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Beyond frontiers: comparing the efficiency of higher education decision-making units across more than one country

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We employ Data Envelopment Analysis to compute the technical efficiency of Italian and English higher education institutions. Our results show that, in relation to the country-specific frontier, institutions in both countries are typically very efficient. However, institutions in England are more efficient than those in Italy when we compare jointly their performances. We also look at the evolution of technical efficiency scores over a four-year period, and find that, in line with an error-correction hypothesis, Italian universities are improving their technical efficiency while English universities are obtaining stable scores. Policy implications are addressed.

Keywords: higher education; efficiency; data envelopment analysis; malmquist indices

Introduction

Following the Bologna Agreement, higher education has been changing rapidly in a number of European countries. The traditional model of continental universities, mostly financed by the state and strongly regulated in their activities, is being challenged both by a model that gives universities a greater degree of autonomy and by the necessity to change both governing and financing paradigms. Analysts consider these changes critical to the future of European higher education: they could be the opportunity for a renaissance of European universities or the cause of their ultimate decline (Lambert and Butler, 2006). A clear reference point for reforming European higher education (HE) has been the suite of policies pursued in many Anglo-Saxon countries:

> although there are exceptions, most European universities and institutions of higher education find it difficult to compete with the best universities in the Anglo-Saxon world. (It necessitates) a more effective use of public subsidies, more efficient modes of financing institutions, more diversity, competition and transparency. (Jacobs and Van der Ploeg, 2005, p. 1)

In the present paper we focus on two European HE systems – those of England and Italy.

Italian HE is characterized by several structural problems. First of all, there is a lack of diversity in institutions' missions: there is no binary system, as in most

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European countries (e.g., in the United Kingdom between universities and colleges,[1] in Germany between universities and *Fachhochschulen*, etc.) to provide a distinction between academic and vocational studies. In Italy, there is only one type of HE institution; namely, universities. Moreover, in the past, students have typically devoted many years to reaching the point of graduation:[2] in 2001, before the introduction of teaching reforms,[3] the average duration of studies was seven years. Many students drop out, and as recently as 1999/2000 as many as 20% of freshmen abandoned the university within their first year.[4]

The situation is now slowly improving, not least because the Bologna Process (initiated in 1999) gave incentives for implementing several reforms: diminishing the average time to graduation, and retaining a higher proportion of students by introducing the Bachelor/Master structure. The rationale for such changes is to improve the efficiency of universities; that is, to enhance their ability to obtain better results (in terms of graduates) by more efficiently use of their resources (both financial and human).

Another trend in Italy is a growing attention to the assessment of research activities. Universities are indeed multiple-output organizations (Cohn *et al*., 1989), so their efficiency cannot be evaluated solely in terms of their ability to improve graduate numbers, but also on the results of their research activities. Law n. 390/1999 established the National Evaluation Committee for the University System (Comitato Nazionale per la Valutazione del Sistema Universitario [CNVSU]), with the explicit aim of evaluating universities' activities. Moreover, in 1999, the Committee for Evaluating Research (CIVR) was established with a specific focus on the qualitative assessment of research. The first assessment exercise was carried out in 2004–2006 (referring to 2001–2003 data), and the results were published in 2006.

Within Europe, it has become common to look to the United Kingdom for a benchmark in terms of HE reform. International rankings[5] show that British institutions are competing with those in the United States for obtaining the best results. These rankings are often research driven, and the top UK institutions – most obviously Oxford and Cambridge but also specific departments in other universities, notably those rated 5* in the research assessment exercises – have clearly established reputations.

Within this context, the objectives of the present paper are two. First we will compare the technical efficiency of Italian universities with English HE institutions; and secondly we will analyse efficiency trends in these two countries over the past few years.

We focus our attention on only one country in the United Kingdom, namely England. This covers most HE activity within the United Kingdom, and importantly allows us to abstract from inter-country differences; for example, in funding mechanisms and in the standard duration of degrees. For instance, honours degrees at bachelor level are awarded after four years of study in Scotland but after three years of study in England. This means that the ratio of new graduates to the total student stock in any one year differs systematically between these two constituent countries of the United Kingdom. The distinction between Italy and the United Kingdom is therefore highlighted (or accentuated) by focusing our attention on English institutions. These, in any event, account for as many as 83% of all undergraduate students in the United Kingdom.

We define technical efficiency as the ability to convert a certain bundle of inputs to the maximum possible amount of output (with current technology, as evidenced by the best performance *observed within sample*) – or, alternatively, the situation in

which as little input as possible is used in producing a certain amount of output (Barrow and Wagstaff, 1989).

Our paper is noteworthy for two main reasons. First, it represents the first attempt to realize a cross-national comparison of HE institutions' efficiency, using institutional data. Moreover, only a handful of studies in this area focus their attention on the issue of productivity changes across time, and we address this matter also in this cross-country perspective.

The remainder of the paper is organized as follows. The second section briefly surveys the relevant literature, while the third describes the main methodological features of our approach. The fourth section presents the results, and the fifth concludes.

Received literature

There are several contributions to the literature that deal with efficiency analysis in the British HE sector. Many of them employ non-parametric techniques – such as Data Envelopment Analysis (DEA), the methodology we use in this paper: see, among other studies, Tomkins and Green (1988), Beasley (1990, 1995), Johnes and Johnes (1992, 1993), Athanassopoulos and Shale (1997), Sarrico *et al.* (1997), Sarrico and Dyson (2000), Johnes *et al.* (2005), Johnes (2006a,b,c). Other authors use parametric tools, especially stochastic frontier analysis (Izadi *et al.*, 2002; Stevens, 2005). All these studies have shown that the relative efficiency of institutions within the HE sector in the United Kingdom is typically quite high.

In Italy, interest in the evaluation of university efficiency using statistical and econometric instruments is much more recent. Preliminary attempts were made by Pesenti and Ukovich (1996a, b) and Rizzi (1999) to evaluate the efficiency of departments within the University of Trieste and the University of Venezia, respectively. At the institutional level only one study was conducted, this being under the supervision of the National Evaluation Committee (Osservatorio Nazionale del Sistema Universitario, 1999): this study has not, however, been published, and its policy implications do not appear to have had impact. Furthermore, an interesting discussion paper by Bonaccorsi *et al.* (2004) proposes the application of robust non-parametric methods for developing indicators of productivity of Italian universities. Lastly, and more recently, Agasisti and Dal Bianco (2006a) use DEA to evaluate the efficiency of all 58 public Italian universities. Matching four inputs and 4 outputs, they evaluate 26 different models, finding that a core of universities performs well for any inputs and outputs specification.

There are only few contributions that involve an analysis of the productivity changes. Worthington and Lee (2005) examine these changes in the Australian university sector between 1998 and 2003. Flegg *et al.* (2004) analyse the trend in efficiency scores of British universities between 1980/81 and 1992/93. Finally, Johnes (2006a) focuses her attention on productivity changes in English HE from 1996/97 to 2002/03. The results provided by these three studies paint different pictures for the different countries and time frames. The first two studies both show an annual average increase in productivity of about 3.5% in the period analysed, finding that this change is due mainly to a positive technological change rather than a real increase in technical efficiency. Johnes reports a positive productivity change as well, again determined by the frontier shift (technological change), but in this case associated with a *negative* trend in technical efficiency.

To the best of our knowledge, there is only one paper concerned with a cross-country analysis of HE institution efficiency (Joumady and Ris, 2005). The authors use a large sample of young graduates' responses to a survey, for an analysis of 209 HE institutions across Europe (eight countries). This survey was conducted in 1994/95 as a special exercise. They define efficiency as the 'capacity of each institution, on one hand, to provide competencies to graduates and, on the other hand, to match competencies provided during the education to competencies required in the job (Joumady and Ris, 2005, p. 189). That paper represents an interesting approach to the cross-country analysis, but the special nature of the survey on which it is based means that it would be a difficult exercise to replicate on a regular basis. Our study, on the other hand, uses regularly published data from both England and Italy, and is distinctive for a number of reasons. First, we focus on a broader definition of efficiency, examining research as well as teaching outputs. Secondly, we use data for the whole population of English and Italian institutions; this is an important consideration in view of the known sensitivity of DEA to outliers. Thirdly, since we rely only on published information, it is possible to conduct our analysis for a recent period. The period covered in the present paper is 2002/03–2004/05. The choice of years is governed by data availability, since Italian data on research have only recently become available. We recognize that this represents a short panel and that data can be subject to blips, but we would argue that an important benefit of keeping the panel short is that this ensures that any trends identified in the data are recent.

Methodology

Data envelopment analysis

We employ DEA to analyse the technical efficiency of English and Italian universities. DEA is a non-parametric tool introduced by Charnes *et al.* (1978). While the aim of the paper is not to analyse the characteristics of DEA linear programming procedures – there is already a huge literature on that (see, e.g., Cooper *et al.*, 2006; Zhu, 2003) – it is necessary that we should first explain something about the basics of the DEA methodology as background for the empirical work that follows.

DEA is a powerful instrument for describing technical efficiency in the public sector (Barrow and Wagstaff, 1989). Organizations in this sector are typically complex, with many inputs and many outputs, and with heterogeneous objectives. The appeal of DEA in this context therefore rests on the fact that it is a method designed specifically to fit a multi-input, multi-output context. Moreover the non-parametric nature of DEA means that it is not necessary to impose a functional form on the production process; this is a particularly useful property of the method in the context of public sector analysis, where it is not obvious that a loss function wherein the weights are market prices can be meaningfully defined. Finally, DEA offers the analyst an array of useful managerial information, including peer groups for the purpose of benchmarking, and an analysis of slacks in terms of amounts of inputs and outputs that could be reduced/improved, so offering policy and practical suggestions to the organizations' managers.

Implicit in the DEA approach is the assumption that an organization should aim to maximize its productivity. We can define productivity, P, more precisely as (Salerno, 2003):

$$P = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{j=1}^{m} d_j x_j} \tag{1}$$

where y_i is the ith output produced, x_j is the jth input used, w_i is the relative importance of output y_i, and d_j is the relative importance of input x_j.

Charnes *et al.* (1978) propose an algorithm to compute the productivity, obtaining the weights that maximize productivity for each institution. In an output-oriented framework (where inputs are fixed and the objective is to maximize outputs), the efficiency of a given unit k, which uses m inputs to produce s outputs, relative to $n - 1$ other institutions, is calculated as:

$$\begin{aligned}
&\max \phi_k + \varepsilon\left(\sum_{r=1}^{s} s_r + \sum_{i=1}^{m} s_i\right) \\
&s.t. \\
&\phi_k y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} + s_r = 0, \quad r = 1,\ldots,s \\
&x_{ik} - \sum_{r=1}^{n} \lambda_j x_{ij} - s_i = 0 \quad i = 1,\ldots,m \\
&\lambda_j, s_r, s_i \geq 0 \quad \forall j = 1,\ldots,n \quad r = 1,\ldots s \quad i = 1,\ldots,m
\end{aligned} \tag{2}$$

where y_{rk} and x_{ik} are the amounts of output r and input i used by unit k, respectively, and s_r and s_j are the output and input slacks, respectively. The result of the algorithm is a set of efficiency scores, where the technical efficiency of k is computed by the ratio $1/\phi_k$. These efficiency scores are based on the definition of an efficient frontier composed of observed and virtual producers: the units for which the efficiency score is equal to one are considered efficient, while the remaining units have a score greater than one, representing the 'distance' of these units from the efficiency frontier. This model is called CCR, after the names of its originators (Charnes, Cooper and Rhodes).

The CCR model assumes constant returns to scale. This is a limiting assumption, not least in the context of large public-sector organizations. A refinement to the model that accommodates variable returns to scale, due to Banker *et al*. (1984), has therefore come to be widely used. This is known as the BCC model (Banker, Charnes and Cooper). The BCC model differs from the CCR model in only one respect, as it has an additional constraint:

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{3}$$

In this paper, we compute both CCR and BCC efficiency scores for English and Italian universities. Moreover, the ratio between CCR and BCC results provide information about the 'scale efficiency', which is the capability of the units in reaping all the benefits in terms of scale effects. The presence of scale effects within HE institutions has been recognized at least since the contribution by Cohn *et al.* (1989), and so it

is appropriate that we should use both CCR and BCC approaches in the present analysis.

Since our study draws on data from a number of years, it is desirable that we should investigate efficiency changes over time. Changes in efficiency scores over time can be determined by two factors: first a change in an individual unit's efficiency, and secondly a shift of the production frontier itself (i.e., changes in the production technology). Because these are simultaneous effects, we use the Malmquist index approach to decompose the determinants of efficiency changes (Johnes, 2004; Zhu, 2003). To explain how this index works, let us consider a decision-making unit that has a change in position from P_t (in period t) to P_{t+1} (in period $t + 1$). Let $P_{t,t}$ denote the nearest point on the efficiency frontier in period t, and let $P_{t,t+1}$ denote the nearest point to P_t on the period $t + 1$ efficiency frontier. Define $P_{t+1,\,t+1}$ and $P_{t+1,\,t}$ analogously. To measure the change in efficiency score, the score should be decomposed in two components: the first related to the change in productivity (efficiency), and the second one to the change in production frontier. The resulting score for the decision-making unit could have benefits or negative effects due to the own productivity change or due to the shift (movement) of the frontier. Formally, the index is computed as:

$$Mo = \frac{OP_{t+1} / OP_{t+1,t+1}}{OP_t / OP_{t,t}} \cdot \left[\frac{OP_{t+1} / OP_{t,t+1}}{OP_{t+1} / OP_{t+1,t+1}} \cdot \frac{OP_t / OP_{t,t}}{OP_t / OP_{t+1,t}} \right]^{\frac{1}{2}} \tag{4}$$

where OP_i is the radial distance between the origin O and the point P_i (Johnes, 2004, pp. 621–624), and $OP_{i,j}$ is the (radial) distance between the origin and the point $P_{i,j}$. The first component of equation (4) is the ratio of technical efficiency in time period $t + 1$ to technical efficiency in the period t. The second component measures the shift in the production frontier.

The so-called Malmquist index (Malmquist, 1953; Caves *et al*., 1982) that results from the product of these two components will be equal to one if there is no net effect of changes in technical efficiency and frontier changes. The Malmquist index will be greater than one if productivity is rising, and less than one otherwise. In this paper, we refer to 'efficiency change' for the first component and to 'frontier shift' for the second one.

The data and the choice of variables

The database we have compiled for use in the present exercise aims to collect data for institutions of HE that are as comparable as possible across the two countries under study. Owing to the several differences among the characteristics of Italian and English HE, we have been forced to adopt some simplifications to obtain such comparability.

First, we are unable separately to consider undergraduate and *taught* postgraduate students as inputs to the production process.[6] This is due to the organization of curricula in Italian universities: the Bachelor/Master structure, which would allow us to separate undergraduate and postgraduate, has been introduced only very recently (Decree n. 509/1999), and so it is only from academic year 2005/06 that it is possible to state that a given student is registered on an undergraduate course (on the one hand) or a postgraduate course (on the other). For this reason, we employ only the total number of taught students in our analysis (which refer to the period from 2001/02 to

2004/05). We are, however, able to identify separately the number of PhD students, and so we do so in all the analyses that follow.

On the output side, however, we are able to identify separately the numbers of bachelor and master *graduates*, considering (in line with the Italian legislation) the grades obtained in pre-reform *Laurea* courses as equivalent to Master degrees.

Secondly, while in England the financial year for the universities coincides with the academic year, in Italy data that refer to the financial year address the time period from January to December. The database we construct is based on the academic year. Financial data for year 200*X* for Italy are matched with student numbers data for the year 200*X* – 200*Y* where $Y = X + 1$. A similar problem occurs with the number of professors, data for which are collected each calendar year. In this case, we consider these numbers together with the number of students of the academic year (e.g., we use the number of students in 2002/03 together with number of professors in 2002). These rules are coherent with the procedures adopted by the National Evaluation Committee for collecting data.

Thirdly, we consider the total number of students, instead of the more commonly accepted full-time equivalent (FTE) measure, because in Italy there is no formal distinction between part-time and full-time students, and so it is not possible to compute the full-time equivalent load.

Finally, note that we do not use the scores deriving from the qualitative assessment of the research activity in the two countries (which in England is carried out by the Higher Education Funding Council for England, and in Italy by the CIVR). This choice is justified by the differences in the procedures adopted for the evaluation, and also by the level of our analysis (i.e., the institutional level, whereas the assessment exercises are conducted at departmental level). Rather, we use research funding as a measure of the market valuation of research that is conducted within each institution.

Following these choices about data collation, we adopt the following measures of teaching and research activities. As inputs, we consider the (total) number of students (STUD), the total amount of financial resources/incomes (INC), the number of PhD students (PHD), and the number of academic staff (STAFF). As outputs, we consider the number of graduates (BACH and MASTER, respectively)[7] and the total amount of external grants and contracts for research (EXT).

Our data about England are obtained by the Higher Education Statistics Agency: we use the two collections, *Students in Higher Education Institutions* and *Resources in Higher Education Institutions*. All the financial data about English universities are reported in thousands of Euros.[8]

Data about Italy are collected annually by the National Evaluation Committee, and they are provided publicly online (www.cnvsu.it). This data source is used in preference to that of the Statistical Office of the Ministry because it provides comprehensive data on student and staff numbers together with financial data, while the latter data-set only includes complete information about student and staff numbers.

Our aim is to conduct the study on the two entire populations. We have complete, reliable, and comparable data about 127 English institutions (out of a total of 133) and about 57 public Italian universities (out of a total of 58). We excluded six institutions in the English sample and one in the Italian sample because of missing data in one of the years we consider.[9] We also excluded all the private Italian universities (of which there are 14) and the private University of Buckingham in England because we do not have financial data about them. We have, therefore, a complete data-set for a total of 184 higher education institutions, which constitute our sample.

Table 1 presents descriptive statistics for the variables, referring to the academic year 2003/04. These provide much useful information. Italian universities are, in terms of student numbers, about twice the size of English institutions: about 28 000 students versus 14 000. This being so, it is not surprising to note that the differences in size between institutions within each country differ, with much more differentiation in Italy than in England. The institutions with the highest number of students are the Open University in England (168 745 students) and Roma La Sapienza in Italy (105 046 students); however, the former is not a traditional university, but one based on distance-learning. Apart from this, the biggest university in England is the University of Leeds with about 35 000 students, confirming that the typical size of institution in England is much smaller than is the case in Italy. (In Italy, some 14 of the 57 institutions have more than 35 000 students.) In England, the smallest institution – the Institute of Cancer Research – has just 60 students; also, there are as many as 18 institutions with less than 1000 undergraduate students. These are mainly mono-disciplinary schools very focused on specific subjects, and in the main they lack university status. In Italy, there are no universities with less than 1000 students, and there is only one school dedicated to only one subject (IUSM, specializing in sports, with 1218 students).

Institutions in England and Italy are, on the other hand, very similar when we come to consider staff numbers. The average number of academic staff is about 950 in both cases. Again, in the two countries the highest number of academic staff is about 4700; but in the Italian case this is the university with the highest number of students (Roma La Sapienza), whereas in England it is the case for University College London (which has 20 000 students and is not therefore one of the largest institutions). In general, it seems that in Italy the numbers of students and academic staff are very highly correlated, whereas in England this is not so clearly the case. In the latter country, the heterogeneity of institutions' missions means that student:staff ratios vary considerably from institution to institution, with research-oriented institutions in general having a lower ratio of students to staff than the more teaching-oriented institutions.

A major difference between the countries is evident in financial matters. On the surface, this difference may not be apparent. Looking at total income we note a great similarity (an average of €150 million in England and €170 million in Italy). But the proportion of this total income that is provide by the State differs considerably across the two countries: in Italy this amounts to 62% of total budget, while in England the corresponding proportion is just 38%, showing a completely different structure of budgets' composition. The number of institutions being much higher, total income of the whole higher education *sector* in England is more than twice that in Italy; but it should be borne in mind that the number of students is quite similar (1 800 000 in England versus 1 600 000 in Italy), so that the income per student is also much higher in England. This evidence on financial data is reflected also in the data on external research funds: here, the mean is three times higher in England than in Italy, showing the real diversity among the two systems in terms of attracting resources from a multiplicity of funders. In both countries, however, there are some institutions that do not raise external resources for research activity.

Significantly, the numbers of total graduates (Bachelors and Masters) from the typical institution are strikingly similar across the two countries. Put alongside the larger number of students in the typical Italian institution, this finding reflects the higher level at which many Italian students have graduated (Masters, or *Laurea*, rather than bachelors), slower progression in Italy than in England, and also a higher rate of drop out or 'wastage'.

Table 1. Descriptive statistics for English and Italian universities, 2003/04.

	Students	Academic staff	Public direct funds (€000)	Total income (€000)	PhD	Bachelor	Masters	External research (€000)
United Kingdom								
Mean	14 166.73	956.73	57 522.29	153 084.02	369.49	2702.60	1118.94	24 685.06
Median	13 350.00	785.00	52 165.15	117 575.20	105.00	2500.00	975.00	6034.34
Standard deviation	16 684.34	862.28	50 199.95	156 292.13	629.68	2678.37	910.58	48 771.34
Maximum	168 745.00	4665.00	247 101.31	916 417.42	4130.00	22 140.00	4265.00	250 090.81
Minimum	60.00	35.00	0.00	5692.40	0.00	0.00	0.00	0.00
Total	1799 175.00	121 505.00	7 305 330.59	19 441 669.98	46 925.00	343 230.00	142 105.00	3135 002.84
Number of units	127.00	127.00	127.00	127.00	127.00	127.00	127.00	127.00
Italy								
Mean	27 767.65	954.28	107 014.98	172 346.21	580.81	710.07	2791.42	8733.35
Median	20 543.00	659.00	76 057.82	114 340.00	372.00	367.00	1778.00	4404.00
Standard deviation	23 394.73	892.88	97 945.51	183 046.91	543.01	926.71	2688.48	10 574.69
Maximum	105 046.00	4788.00	523 488.00	815 481.00	2520.00	4812.00	13 965.00	40 492.00
Minimum	1218.00	24.00	0.00	8941.00	0.00	19.00	0.00	0.00
Total	1 582 756.00	54 394.00	6 099 853.99	9 823 734.00	33 106.00	40 474.00	159 111.00	497 801.00
Number of units	57.00	57.00	57.00	57.00	57.00	57.00	57.00	57.00

Finally, note that the average number of PhD students in Italy is higher than in England; however, the concentration of PhD provision in a relatively small number of institutions in England is also a characteristic feature of the data, and it should be noted that the English institution with most PhD students has about twice as many such students as does its Italian counterpart.

Results

Analysis in academic year 2003/04

The first step of our empirical analysis involves the computation of efficiency scores referring to a single academic year, namely 2003/04.[10] To begin, we run both BCC and CCR output-oriented models separately for England and Italy. We calculate for each university the technical efficiency (CCR model), defined as the product of its pure technical efficiency and scale efficiency.[11] The results are presented in Table 2.[12]

The efficiency scores are consistent with previous studies adopting DEA, in that the mean efficiency scores, in both countries, are quite high. That is, *in relation to the frontier that applies within an institution's own country*, the performance of the typical institution is good. (What is 'high' or 'good' in this context is, of course, a value judgement; we use the terms here for the sake of comparison with results that we obtain later.) The standard deviations of the efficiencies are quite low (<0.15), confirming that the distribution of measured efficiencies is fairly compressed. The minimum value also confirms this finding: there are no universities with a score lower than 0.42. These results across the two countries are very similar. The proportion of efficient units is about 40% in both countries.

The efficiency scores that result from application of the CCR model are, of course, lower, due to the presence of scale inefficiencies. In England, of the 50 technically efficient institutions, as many as 24 are not also scale efficient. The corresponding

Table 2. Efficiency scores: separate analyses by country, 2003/04.

	BCC efficiency	CCR efficiency	Scale efficiency
England			
Mean	0.89	0.81	0.92
Median	0.92	0.79	0.96
Standard deviation	0.12	0.13	0.09
Minimum	0.42	0.42	0.67
Maximum	1.00	1.00	1.00
Observations	127	127	127
Number of efficient units	50	26	27
Italy			
Mean	0.89	0.82	0.93
Median	0.92	0.83	0.96
Standard deviation	0.14	0.15	0.08
Minimum	0.53	0.45	0.65
Maximum	1.00	1.00	1.00
Observations	57	57	57
Number of efficient units	25	16	16

figures for Italy are 9 out of 25. That said, scale efficiency is fairly high on average (more than 0.92 in both countries).

We next ran a DEA on the pooled sample of Italian and English institutions. When this is done the findings change considerably. Before reporting these findings, however, we must qualify them with an important caveat. The method of DEA is designed to handle the comparison of efficiency across institutions that are heterogeneous in terms of the weight that they attach to the various inputs and outputs. However, this is not the only type of heterogeneity that might be of importance. Institutions differ also in terms of the economic and regulatory environment in which they are placed. A substantial literature has developed recently that proposes methods to deal with such heterogeneity (see, e.g., Dyson *et al*., 2001; Brown, 2006). Now it is clear that there are differences in the environment between England and Italy, and to at least some extent these might contribute to an explanation of systematic patterns of measured efficiencies between these two countries. It could, for example, be the case that heterogeneity in the production process explains why institutions in one country appear to be less efficient than those in the other. The extent to which such heterogeneity can be thought of as justifiable or a manifestation of efficiency differentials is moot. With a sample of only two countries in the present exercise, it is clearly not possible to seek an explanation of differences in measured performance by methods such as regressing efficiencies against country-specific cofactors. Unfortunately, therefore, we have little option but to note this issue as a caveat without attempting to mitigate the issue.

The cross-country results are presented in Table 3. In the first column, we report the BCC efficiency scores. The average efficiency is somewhat lower than that obtained in the single country DEA exercises, but this effect is due mainly to the worse measured performance of Italian universities. The 50 efficient English units are all (but one) still efficient, whereas the number of Italian universities considered efficient is very much decreased (from 25 to 11). These 11 are efficient for a variety of reasons: some (e.g., IUSM Roma) are very small universities employing low levels of resource. At the other extreme Roma La Sapienza is the biggest university, and scores well because of high levels of output. This feature is common to the some other big universities (for instance, Bologna and Padova too obtained the maximum efficiency score). However, all of these (big and small) units in Italy are then penalized in terms of scale efficiency (they have scores <0.6).

The mean score for the Italian universities is now much lower (at 0.77), while the same mean score remains high in the case of English institutions. The different frontier that is estimated for this pooled case shows in sharp relief the existence of very poor performer units in Italy: there are 10 universities with a score below 0.60, and, of these, 3 have scores below 0.40. The relatively poor performance of Italian institutions in this exercise is in one respect surprising: since these institutions have large numbers of Masters-level students, they typically have a high weight on graduates at this level, and a correspondingly low weight on graduates at bachelor level (see Table 3). One might therefore expect them to perform well in an international DEA exercise owing to their distinctive output vectors. However, this is not the case – primarily because student drop-out rates are relatively high in Italy and, at Masters level in particular, very low in England.

In the second column of table 3, we provide information about CCR efficiency scores. These paint an even clearer picture, due to the effect of scale inefficiencies that broaden the differences among the two countries. Here, there are only five Italian

Table 3. Efficiency scores and virtual weights: cross-country analysis, 2003/04.

	BCC efficiency	CCR efficiency	Scale efficiency	VW Bachelor	VW Masters	VW research
All						
Mean	0.85	0.76	0.90	39.72%	47.20%	13.08%
Median	0.86	0.75	0.95	34.23%	35.11%	2.84%
Standard deviation	0.15	0.17	0.12	35.07%	35.39%	20.80%
Minimum	0.39	0.25	0.41	0.00%	0.00%	0.00%
Maximum	1.00	1.00	1.00	100.00%	100.00%	100.00%
Observations	184	184	184	184	184	184
Number of efficient units	60	30	30	–	–	–
United Kingdom						
Mean	0.87	0.81	0.93	55.46%	29.85%	14.70%
Median	0.92	0.79	0.96	62.58%	22.87%	3.45%
Standard deviation	0.13	0.13	0.10	30.75%	24.98%	23.65%
Minimum	0.42	0.42	0.67	0.00%	0.00%	0.00%
Maximum	1.00	1.00	1.00	100.00%	100.00%	100.00%
Observations	127	127	127	127	127	127
Number of efficient units	49	25	25	–	–	–
Italy						
Mean	0.77	0.64	0.84	5.58%	87.74%	6.69%
Median	0.77	0.62	0.87	0.44%	94.19%	0.70%
Standard deviation	0.17	0.18	0.16	13.11%	16.32%	9.76%
Minimum	0.39	0.25	0.41	0.00%	0.00%	0.00%
Maximum	1.00	1.00	1.00	100.00%	100.00%	40.43%
Observations	57	57	57	57	57	57
Number of efficient units	11	5	5			–

universities that remain efficient, due to their joint scale and pure efficiency; namely, Molise, Macerata, Politecnico di Milano, Salerno, Teramo. The average score in Italy is about 0.65, while in England it is still greater than 0.8.

Finally, there is also a gap between the countries in terms of the scale efficiency scores (column 3). Here the difference is less pronounced, but on average English institutions have a score that is about 0.09 higher than Italian universities. More insights about the role of returns to scale are obtained computing the number of institutions facing decreasing, constant and increasing returns (see Table 4), to understand the 'direction' of scale effects. It is worth noting that, in both the countries, a large number of institutions experience decreasing returns to scale, suggesting the case for diminishing the scale of their operations. Note that, on average, the institutions' size is very much lower in England, but this does not imply that they are necessarily scale efficient (a high proportion of them, about 60%, faces decreasing returns to scale). In Italy, the phenomenon is very clear: even if there are a few institutions (about 7%) that could efficiently boost the scale of their activities, most of them (more than 80%) should reduce the scale of their operations. This echoes a finding, obtained from a parametric analysis, reported in a companion paper by Agasisti and Johnes (2006).

Table 4. Institutions with decreasing, constant and increasing returns to scale, 2003/04.

Returns to scale	Decreasing	Decreasing (%)	Constant	Constant (%)	Increasing	Increasing (%)
England	77	60.63	26	20.47	24	18.90
Italy	47	83.93	5	8.93	4	7.14

It is useful to report the above results also in diagrammatic form. Figures 1–4 show the efficiency scores for each institution (ranked from lowest to highest from left to right) obtained by BCC analysis for, respectively, the case of: England in the analysis comprising all institutions; England in the analysis comprising only English institutions; Italy in the analysis comprising all institutions; and Italy in the analysis comprising only Italian institutions. It is readily seen that the two graphs for England are virtually identical to one another, while in the case of Italy the number of institutions that appear to be efficient is much greater when the comparison group contains only Italian institutions than is the case when the group includes also English institutions.

We also compute the virtual weights (VWs) associated with the two outputs considered (columns 4 and 5 of Table 3).[13] Since we have only three outputs, one for undergraduate teaching, one for postgraduate teaching and one for research, we can interpret the results in terms of relative institutions' strengths with respect to these. Again, the results are interesting. Firstly, we note that Italian universities are more focused on teaching matters (on average, the VW associated with graduates – sum of Bachelors and Masters – is 7% higher than for English institutions).[14] Conversely, English institutions place more attention upon research: among English institutions there is one that is completely focused on research (VW = 99.9%), whereas in Italy the maximum value attached to it is about 40%. Moreover, there are 16 English institutions (more than 10% of the total) that have a VW for teaching that lies below 50% (i.e., they are strongly research-oriented).

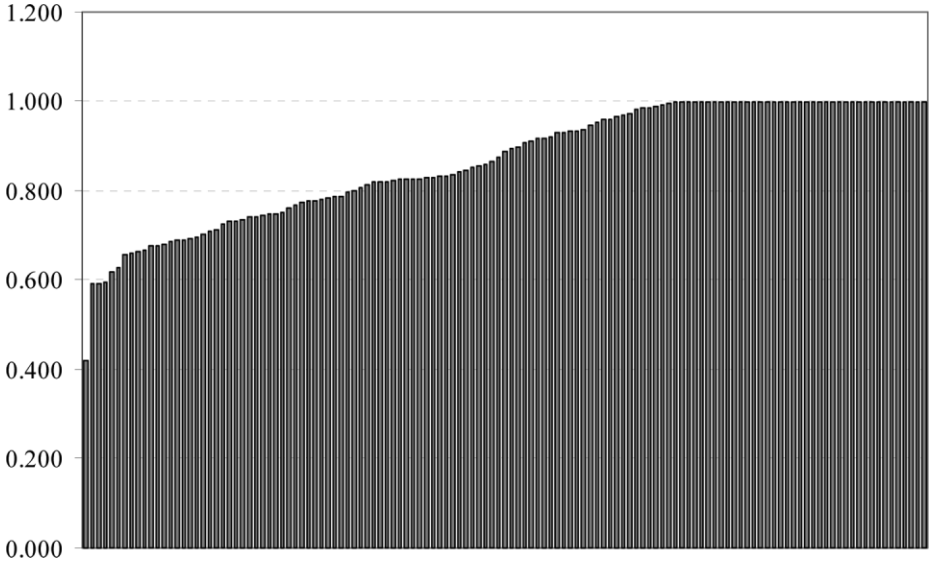

Figure 1. Efficiency scores, England (all institutions).

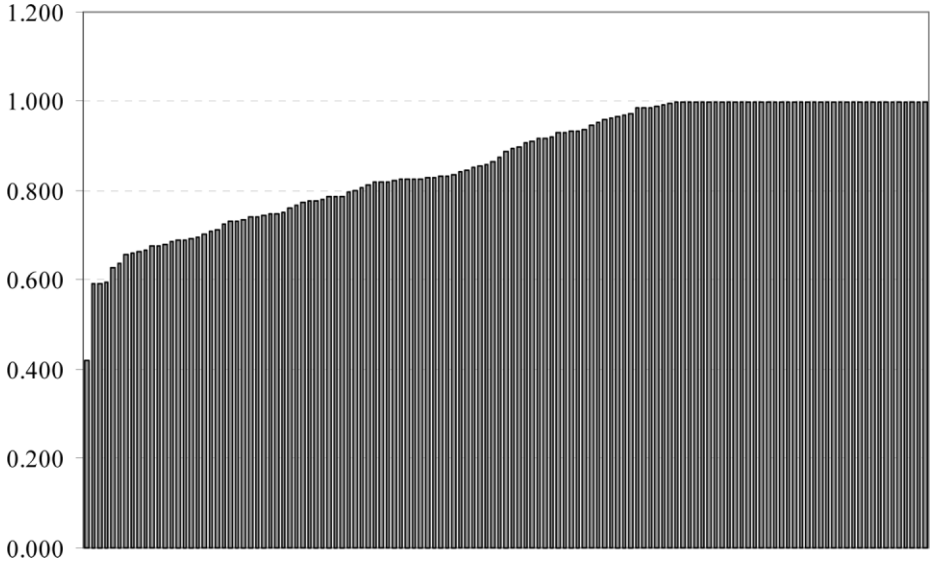

Figure 2. Efficiency scores, England (only English institutions).

An unfortunate characteristic of DEA is that, as a non-statistical technique, it lacks the toolkit of statistical inference, which econometricians routinely use as guidance in the choice of model specification. It is doubly important, therefore, in conducting analyses of this kind that we should check for the robustness of results (Johnes and Johnes, 1993). We have conducted DEA exercises on a variety of models in order to

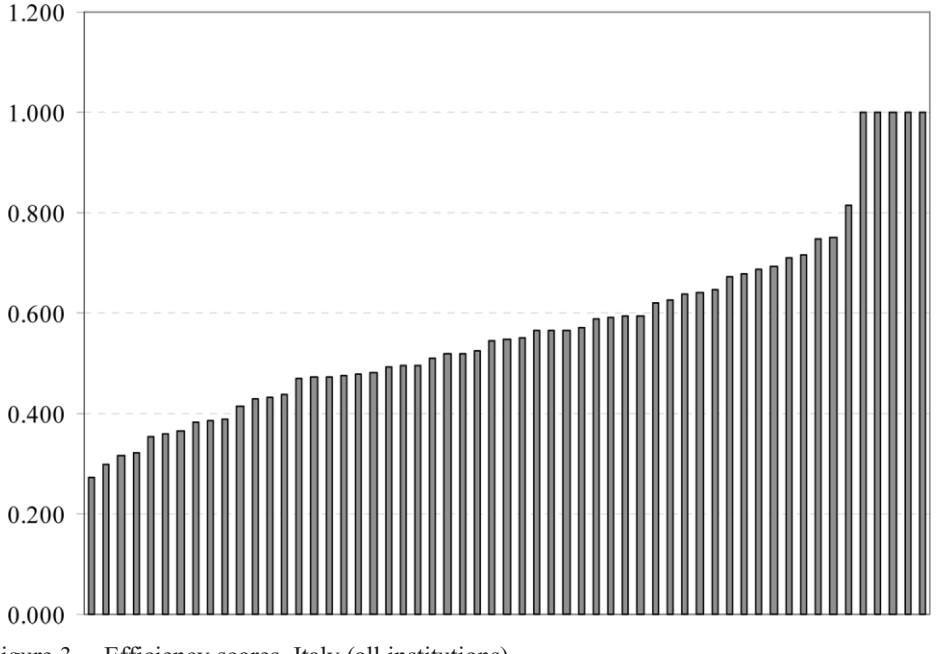

Figure 3. Efficiency scores, Italy (all institutions).

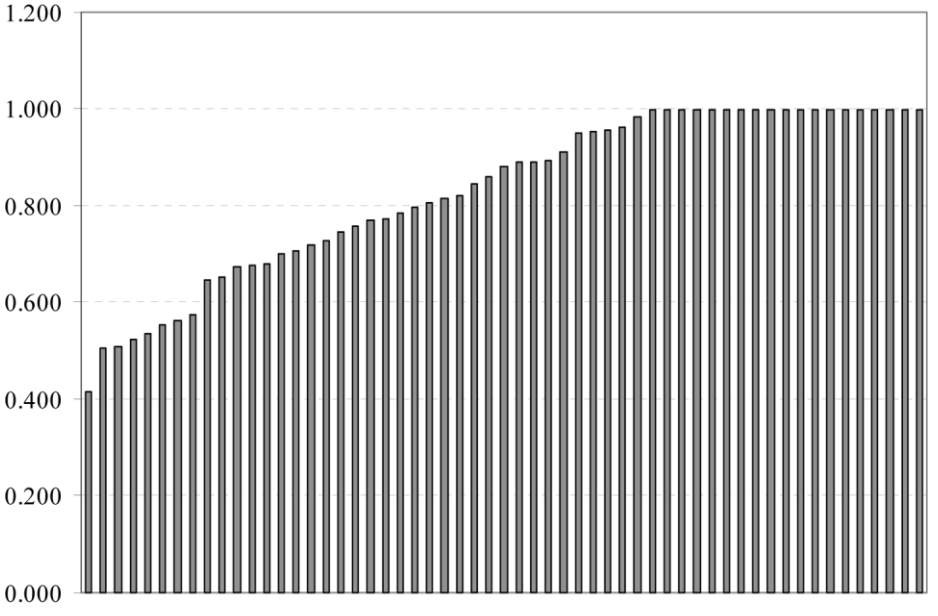

Figure 4. Efficiency scores, Italy (only Italian institutions).

ensure that there is no fragility in the results reported here. In particular, we have repeated the above analysis but excluding institutions that are, in some sense, outliers – the Open University and small institutions with fewer than 1000 students. We have also repeated the analysis but excluded from the list of inputs the number of students. In both cases, the impact on the results is negligible.[15]

Dynamic analysis for the period 2001/02–2004/05

To understand more deeply the relative efficiency of the two HE systems, an analysis of their evolution seems useful. For this purpose, we look at the change in efficiency scores over a longer period (2002/03–2004/05) and we compute Malmquist indexes over this period. In both cases we jointly consider all the English and Italian institutions, because our main objective is to compare the trends in relative efficiency across the two countries.

The results of a BCC model for all of the academic years considered are presented in Table 5. In the first part of the table, the results show evidence of a general trend that suggests an improvement of the efficiency scores (on average), albeit with a small magnitude (about 0.02 over the whole period). This occurs alongside a non-negligible increase in the number of efficient units. Looking at the separate results, we note that the higher number of efficient units refers to English institutions, and also the increase of average efficiency scores. (Italian universities' scores are oscillating in the different periods.)

The Malmquist index results confirm the general improvement in efficiency scores, at the same time providing evidence of some country level differences (Table 6).

In the period considered, English institutions (on average) experienced stationary performances. In fact, the Malmquist index exceeds one, but the net (technical) efficiency change is almost zero. The resulting Malmquist index is marginally above

Table 5. Efficiency scores (BCC model) for the period 2001/02–2004/05, cross-country analysis.

	2002/03	2003/04	2004/05
All			
Mean	0.832	0.848	0.853
Standard deviation	0.144	0.150	0.150
Efficient units	46	60	62
England			
Mean	0.877	0.872	0.881
Standard deviation	0.124	0.126	0.125
Efficient units	35	49	50
Italy			
Mean	0.786	0.768	0.775
Standard deviation	0.173	0.169	0.170
Efficient units	11	11	12

unity, indicating overall progress, only because the positive shift of the efficiency frontier itself. This finding is coherent with the results of Johnes (2006a) in her analysis of the productivity changes in English universities, where she finds a modest negative change in technical efficiency.

By way of contrast, Italian universities achieved stronger improvement in their performance (the Malmquist index being close to 1.1), this being exclusively due to a strong, real (technical) efficiency improvement (the efficiency change is 1.775). Consistent with our prior expectations, a major positive change occurred in 2002/03, when the reform process on teaching issues was implemented. Also these results are coherent with recent analysis of the sector in Italy (CNVSU, 2005). However, we detect the presence of negative effects due to frontier shifts: we discuss possible explanations later.

Policy implications

Our findings have a number of policy implications, although at this stage these should be regarded as somewhat speculative. The first concerns differentiation among HE

Table 6. Malmquist indexes for the period 2001/02–2004/05, cross-country analysis.

	From 2002/03 to 2003/04	From 2003/04 to 2004/05	Whole period
England			
Malmquist index (average)	1.066	1.005	1.085
Efficiency change (average)	1.063	0.963	1.020
Frontier shift (average)	1.006	1.044	1.069
Italy			
Malmquist index (average)	1.067	0.935	1.094
Efficiency change (average)	1.847	0.969	1.775
Frontier shift (average)	0.616	0.967	0.648

institutions. In Italy, universities are broadly similar to one other: all devote their main attention to teaching issues and obtain a high proportion of their budget by public grants. In England, by way of contrast, there are institutions that are almost completely devoted to teaching, and others that are very heavily involved in research matters; many do both. Overall, the English picture is one of much greater heterogeneity than in the Italian case. Indeed it may be that specialization is one of the determinants of the relatively strong performance of the English institutions in our sample, bearing in mind that DEA effectively allows institutions to define their own missions. Another possible explanation for the relatively strong performance of English institutions may be their lower dependency on public funds; this makes institutions more open to competitive pressures and this in turn may enhance efficiency. Both of these observations may offer clues that might be helpful in stimulating further efficiency, especially in the case of Italian institutions. In fact, the specialization towards teaching or research could affect the capability of institutions in obtaining comparative advantage (through specialization itself) and relatively better performance. Similar results were previously obtained by Johnes (1998) in his analysis of UK HE cost structure.

The size of Italian institutions is (on average) much higher than is the case for English ones. There are many universities with more than 40 000 students, while in England there are no universities of this size (other than the Open University). Even if it would appear that the scale efficiency scores are similar, the analysis showed that the largest universities in Italy have exhausted scale economies, and their huge dimensions only create congestion effects (Agasisti and Johnes, 2006; Agasisti and Dal Bianco, 2006b). In both countries there may be scope to achieve greater scale efficiency by reallocating students between institutions – although devising incentive mechanisms for this to be done may be problematic. In Italy, it seems that favouring the growth of smaller institutions, which are experiencing significant increasing returns, could be a possible route forward, although this would need to be achieved alongside a persistent attempt to reduce the size of the biggest universities. Increasing the number of institutions in Italy, partly through divestment, seems to offer the promise of greater efficiency.

Our findings about the relatively low average efficiency scores of Italian universities, compared with others in Europe, are consistent with recent studies based on analysis of performance indicators (see Lambert and Butler, 2006) and on DEA (see Joumady and Ris, 2005). However, some encouraging signals derive from the analysis of time trends, which shows a positive improvement – albeit over a short period of time – of the technical efficiency scores of Italian institutions. One might speculate that this, if indeed it is a trend that is set to continue, is due to two main facts. The first is the implementation of teaching reforms (Decree n. 509/1999), which introduced the Bachelor/Master structure, allowing more students to obtain a qualification. Indeed, major problems of Italian HE have historically been the high drop-out rates and the long time to graduation, both of which are at least partially addressed by the introduction of an intermediate qualification (Bachelor). The second possible reason for recent improvements is the growing attention to efficiency in public expenditures, which incentivizes universities to look for other sources of income. Further incentivization, based on resource allocation linked to performance measurement, is likely to lead to further improvement in performance. However, the strong effects of frontier shifts suggest that the positive role of an improved technical efficiency must be sustained by developments in the production techniques (e.g., distance learning, higher qualitative standards, information and communications technology, etc.)

English institutions, on the other hand, are often regarded as the most effective in Europe. Their position is in part due to their structural differences with the continental universities and the existence of strong market-like incentives. Our findings reveal that this perception (at least as far as a comparison with Italian institutions is concerned) is based on fact, but that the efficiency premium attached to English institutions is eroding, albeit slowly. As a consequence, English HE should reconsider its competitive advantages, for renewing strategies in a European HE context that is rapidly becoming more competitive. Johnes (2006a) points out the positive effects of technology changes in the period 1996–2003 (e.g., a wide use of information and communications technology and e-learning), but also advises about the risks of declining technical efficiency, where the frontier defined by the most adventurous institutions becomes increasingly distant from other colleges and universities.

Obviously, our results must be interpreted with caution, not least because the difficulty of adequately modelling the production processes of universities, especially in a context where data collated across countries are less than perfectly comparable. However, our experimentation with alternative specifications of the models suggests that the findings are robust – and they are consistent with more recent similar studies based on single-country data-sets (Agasisti and Dal Bianco, 2006a; Agasisti and Johnes, 2006; Johnes, 2006a).

Concluding remarks

This paper presents the results of a DEA exercise conducted on Italian and English HE institutions, with the aim of comparing their relative technical efficiency. The first step is an estimation of institutions' efficiency measured against their own country's frontier. Following on from that, we compute a frontier based on data pooled across the two countries, and focus on the implications of this analysis for the efficiency scores. Finally, the analysis is placed in a multi-period framework, to highlight the trend in efficiency scores in the period considered (2002/03–2004/05). Interesting results have emerged.

When conducting an intra-country analysis, both in England and Italy the performance of institutions appears to be good, with an average efficiency score in excess of 0.8. This is a result very much in line with previous research in this field (see Salerno, 2003, for a brief review).

In the second part of the empirical testing, we have conducted a pooled analysis across countries and note that the typical English HE institution is (measured as being) much more efficient than its Italian counterpart. When the data are pooled across countries in this way, the efficient frontier lies further above the out-turn for the characteristic Italian institution than is the case when the frontier is estimated on Italian data alone. While many English institutions have efficiency scores of over 0.82 in the pooled analysis, the corresponding scores for Italian institutions drops to about 0.7.

Over time, however, the trend in Italy is in a positive direction, with institutions becoming more technically efficient with respect to the frontier. Meanwhile, for English institutions, no gains in efficiency were realized in the period considered. Our analysis finds that the positive changes in productivity for English universities over the time period considered here have been driven by frontier shifts (i.e., the improvement in technology), while technical efficiency of individual institutions has been stationary. By way of contrast, Italian universities are strongly improving their technical efficiency, but they have not benefited from positive shifts in the frontier.

Several implications for policy emerge from our analysis. The first concerns the degree of diversification within each country. English HE appears to be much more diversified than is the case in Italy, where only one type of institution exists (namely, universities). This factor could affect the capability of institutions to specialize in some activities, so obtaining a well-defined comparative advantage and consequently better performance.

The second policy conclusion concerns the size of institutions. On average, English institutions are much smaller than those in Italy, but they are able to benefit from scale effects that seem to be exhausted for the big Italian universities. Thirdly, our work sheds some light on recent reforming processes. These would appear already to have contributed significantly to the improvement of institutions' performances in Italy, especially in terms of technical efficiency.

This work is, to the best of our knowledge, the first to compare systematically the efficiency of HE institutions located in different countries using a population of institutions. This matter is important for policy purposes, not least because of the growing role of the European Union in sustaining HE developments. A natural extension of our work would be to extend the data-set to include all institutions from all European Union countries. This would be demanding in terms of data requirements. There is arguably an important role for the European statistical agencies to play in compiling internationally comparable data-sets on HE.

Notes

1. It may, in fact, be an oversimplification to regard the British system as binary. The binary divide between universities and polytechnics was abandoned in 1992, and there is now a heterogeneity of types of higher education institution in the United Kingdom. A popular classification is: the top five (Oxford, Cambridge, University College London, Imperial College London, and the London School of Economics); universities in which the modal score in the research assessment exercise is five; universities in which the modal score in the research assessment exercise is four; other universities; colleges of higher education; and higher education provided within further education colleges.
2. This characteristic is common for several European countries (see Lambert and Butler, 2006).
3. Teaching reforms were initiated with Decree Number 509/1999, and subsequently several other decrees regulated the new framework. The implementation of the reform starts in the academic year 2001/02.
4. This quantitative information is obtained by the National Evaluation Committee for the University System (CNVSU). See the CNVSU website (www.cnvsu.it).
5. For example, those published by the *Times Higher Education Supplement* (6 October 2006).
6. We view students as an input to the production process while graduates are an output. One way in which institutions might differ in efficiency is therefore in terms of the rate at which students are converted into graduates. This is likely to differ across institutions owing to differences in the rate of non-completion (drop out) and in the standard length of the degree programme.
7. The number of PhD graduates is not included as an output, because in Italy there are reliable data only about the number of students at this level, and not about the degrees awarded (see CNVSU database; www.cnvsu.it). However, we maintain the number of PhD students as an input because of their contribution to research activities, and, in many cases, to teaching activities too.
8. We converted the data using the medium Exchange Rate EUR–GBP provided as an average for the December of each year (2001, 2002, 2003) by the European Commission and Eurostat. These rates were 0.6236 in 2001, 0.6395 in 2002, and 0.7048 in 2003. The 2004 exchange rate is extracted from the Eurostat website and represents an average value for the whole year (rate = 0.67866).

9. In the United Kingdom, the excluded institutions are: the Birmingham College of Food, Tourism and Creative Studies; the Courtauld Institute of Art; the Northern School of Contemporary Dance; University College Winchester; King Alfred's College, Winchester; and the London Metropolitan University. The excluded institution in Italy is Napoli Parthenope.
10. All the results presented in this paper are obtained using DEA Excel Solver© (see Zhu, 2003).
11. Here and below, the results show average values for CCR, BCC and scale efficiency. Obviously, the product between the average BCC and average scale efficiency does not calculate the average CCR (this explains the apparent incoherence in the tables).
12. We use an output-oriented DEA, and report the results as the reciprocal of the output distance function, for obtaining a set of efficiency score between zero and one.
13. VWs are defined as the set of weights that maximizes the efficiency scores. See Zhu (2003) for details of their computation.
14. As noted earlier, the weight attached to Masters graduates is relatively high in Italy, owing to the large proportion of students that study to this level. Nevertheless, owing to the low drop-out rate of Masters students in England, Italian institutions that attach high weight to Masters graduates often fail to perform as efficiently as their English counterparts.
15. So much so that we do not report them here. The results are, however, available from the authors on request.

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