input approach using production function 2.

According to our estimates, the variable DISTANCE has a non-liner effect on teaching efficiency. Indeed, the variable DISTANCE has a negative sign, whereas the variable $DISTANCE^2$ has a positive sign, although its size is very small, thus indicating a negative but decreasing impact of DISTANCE on teaching efficiency. Our results suggest that competition induces faculties to carry out the teaching activity in a more efficient way.

6. Sensitiveness analysis

We check the sensitiveness of the efficiency scores estimated. First, we split the *total number of academics* in *number of professors* and *number of researchers*. Second we weight number of undergraduates and number of postgraduates for the average graduation mark, thus defining two new measure of outputs, *quality of undergraduates* and *quality of postgraduates*. By combining these alternative measures of inputs and outputs, we define additional production functions. All the production functions defined are summarised in Table 7.

Table 7. Production functions for robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INPUT								
Number of academics	X	X			X	X		
Number of professors			X	X			X	X
Number of 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

In Table 8 (reported in Appendix) we show the correlation matrix of efficiency scores. Efficiency scores obtained under the input approach are correlated at least than 96%. 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.

7. Summary and conclusions

In this study we shed light on the effect of competition on teaching 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 in a more efficient way.

Further results indicate, on average, the poor performance of Italian faculties. Developments for future research could be to include a direct measure for research performance based on publications.

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Appendix

Tab. 2. List of universities.

List of 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 Milano
5	Politecnico di Torino
6	Seconda Università degli Studi di Napoli
7	Università "Campus Bio-Medico" Roma
8	Università "Cà Foscari" di Venezia
9	Università "Carlo Cattaneo" LIUC Castellanza
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

Tab. 8. Correlation matrix.

		OUTPUT APPROACH								INPUT APPROACH							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
	1	1															
	2	0.8001	1														
	3	0.9739	0.7815	1													
OUTPUT	4	0.7992	0.9842	0.8102	1												
APPROACH	5	0.9974	0.8014	0.9685	0.7980	1											
	6	0.8116	0.9979	0.7909	0.9813	0.8162	1										
	7	0.9747	0.7865	0.9974	0.8126	0.9738	0.7990	1									
	8	0.8102	0.9835	0.8192	0.9978	0.8124	0.9844	0.8251	1								
	1	0.3365	0.3447	0.3877	0.3730	0.3117	0.3359	0.3693	0.3648	1							
	2	0.3594	0.3391	0.4100	0.3682	0.3351	0.3315	0.3920	0.3611	0.9861	1						
	3	0.2830	0.3069	0.3250	0.3366	0.2574	0.2962	0.3053	0.3265	0.9753	0.9605	1					
INPUT	4	0.3056	0.3069	0.3471	0.3376	0.2805	0.2973	0.3281	0.3285	0.9610	0.9742	0.9850	1				
APPROACH	5	0.3446	0.3497	0.3955	0.3781	0.3209	0.3421	0.3784	0.3711	0.9983	0.9855	0.9752	0.9622	1			
	6	0.3671	0.3437	0.4172	0.3728	0.3439	0.3371	0.4005	0.3668	0.9829	0.9982	0.9588	0.9744	0.9856	1		
	7	0.2988	0.3214	0.3375	0.3491	0.2755	0.3129	0.3203	0.3414	0.9735	0.9596	0.9982	0.9842	0.9753	0.9597	1	
	8	0.3238	0.3246	0.3618	0.3534	0.3012	0.3171	0.3454	0.3466	0.9579	0.9720	0.9819	0.9980	0.9610	0.9742	0.9847	1