Handling negative data using Data Envelopment Analysis: a directional distance approach applied to higher education

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Abstract

This paper applies a data envelopment analysis (DEA) method to assess technical efficiency of both private and public universities in Italy. Moving from the traditional context where inputs and outputs are assumed to be non-negative, a directional distance function approach has been applied in order to handle both desirable (i.e. number of graduates) and undesirable (i.e. number of dropouts) outputs. The findings based on a panel from academic year 2003/2004 to 2007/2008 reveal the presence of interesting geographical (both by macro areas and regions) and ownership (private, public) effects. Several quality and quantity proxies have also been used in order to check whether the estimates depend on the output specification. Finally, the possible evidence of variation in the universities' performances by subject of study has been taken into account in order to check whether the results are still consistent comparing universities within subject rather than across subjects.

Keywords: Data envelopment analysis; Negative data in DEA; Directional distance function; Higher education

JEL-Codes: I21, I23; C14; C67

1. Introduction

A growing number of researchers analysed the efficiency of educational institutions.[1] The concept of efficiency follows the Debreu (1951) and Farrell's (1957) definition. The efficiency analysis determines the scores that give rise to the efficiency ranking of reference, by calculating the optimal distance from the border. Specifically, the term efficiency refers to the degree of adhesion observed in the production process to a given standard of optimality. In other words, the definition of efficiency is based on measuring the reduction (expansion) in radial input (output) that is compatible with a given output (input) vector. Focusing on higher education institutions (HEIs), different methods have been used in order to perform the efficiency analysis such as parametric and non-parametric. Specifically, the non-parametric methods, as Data Envelopment Analysis (DEA) and Free Disposable Hull (FDH), proposed by Charnes et al. (1978) and due to the original contribution of Farrell (1957), are based on deterministic frontier models (see also Cazals et al. 2002). Among them, DEA model, extended by Banker et al. (1984), is especially adequate to evaluate the efficiency of non-profit entities that operate outside the market, since for them performance indicators, such as income and profitability, do not work satisfactorily (for more theoretical details on DEA see Coelli et al. 1998; Cooper et al. 2006).

Traditionally, DEA assumes non-negativity of the inputs and outputs; however, the application of efficiency analysis, dealing with negative data, has been increasingly taken into account in the literature (see Pastor and Ruiz, (2007) and Thanassoulis et al. (2008) for a review) even though, to the best of our knowledge, it is almost new in the higher education environment. This is mostly due to the fact that the main indicators which have been used in the literature for evaluating the efficiency of HEIs are positive or desirable outputs. In effect, specifically considering the teaching process, a widespread proxy of the universities' performances is the number of graduates (see among others Bonaccorsi et al. 2006; Agasisti and Dal Bianco, 2009; Johnes, 2006; Athanassopoulos and Shale, 1997; Madden et al. 1997). However, in the last decades, the problem of interrupted careers (i.e. drop out, thus a non-desirable output) has become an increasing concern in tertiary education,[2] given that a substantial number of students enter in the higher education system and leave without at least a first tertiary degree[3]. As Belloc et al. (2010) pointed out "university financing issues as well as the employment implications of university drop-out have made the understanding of withdrawing decisions a central concern for higher education policies and institutions' organization". Regarding Italy, "the reduction of drop-out rates is also at the core of recent reforms of the national university system, as increased retention has become the goal of many quality assessments and reorganizational efforts in Italian higher education institutions" (again Belloc et al. 2010). Specifically, the attention has been principally paid to the transition between the 1st and the 2nd year which is considered[4] as one of the weaknesses of the Italian higher education system (CNVSU, 2011)[5]. In the last years the percentage of students who dropped out after the 1st year has been

[1] See Worthington (2001) for a survey on frontier efficiency measurement techniques in education.

[2] According to Lambert and Butler (2006), "High drop-out rates are a sign either that the university system is not meeting the needs of its students, or that young people are using universities as a convenient place to pass a year or two before getting on with their lives. In a mass access system with no selection and high youth unemployment rates, it may be quite rational for a student to sit around for a year or two before dropping out. But this is hardly an efficient use of public resources".

[3] On average 31% of students entering tertiary education leave without at least a first tertiary degree among the 18 OECD countries for which data are available in 2008 and even though dropping out does not always represent a failure of individuals or inefficiency of universities, a high dropout rate shows that the higher education system did not probably match the students' expectations and needs (OECD, 2010). To see why it is important to analyse the student persistence in higher education, individuals with a tertiary level of education have a greater chance of finding a job, a lower unemployment rate, a higher possibility of having a full time contract and earn more than those who do not have a university degree (OECD, 2011).

[4] Along with the increasing cost per student, the high number of freshmen who do not acquire any credit, the high number of irregular students and the increasing length of the time to get the degree

[5] According to Cappellari and Lucifora (2009), the "system was often criticised for its inefficiencies in terms of low enrollment, high drop-out, excessive actual length of studies".

reduced but it is still very high[6]. In order to deal also with this issue and to improve the effectiveness of the universities, the Italian higher education system has been reformed mainly in the 1990s and at the beginning of the 2000s[7]. Consequently, universities have started to be funded according to their level of virtuosity and both quantitative and qualitative indicators[8] were developed to accurately evaluate their productivity in research and teaching. Through those parameters, the quality of education was meant to increase also by reducing the number of students who leave universities[9]. This means that there is a need of taking into account also this indicator when measuring the universities' performances. However, in the related literature, as far as we know, the dropout rate has not been included among the outputs according to which, given certain inputs, HEIs' performances have been measured. An exception is represented by Agasisti and Salerno (2007) [10] who, with the aim of assessing the cost efficiency of Italian universities, used the institution's drop-out rate between the 1st year and the 2nd year as a measure for education quality; assuming that "quality is best captured by the satisfaction of those who are actually purchasing the education", they considered the dropout rate as "an outcome-oriented measure"[11].

It is known that "when undesirable outputs are present, it is by definition not desirable to expand bad outputs. Thus to measure productivity under these circumstances, a directional distance function approach should be considered" (Fare and Grosskopf, 2010). Specifically, the directional distance function for measuring efficiency (going back to the seminal work of Chambers et al. 1998) is a non-radial approach and allows to handle negative variables or undesirable inputs-outputs, varying the direction vectors chosen by the researcher[12]. Thus, in this paper the dropout between the 1st and the 2nd year is

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[6] Specifically, considering the period from the academic year 2002-2003 to the academic year 2008-2009, on average 20.35% of entrants in the Italian tertiary education institutions did not enroll in the 2nd year (CNVSU, 2007, 2011). Considering the same time span, 18.02% of entrants, instead, is considered inactive, meaning that these students did not acquire any credit during the 1st year at university.

[7] See Potì and Reale (2005), Bini and Chiandotto (2003) and Buzzigoli et al. (2010) for a brief review of the university system in Italy.

[8] On the move towards increased efficiency of universities, also in a different geographical setting such as the United Kingdom, Johnes and Johnes (1995) have underlined that "the move towards greater efficiency has led to a clamour for performance indicators of various sort".

[9] The all Europe higher education sector went through a wave of reforms in the last two decades. The so-called "Bologna process" changed university curricula in several European countries. In Italy, the process of reform was adopted in 1999 through the Decree n. 509/1999. Among the main goals such reform was supposed to reach, decrease the number of students leaving the tertiary education system was one of the most important (CNVSU, doc. 07/2007). Analysing the process of reform in Europe, Lambert and Butler (2006), claimed that "If the reforms are successfully implemented, the results could range far beyond the changes in the curricula which are at their core. University teaching could become more efficient and cost-effective, and drop-out rates could fall".

[10] See also Zoghbi et al. (2013) who, with the aim of measuring the education of production efficiency for Brazilian universities through a stochastic frontier analysis, included the dropout ratio for each HEI in the production function, in order to control for the eventual heterogeneity between freshman and senior students.

[11] Among the different models presented in the analysis, they preferred to focus on that one which takes into account the dropout as a quality measure. They conclude that "although students may drop out for reasons other than dissatisfaction and we could not control for the quality of postgraduate training in this study, productivity increases when education quality is based on the perceptions of those actually purchasing the service".

[12] As underlined by Portela et. al. (2004), traditionally one way of taking into account negative data, is transforming them such as adding an arbitrary large number, in order to have all positive data (see Pastor, 1994 and Lovell, 1995). The disadvantage is that operating through this type of transformation lead to problems with the estimation of the efficiency scores (Ali and Seiford, 1990), even though for some models this issue does not represent a problem. For instance, the variable return to scale model presented by Charnes et al. (1985) is translation invariant. However, it still has some problems such as not providing an efficiency score readily interpreted and it also yields the furthest target in respect of an inefficient unit. Another solution is represented by the variable return to scale model presented by Banker et al. (1994) which instead provides an efficiency score in presence of negative data, but only through transformation data. In other words, there are no DEA models which are able to deal with negative data and provide efficiency scores readily interpreted, without transforming the data. For this reason a solution might be using the directional distance model proposed by Chambers et al. (1998) which is the one we implement in this work. As far as we know there is also another procedure proposed by Portela et al. (2004) known as the Range Directional Model (RDM) which is both translation and unit invariant in order to deal with negate data. However, this procedure has a drawback which is that the direction towards the production frontier is in a sense biased towards the factors with the largest potential for improvement. This is a problem particularly relevant in our case. Moreover, we think it does not fit particularly well with our aim given the structure of our data (i.e. one of the output we take into account is all negative).

used as a bad (undesirable) output, along with the number of graduates as a good (desirable) output[13], using a directional distance function approach in a non-parametric setting (see also Kerstens and Van de Woestyne, 2011; Portela et al. 2004), to estimate technical efficiency of 72 (both public and private) universities in Italy. Following this approach, we believe to obtain more reliable efficiency estimates of the HEIs' performances, accurately taking into account that universities not only maximize the number of graduates but also minimize the number of leavers as the Italian Ministry of Education, Universities and Research guidelines clearly suggest (CNVSU, doc. 07/2007)[14]. The empirical evidence, based on a panel from academic year 2003/2004 to 2007/2008, reveals the presence of interesting geographical (both by macro areas and regions) and ownership (private, public) effects. The use of several quality and quantity proxies has been explored in order to check whether the estimates are sensible to the output specification. Moreover, the possible evidence of variation in the universities' performances by subject of study has been also taken into account. In other words, we explore whether the results are still consistent comparing universities within subject (i.e. faculty) rather than across different subjects (i.e. faculties).

The rest of the paper is organized as follows. Section 2 describes the methodology, Section 3 illustrates the research design, Section 4 gives information about the data, Section 5 describes the empirical results, Section 6 provides a sensitive analysis and finally Section 7 concludes.

2. Methodology

Let assume $x = (x_1, \dots, x_N) \in \Re_+^N$ to be an input vector transformed to obtain an output vector $y = (y_1, \dots, y_M) \in \Re_+^M$. In this framework, the technology T can be described as follows:

$$T = \{(x, y): x\ can\ produce\ y\} \tag{1}$$

In this paper, we implement a specific procedure so called "directional distance function".[15] In a generic form, following Chambers et al. (1998), this technique can be described as follows:

$$\overrightarrow{D_T}(x, y;\ g_x, g_y) = \sup\{\beta: (x - \beta g_x, y + \beta g_y)\ \in\ T\} \tag{2}$$

where $g = (g_x, g_y)$ denotes a directional vector. Assuming an arbitrary direction to be $d \in \Re_+^m$, the directional distance or excess function can be also defined in this way:

$$e = e(x, y; T, d) = \max\{e \in \mathbb{R}_+ | (x - ed, y + ed) \in T\} \tag{3}$$

where a high degree of excess reflects a high (in absolute value) amount of slack and a considerable amount of inefficiency. The main advantage of this method, belonging to the class of non-radial approach, is the flexibility. In fact, it allows to handle negative data or undesirable outputs-inputs, especially in managerially oriented benchmarking models (as suggested also by Portela et al. 2004). However the applicability of this method imposes some fundamental requirements.

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[13] Traditionally, the more frequently adopted indicators are those related to non-completion rates, degree results, first destination of new graduates, unit costs. This is the set of indicators proposed by Johnes and Taylor (1990), who discussed in depth the importance of using performance indicators (PIs) in higher education

[14] In other words, the analysis takes into account that some universities might perform particularly well when graduates are taken into account but have a high dropout rate and vice versa.

[15] Basically, the main purpose of directional distance functions, that represent an alternative or generalization of Farrell's proportional approach, where all inputs are reduced or all outputs are expanded by the same factor but not simultaneously, is to determine improvements in a given direction d, in addition to measure the distance to the frontier in such d-units. Generally speaking, its role (related to efficiency measure) is to simultaneously seek to contract input and expand output.

One of the main condition concerns the choice's rule of the directional vector, since a wrong specification could lead to accept the infeasibility assumption. By definition, the direction of $g \in (-\Re_{+}^{N}) \times (\Re_{+}^{M})$ is infeasible at $z = (x, y) \in T$ if $\Delta\,(z, g) = \{z + \delta g: \delta \in \mathbb{R}\} \cap T = \emptyset$. In other words, the directional distance function (so called $D_T(z; g)$) at point z and direction g is not well defined, i.e.$-\infty$. So, the optimal choice of direction vector assumes a high relevance in application and theory framework in order to determine the deviations from the boundary of technology. As shown by Briec and Kerstens (2009), in the case of more than two output dimensions and of a non-null output direction vector, the directional distance may be infeasible, but it's not our case.

However, to overcome the problem related to the "infeasibility", we follow the line suggested by Fare and Grosskopf (2000). In order to guarantee link and symmetry with the traditional distance functions, which are defined in the direction of the observed input or output mix for each observation, we impose the direction vector to be equal to the value of the observation (see Chambers et al. (1998) and recently Bogetoft and Otto (2011) for additional details about the choice of the directional vector). To the best of our knowledge, in higher education there are no works which make use of the directional distance function in order to assess technical efficiency of specific decision-making units (i.e. faculty, department or university). Our main contribution is then to implement this specific technique considering undesiderable outputs (in our case the number of dropouts), which is, instead, not allowed, using Farrell efficiency (radial approach).

For the purpose of this paper, we only formalize the output-oriented approach. Assuming $g = (0, g_y)$, the directional distance output distance function is reached as follows:

$$\overrightarrow{D_o}(x, y; g_y) = \sup\{\beta: (y + \beta g_y \in P(x) \subseteq \Re_{+}^{M}\} \tag{4}$$

where $\overrightarrow{D_0}(x, y; g_y) = \overrightarrow{D_o}(x, y; 0, g_y)$. Using a directional distance function and assuming $g_x = x$ and $g_y = y$, it's possible to derive the conventional Shephard output distance function[16] as follows:

$$\overrightarrow{D_o}(x, y; y) = \frac{1}{D_0(x, y)} - 1 \tag{5}$$

The Shephard's distance function in the output oriented context becomes:

$$D_0(x, y) = \inf\{\theta: \frac{y}{\theta} \in P(x)) \subseteq \Re_{+}^{M}\} \tag{6}$$

The conventional linear programming problem corresponding to the directional distance or excess function, i.e. e, in DEA-oriented output approach is formally described as:

$$max_{e, \lambda^1, \dots, \lambda^K} \quad e \tag{7}$$

$$s.t. \quad x \geq \sum_{k=1}^{K} \lambda^k x^k \tag{8}$$

$$y + ed \leq \sum_{k=1}^{K} \lambda^k y^k \tag{9}$$

$$\lambda \in \Lambda^{K}(y) \tag{10}$$

[16] Note that Shephard's distance functions have a multiplicative structure, while directional functions follow an additive framework.

3. Research design

3.1. Inputs

The first input is the number of professors (PROF). It is a measure of a human capital input and it aims to capture the human resources used by the universities for teaching activities.

The second and third inputs are the number of enrolments with a score higher the 9/10 in secondary school (ENR_HSG) and the number of enrolments who attended a lyceum (ENR_LYC), respectively. Indeed, among the inputs which are commonly known to have effects on students' performances there is the quality of the students on arrival at university. There is a strong evidence that the type of secondary high school and pre-university academic achievement are important determinants of the students' performances (Boero et al, 2001; Smith and Naylor, 2001; Arulampalam et al. 2004; Lassibille, 2011). The underlying theory is that ability of students lowers their educational costs and increases their motivation (DesJardins et al. 2002). Thus these two inputs aim to capture the quality of students on arrival at university (i.e. proxies of the knowledge and skills of students when entering tertiary education).

The fourth and last input is the total number of students (STUD) in order to measure the quantity of undergraduates in each university.

3.2. Outputs

The first output is the number of enrolments who drop out at the end of the 1st year (DROU). As already pointed out in Section 1, a high number of leavers is considered a signal of a system that does not work perfectly. Consequently, it is used as an undesirable output.

The second output is the number of inactive enrolments, meaning those students who do not take any exam at the end of the first year (INACT_ENR)[17]. We use this measure as a proxy of the dropout as so as a bad output.

The first two outcomes above mentioned (DROU and INACT_ENR) are both measured at the end of the 1st year. This follows the Italian Ministry of Education, Universities and Research guidelines, according to which, universities are evaluated also on the base of indicators such as the number of students leaving university after the 1st year or the number of students who enroll in the 2nd year having acquired a certain amount of credits. In other words, the transition between the 1st and the 2nd year has been considered as the main checkpoint to evaluate the regularity of the educational path.

The third output considered in the number of total inactive students, meaning those who did not take any exam (INACT_STU). We, again, consider this measure as an undesirable output.

Moving to desirable outputs, according to Catalano et al. (1993) "the task assigned to universities is to produce graduates with the utilization and the combination of different resources" and Madden et al. (1997) used the number of graduates under the hypothesis that the higher is the number of graduates the higher is the quality of teaching[18]. Also Worthington and Lee (2008) considered the number of undergraduate degrees awarded an obvious measure of output for any university. Thus, the fourth output is the number of graduates weighted by their degree classification (GRAD_MARKS)[19], in order to

[17] This choice is due to the fact that, according to the National Committee for the Evaluation of the University System (CNVSU) guidelines, among the weaknesses of the Italian higher education system there is also the high number of inactive students, meaning those students who do not pass any exam or acquire any credit during the 1st year.

[18] The liability of this measure is still not clear in the literature. See Kao and Hung (2008) and Abbott and Doucouliagos (2003) for a discussion.

[19] In order to weight the graduates according to their degree marks, we apply the following procedure: GRAD_MARKS =1* graduates with marks between 106 and 110 with distinction +0.75*graduates with marks between 101 and 105 + 0.5*graduates with marks between

capture both the quantity and the quality of teaching[20]. The last output choice reflects what the National Committee for the Evaluation of the University System (CNVSU) guidelines consider a weakness of the Italian higher education system, such as the increasing length of time to get the degree (CNVSU, 2011). Thus, the fifth output is the number of graduates weighted by their age at the time of the graduation (GRAD_TIME)[21].

3.3. Specification of the models

To reveal whether the results are sensitive to the specification of the outputs used in the analysis, we implement different models as summarized, below, by Table 1.

In the benchmark model (Table 1, Model 1), the number of professors (PROF), the number of enrolments with a score higher than 9/10 in secondary school (ENR_HSG), the number of enrolments who attended a lyceum (ENR_LYC) and the total number of students (STUD) are used as inputs, while the number of enrolments who drop out at the end of the 1st year (DROU) and the number of graduates weighted by their degree classification (GRAD_MARKS) are used as outputs. Keeping constant the input side, we then explore whether the number of enrolments who did not take any exam at the end of the 1st year (INACT_ENR) and the number of total students who did not take any exams (INACT_STU) might be considered as a good proxy for the dropout phenomenon (see Table 1, Models 2 and 3). Furthermore, we replicate the analysis performed in Models 1, 2 and 3, as above mentioned, but instead of using the number of graduates weighted by their degree marks (GRAD_MARKS), we use the number of graduates weighted by the time to get the degree (GRAD_TIME), as one of the outputs (see Table 1, Models 4, 5 and 6). In this way we are able to explore whether a different weight given to the number of graduates might affect the results.

In estimating our models, we rely on two packages based on the freeware R (FEAR 1.13, Benchmarking 0.18).

Table 1– Specification of outputs and inputs

Models	*Inputs*	*Outputs*
Model 1	*PROF; ENR_HSG;ENR_ LYC; STUD*	*DROU; GRAD_MARKS*
Model 2	*PROF; ENR_HSG;ENR_ LYC; STUD*	*INACT_ENR; GRAD_MARKS*
Model 3	*PROF; ENR_HSG;ENR_ LYC; STUD*	*INACT_STUD; GRAD_MARKS*
Model 4	*PROF; ENR_HSG;ENR_ LYC; STUD*	*DROU; GRAD_TIME*
Model 5	*PROF; ENR_HSG;ENR_ LYC; STUD*	*INACT_ENR; GRAD_TIME*
Model 6	*PROF; ENR_HSG;ENR_ LYC; STUD*	*INACT_STUD; GRAD_TIME*

Notes:
PROF: Number of professors
ENR_HSG: Number of enrolments with a score higher than 9/10 in secondary school
ENR_ LYC: Number of enrolments who attended a lyceum
STUD: Total number of students
DROU: Number of enrolments who drop out at the end of the 1st year
INACT_ENR: Number of inactive enrolments at the end of the 1st year
INACT_STUD: Number of inactive students
GRAD_MARKS: Number of graduates weighted by their degree classification
GRAD_TIME: Number of graduates weighted by the time to get the degree

91 and 100+0.25*graduates with marks between 66 and 90. The weights have been chosen so that the distance between two ranks is $1/4 = 0.25$.

[20] We've also used, for robustness check, just the number of graduates without weighting by their degree classification and the results are similar.

[21] In order to weight the graduates according to their degree marks, we apply the following procedure: GRAD_TIME =1*graduates with age <23 years+0.75*graduates with age of 23 or 24 years +0.5*graduates with age of 25 or 26 years + 0.25*graduates with age >26 years. The weights have been chosen so that the distance between two ranks is $1/4 = 0.25$.

4. Data

The dataset refers to 72 Italian universities (61 of them are public and 11 are private) from academic year 2003/2004 to 2007/2008[22] and it has been constructed using data which are publicly available on the National Committee for the Evaluation of the University System (CNVSU) website[23].

From the descriptive statistics (see Table 2, below), it is interesting to notice that, considering the four geographical areas in which we have aggregated the universities, the Southern area is characterized by the highest number, on average, of enrolments with a score higher than 9/10 in high school and enrolments who attended a lyceum.

Despite that, the universities of the Southern regions show the highest number of enrolments who drop out and of both inactive enrolments and inactive students. Still considering the performances by geographical areas, on average, the North-Western and the North-Eastern areas perform slightly better than other areas if we consider the number of graduates weighted by their degree marks. More stable across the areas is the performance indicator based on the number of graduates weighted by the time to get the degree.

Turning to the bad outputs, the North-Western area perform better than other areas, while the Southern area, instead, have the worst performances. If we separate the performances between private and public universities, on average over the time span considered in the analysis, private owned universities seem to be more virtuous according to the bad output indicators.

Table 2– Definition of the variables and descriptive statistics – Mean values by geographical areas and by ownership

		Mean values					
		North-Western	*North-Eastern*	*Central*	*Southern*	*Public*	*Private*
Inputs							
PROF	*# of professors*	790.51	970.5	875.65	766.54	948.85	193.65
		(741.63)	(845.36)	(1147.59)	(732.90)	(886.74)	(398.36)
ENR_HSG	*# of enrolments with a score higher than 9/10 in secondary school*	1836.01	1883.86	1932.83	1976.44	2120.80	786.52
		(1564.62)	(1927.17)	(2421.05)	(1984.80)	(2066.48)	(1008.02)
ENR_ LYC	*# of enrolments who attended a lyceum*	1094.91	1304.28	1097.24	1349.21	1349.75	491.89
		(866.51)	(1281.74)	(1048.23)	(1278.59)	(1162.60)	(616.34)
STUD	*Total number of students*	21922.85	26244.7	25575.98	26287.84	28120.14	8169.09
		(18388.58)	(25110.15)	(30835.39)	(22150.01)	(24850.52)	(10466.29)
Good Output							
GRAD_MARKS	*# of graduates weighted by their degree classification*	2566.32	2800.01	2094.63	1646.77	2342.73	1199.38
		(2079.30)	(2800.69)	(2336.90)	(145457)	(2189.07)	(1543.03)
GRAD_TIME	*# of graduates weighted by the time to get the degree*	2355.10	2825.88	2634.83	2182.79	2679.39	1136.47
		(2009.82)	(2676.62)	(2976.03)	(1912.18)	(2429.34)	(1489.69)
Bad Output							
DROU	*# of enrolments who drop out at the end of the 1st year*	546.12	855.31	867.55	1131.75	1010.75	163.81
		(556.23)	(1028.61)	(1102.54)	(1165.05)	(1067.87)	(204.98)
INACT_ENR	*# of inactive enrolments at the end of the 1st year*	514.57	628.56	885.21	1144.09	969.12	155.49
		(519.99)	(746.91)	(1327.23)	(1773.72)	(1394.49)	(269.82)
INACT_STUD	*# of inactive students*	3396.365	4545.91	5594	5683.93	5718.16	571.36
		(3713.55)	(5010.63)	(8297.16)	(6292.20)	(6474.71)	(562.50)

Note: Authors calculation on data collected by the Italian Ministry of Education, Universities and Research Statistical Office

[22] The dataset originally contained data on 81 universities. Nine universities are excluded from our analysis because of incomplete data. This leaves us with a sample of 72 universities.

[23] Specifically, data have been collected by the Italian Ministry of Education, Universities and Research Statistical Office.

5. The Empirical Evidence

5.1. Variable return to scale versus constant return to scale efficiency scores

As suggested by Portela et al. (2004), “in the presence of negative data variable return to scale (VRS) technologies need to be assumed”. Thus, in this paper we focus on technical efficiency using a directional distance method assuming VRS. For robustness, we have also estimated a constant return to scale (CRS) model and to provide a more accurate indication on these differences, we perform a Kruskal-Wallis test for each year (see Table 3, below) which suggests to reject the null hypothesis[24] that the sample means of the efficiency scores by models (VCR vs CRS) are the same. Then, we prefer and report the VRS efficiency scores estimates. Moreover, the VRS is probably the most reliable in our case as suggested by Agasisti (2011) who argued that the assumption of constant return to scale is restrictive because it is reasonable “that the dimension (number of students, amount of resources, etc.) plays a major role in affecting the efficiency” especially if we consider, as we do, the DMUs trying to achieve pre-determinate outputs, given certain inputs. Efficiency estimates have been obtained through an output oriented model, following Agasisti and Dal Bianco (2009) who claimed that “as Italian universities are increasingly concerned with reducing the length of studies, and improving the number of graduates, in order to compete for public resources, the output-oriented model appears the most suitable to analyse higher education teaching efficiency”.

5.2. Directional distance function results by geographical areas and by ownership

A directional distance function approach has been applied to Models 1-6 (see Table 1 for details) in order to estimate technical efficiency of 72 Italian universities using data from academic year 2003/2004 to 2007/2008. The efficiency estimates are presented in Table 4 (results are displayed by geographical areas such as North-Western, North-Eastern, Central and Southern areas and by type of ownership such as public and private).

Starting from the baseline model (see Table 4, Model 1) where PROF, ENR_HSG, ENR_LYC and STUD are used as inputs, while DROU and GRAD_MARKS are used as outputs, it is clearly evident that the private sector is more efficient than the public sector.

Table 3 - Kruskal-Wallis test. Variable return to scale versus constant return to scale efficiency scores

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
2003/2004	*0.0217*	*0.0010*	*0.0021*	*0.0515*	*0.0403*	*0.0000*
2004/2005	*0.0007*	*0.0002*	*0.0000*	*0.0087*	*0.0147*	*0.0000*
2005/2006	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0014*	*0.0000*
2006/2007	*0.0000*	*0.0000*	*0.0000*	*0.0004*	*0.0006*	*0.0000*
2007/2008	*0.0000*	*0.0000*	*0.0000*	*0.0004*	*0.0109*	*0.0000*

[24] The following hypotheses has been tested: $H_0: \theta_{VRS} = \theta_{CRS};\ H_1: \theta_{VRS} \neq \theta_{CRS}$.

Table 4- Technical Efficiency – Directional distance efficiency scores by geographical areas and by ownership

			Model 1					Model 2					Model 3		
	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Geographical areas															
North-Western	0.8023	0.6937	0.7188	0.7875	0.7879	0.7562	0.7041	0.7468	0.7902	0.7716	0.7831	0.8004	0.8219	0.8526	0.8199
North-Eastern	0.7718	0.7124	0.7222	0.7277	0.7310	0.7928	0.7168	0.7145	0.7630	0.7227	0.8201	0.8337	0.8024	0.8440	0.7956
Central	0.8013	0.7618	0.7632	0.7973	0.7937	0.7434	0.7435	0.7565	0.7938	0.7735	0.8374	0.8484	0.8629	0.8748	0.8545
Southern	0.5494	0.5096	0.5348	0.6287	0.6193	0.5075	0.5331	0.5303	0.6179	0.5818	0.6254	0.6586	0.6905	0.7553	0.7106
Ownership															
Public	0.6567	0.6098	0.6117	0.6829	0.6799	0.6175	0.6074	0.6151	0.6867	0.6576	0.7114	0.7348	0.7477	0.7949	0.7546
Private	1.0000	0.8724	0.9711	0.9574	0.9510	0.9793	0.9302	0.9655	0.9486	0.9224	0.9517	0.9568	0.9873	0.9779	0.9700
			Model 4					Model 5					Model 6		
	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008
Geographical areas															
North-Western	0.7573	0.6710	0.7326	0.7557	0.7986	0.6824	0.6761	0.7137	0.7437	0.7280	0.8067	0.8227	0.8355	0.8616	0.8344
North-Eastern	0.6994	0.6228	0.7338	0.6620	0.7100	0.7162	0.6060	0.7008	0.6820	0.6326	0.8023	0.7608	0.8000	0.7993	0.7424
Central	0.6634	0.5626	0.6770	0.6941	0.7184	0.5858	0.5261	0.6587	0.6837	0.6684	0.7352	0.6807	0.7775	0.7685	0.7570
Southern	0.4292	0.3431	0.4402	0.4688	0.4981	0.3837	0.3647	0.4126	0.4589	0.4309	0.5029	0.4769	0.5630	0.6097	0.5529
Ownership															
Public	0.5497	0.4686	0.5695	0.5704	0.6107	0.5010	0.4625	0.5412	0.5685	0.5434	0.6427	0.6114	0.6770	0.7039	0.6584
Private	0.9458	0.8184	0.8827	0.9285	0.9295	0.8883	0.8311	0.8818	0.9022	0.8746	0.9038	0.9191	0.9614	0.9432	0.9435

Table 5 - Kruskal-Wallis test. Sample means comparison of the efficiency scores among all the models

	Model 2 vs Model 1	Model 3 vs Model 1	Model 5 vs Model 4	Model 6 vs Model 4	Model 4 vs Model 1	Model 5 vs Model 2	Model 6 vs Model 3
2003/2004	0.2786	0.2754	0.2887	0.0129	0.0079	0.0165	0.1490
2004/2005	0.8754	0.0087	0.9489	0.0000	0.0035	0.0013	0.0057
2005/2006	0.9021	0.0018	0.3591	0.0028	0.2525	0.0332	0.0907
2006/2007	0.9325	0.0201	0.8820	0.0005	0.0068	0.0082	0.0108
2007/2008	0.5259	0.0722	0.0465	0.1253	0.1215	0.0039	0.0115

The estimates also reveal the presence of some geographical effects (by macro-areas) with institutions in the Central-North area (North-Western, North-Eastern and Central) outperforming those in the Southern area[25]. This evidence is confirmed by the Kruskal-Wallis test which clearly leads to reject the null hypothesis that the sample means of the efficiency scores between the Central-North regions and the Southern regions of Italy are the same. The test also shows that the sample means of the efficiency scores of the private sector are statistically different from the public sector[26].

We then use INACTIVE_ENR and INACTIVE_STU in order to measure the dropout phenomenon through two alternative measures (respectively Models 2 and 3, in Table 4). The empirical evidence of Model 1 is generally confirmed by both Models 2 and 3 (with a slightly increase in the efficiency estimates in Model 3) where the Southern area is less efficient than the other areas and the private sector still outperforms the public one[27]. The use of different models allows us to analyse whether the results obtained are sensitive to the change in the output specification. In order to have a closer look at these differences formally, we again make use of the Kruskal-Wallis test. The estimates (see Table 5, above) show that the sample means of the efficiency scores of model 1 are not statistically different from Model 2. As the two models differ only from the use of DROU (Model 1) and INACT_ENR (Model 2), this suggest that the number of enrolments that did not take any exam at the end of the 1st year (INACT_ENR) might be a good proxy of the students who do not renew the enrolment in the 2nd year (DROU). The test shows, instead, that the sample means of the efficiency scores obtained in Model 3 differ from those obtained in Model 1, suggesting that the number of total students who do not take any exam (INACTIVE_STU) reflects a broader picture of the dropout phenomenon (i.e. not restricted between the 1st and the 2nd year)[28].

The results seem to be, instead, more qualitatively sensitive to the combination of outputs used in Models 4, 5 and 6 (see Table 1 for details on the models) when we basically repeat the same analysis of Models 1, 2 and 3 but instead of using GRAD_MARKS as one of the outputs, we use GRAD_TIME. Now (see Table 4), the North-Western area more remarkably outperforms all other areas (being also confirmed that the Southern area is the less efficient). Moreover, the results could be extended to the entire Northern area as also the North-Eastern area is more efficient than the Central and the Southern areas in most of the years considered. Finally, the private sector still maintains a higher efficiency level than the public sector. We again use the Kruskal-Wallis test in order to gain more information behind these differences. First of all the results of the test confirm the differences previously commented both by geographical areas and by ownership of the institutions[29]. Moreover, when we compare Model 4 vs Model 1, Model 5 vs Model 2 and finally Model 6 vs Model 3, the estimates show that the sample means of the efficiency scores among models are statistically different (see Table 5). This suggests that measuring the performances of the universities by taking into account, separately, the number of graduates weighted by their degree marks and the number of graduates weighted by the time to get the degree is probably not enough. A measure which takes into account both would be probably a more complete outcome.

Figure 1 below, instead, graphically summarizes the results obtained grouping the universities according to the different regions in which they are located.

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[25] Specifically, on average and among those in the Central-North area, there is evidence that the North-Western and the Central areas slightly outperform the North-Eastern area, especially for the first three models.

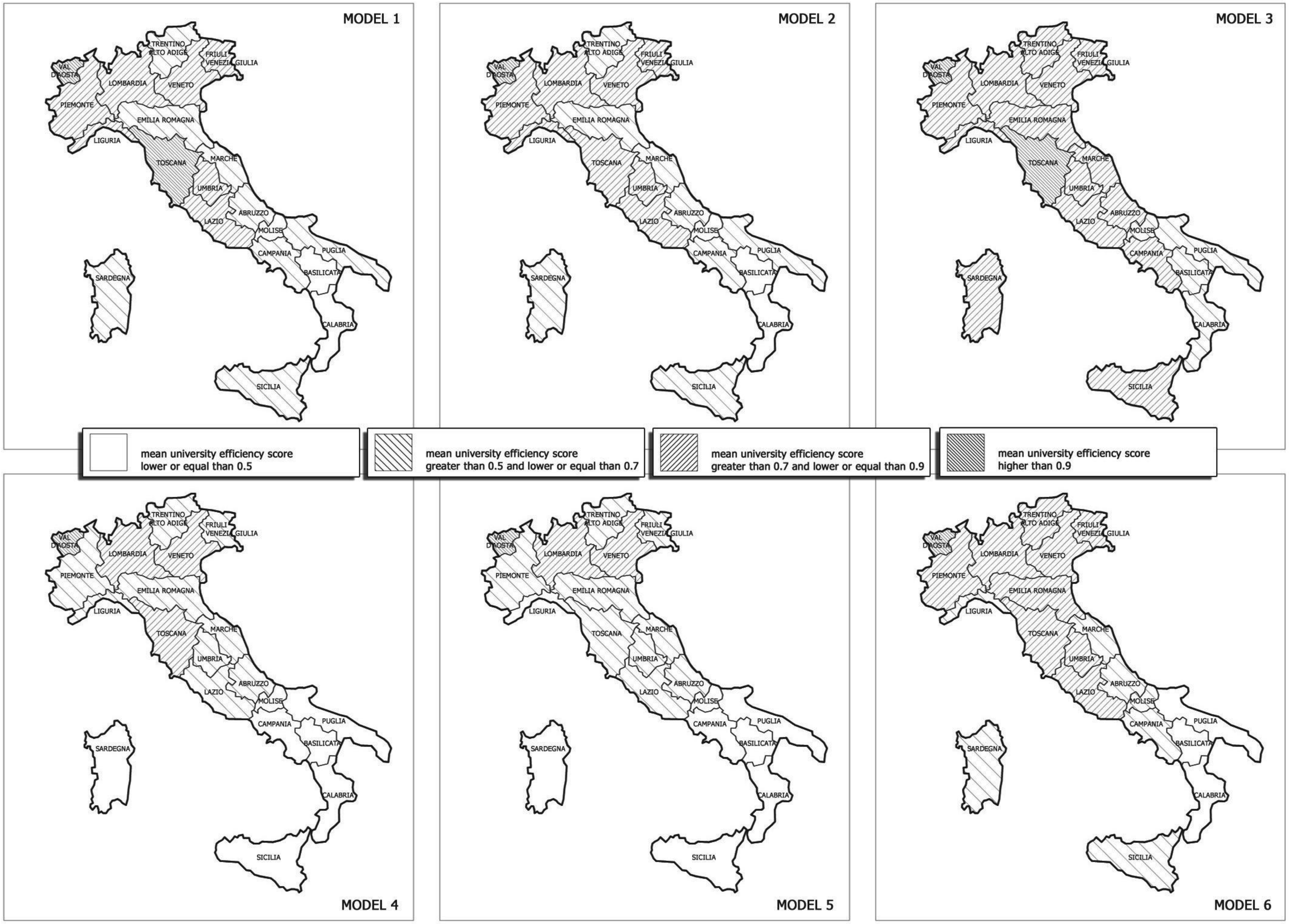
[26] For the sake of brevity the results of these tests are not presented in the paper and are available on request.

[27] Again the Kruskal-Wallis test (not presented in the paper and available on request) shows that the sample mean of the efficiency scores of the Southern area is statistically different from the other areas and also that the sample mean of the efficiency scores of the private sector is statistically different from the public sector.

[28] The same conclusion might be deduced by comparing Model 5 vs Model 4 and Model 6 vs Model 4.

[29] For the sake of brevity the results of these tests are not presented in the paper and are available on request.

Figure 1 - Technical Efficiency – Directional distance efficiency scores by regions



We divide the regions in 4 groups as follow: low (mean university efficiency score lower or equal than 0.5), medium (mean university efficiency score greater than 0.5 and lower or equal than 0.7), medium-high (mean university efficiency score higher than 0.7 and lower or equal than 0.9) and high (mean university efficiency score higher than 0.9). Considering the estimates obtained in Model 1, our benchmark model, Basilicata, Calabria and Molise have low efficiency scores, Trentino Alto Adige, Emilia Romagna, Marche, Abruzzo, Campania, Puglia, Sicilia and Sardegna have medium efficiency scores, Piemonte, Lombardia, Veneto, Friuli Venezia Giulia, Umbria and Lazio have medium-high efficiency scores and finally only two regions, Val d'Aosta and Toscana have very high performances. Interestingly, according to Model 3, none of the regions perform lower than 0.5, while according to Models 4, 5 and 6 almost all the Southern regions perform very low (lower than 0.5). On the other hand the regions from the Northen Italy constantly perform (almost in all models) quite well (between 0.7 and 0.9).

5.3. Directional distance function results for each university

Table 6, below, summarizes the efficiency estimates for each university in the sample. The mean efficiency of all universities, considering Model 1, is 0.6943 with around 47% of the universities having a level of efficiency over the sample mean. As we have already pointed out before, private universities perform better than public ones (all the private universities have a level of efficiency over the sample mean) and the universities located in the Central-North area perform better than those in the Southern area (80% of the universities with a level of efficiency over the sample mean are located in the Central-North area).

Three of the most important private institutions such as Milano Bocconi, Milano Cattolica and Roma LUISS are very efficient in almost all the models. Among the public institutions, Bologna, Roma La Sapienza, Milano Politecnico, Padova, Torino, Chieti e Pescara, Siena and Milano do perform particularly well. Keeping the attention on the public institutions, interestingly, Bari, Cagliari, Catania, Firenze, Genova, Palermo, Roma Tor Vergata and Roma Tre perform better when GRAD_MARKS (along with DROU, INACT_ENR and INACT_STU) instead of GRAD_TIME is used as output. This result could be explained again by the fact that (as we have already underlined before) separately weighting graduates by their degree marks and by the time to get the degree is not as informative as could be weighing for both. Moreover, it also suggests that in some universities students get the degree with good grades, but later in time.

Still taking into account the geographical effects, some information could be gained also when we consider the big city areas where the many universities are located. For instance, the Rome area (where Roma IUSM, Roma LUISS, Roma LUMSA, Roma La Sapienza, Roma Tor Vergata and Roma Tre are located), is particularly efficient with an average efficiency of 0.8924 among all the years and considering Model 1. The Milan area (where Milano, Milano Bicocca, Milano Bocconi, Milano Cattolica, Milano IULM, Milano Politecnico and Milano San Raffaele are located) also shows good performances with an average of 0.8481 among all the years and considering Model 1. Finally the Naples area (where Napoli Benincasa, Napoli Federico II, Napoli II, Napoli L'Orientale and Napoli Parthenope are located), shows lower performances with an average of 0.6487 among all the years and considering Model 1.

Table 6 - Technical Efficiency – Directional distance efficiency scores by university

		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1	Aosta	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	Bari	0.8682	0.8005	0.8670	0.5911	0.4423	0.6389
3	Bari Politecnico	0.3961	0.3965	0.5139	0.3347	0.3510	0.3322
4	Basilicata	0.3928	0.3673	0.5531	0.3154	0.3024	0.3777
5	Bergamo	0.4977	0.4905	0.6970	0.6134	0.5911	0.7475
6	Bologna	0.9933	1.0000	0.9975	1.0000	1.0000	1.0000
7	Bolzano	0.8626	0.8890	0.9290	0.8676	0.9304	0.9320
8	Brescia	0.4221	0.4053	0.5293	0.4420	0.4250	0.5769
9	Cagliari	0.7281	0.7303	0.7994	0.4395	0.4113	0.6044
10	Calabria	0.6079	0.5938	0.7318	0.4549	0.4192	0.6336
11	Camerino	0.3479	0.3261	0.5869	0.3081	0.2938	0.4759
12	Casamassima - J.Monnet	0.8947	0.9803	0.9086	0.8809	0.9823	0.9186
13	Cassino	0.4539	0.4316	0.7134	0.4230	0.3961	0.6498
14	Castellanza LIUC	1.0000	1.0000	0.9809	1.0000	1.0000	0.9633
15	Catania	0.5736	0.6166	0.7279	0.3972	0.3823	0.4886
16	Catanzaro	0.3547	0.3264	0.5065	0.3449	0.3144	0.4763
17	Chieti e Pescara	0.9833	0.9742	0.9857	0.8979	0.7958	0.9117
18	Ferrara	0.5291	0.5251	0.6532	0.4905	0.4492	0.5880
19	Firenze	0.9140	0.8957	0.8963	0.5929	0.5605	0.6699
20	Foggia	0.3128	0.3570	0.4846	0.2419	0.3604	0.3287
21	Genova	0.7692	0.7713	0.7937	0.5453	0.4806	0.6639
22	Insubria	0.4667	0.4572	0.6101	0.4801	0.4642	0.6017
23	Lecce	0.5291	0.5170	0.7242	0.2992	0.2640	0.5197
24	L'Aquila	0.5930	0.5882	0.6857	0.4584	0.4248	0.4572
25	Macerata	0.6708	0.6550	0.8544	0.5064	0.4896	0.7149
26	Marche	0.5165	0.5611	0.6754	0.4354	0.4871	0.5100
27	Messina	0.5028	0.5287	0.7079	0.3357	0.3273	0.5106
28	Milano	0.7404	0.7368	0.8226	0.6212	0.5873	0.8034
29	Milano Bicocca	0.6837	0.6047	0.7481	0.7006	0.5654	0.7890
30	Milano Bocconi	1.0000	1.0000	0.9842	1.0000	1.0000	0.9886
31	Milano Cattolica	1.0000	0.9755	1.0000	0.8619	0.7195	1.0000
32	Milano IULM	0.9360	0.8992	0.9631	1.0000	1.0000	1.0000
33	Milano Politecnico	0.7256	0.7645	0.6941	1.0000	1.0000	1.0000
34	Milano San Raffaele	0.8512	0.9043	1.0000	0.8527	0.9012	1.0000
35	Modena e Reggio Emilia	0.5990	0.5635	0.7093	0.6443	0.5537	0.7460
36	Molise	0.4273	0.3985	0.6532	0.3943	0.3708	0.5597
37	Napoli Benincasa	1.0000	1.0000	1.0000	0.6125	0.5938	0.7957
38	Napoli Federico II	0.7545	0.7202	0.8277	0.5474	0.5440	0.6789
39	Napoli II	0.6253	0.5385	0.6177	0.5240	0.4102	0.5702
40	Napoli L'Orientale	0.5223	0.5088	0.7056	0.4048	0.4029	0.4939
41	Napoli Parthenope	0.3417	0.3329	0.5373	0.2951	0.2944	0.4587
42	Padova	0.9865	0.9969	0.9819	0.9822	0.9803	1.0000
43	Palermo	0.6907	0.6801	0.8126	0.3859	0.3639	0.5781
44	Parma	0.5750	0.5768	0.6892	0.4799	0.4572	0.6385
45	Pavia	0.7721	0.8025	0.7646	0.6064	0.5464	0.7439
46	Perugia	0.6325	0.6105	0.7383	0.4834	0.4304	0.6474
47	Perugia Stranieri	0.9368	0.9227	0.9542	0.8648	0.8493	0.8656
48	Piemonte Orientale	0.5233	0.4409	0.6305	0.5801	0.4733	0.6587
49	Pisa	0.8132	0.7209	0.8471	0.5701	0.4723	0.6928
50	Reggio Calabria	0.3484	0.3057	0.5017	0.2787	0.2493	0.3468
51	Roma IUSM	0.9669	1.0000	0.9613	0.9676	1.0000	0.9515
52	Roma LUISS	1.0000	0.8984	0.9655	0.9024	0.6231	0.7599
53	Roma LUMSA	0.9101	0.8946	0.9249	0.9330	0.8814	0.9186
54	Roma La Sapienza	1.0000	1.0000	1.0000	0.9809	0.9766	0.9895
55	Roma Tor Vergata	0.7028	0.7305	0.8394	0.4184	0.4104	0.5954
56	Roma Tre	0.7750	0.7146	0.8180	0.4201	0.4105	0.5878
57	Salerno	0.5308	0.4916	0.6833	0.3760	0.3365	0.5017
58	Sannio	0.3690	0.2983	0.3847	0.3302	0.2606	0.2743
59	Sassari	0.4504	0.4123	0.6376	0.3395	0.2880	0.4655
60	Siena	0.9844	0.9313	0.9643	0.8531	0.7650	0.8623
61	Siena Stranieri	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
62	Teramo	0.4087	0.3894	0.6436	0.4165	0.4103	0.6049
63	Torino	0.9071	0.9522	0.9247	0.7872	0.7896	0.8690
64	Torino Politecnico	0.5920	0.6091	0.7220	0.5410	0.5059	0.7417
65	Trento	0.5023	0.4738	0.6440	0.4646	0.4358	0.6069
66	Trieste	0.9666	0.9761	0.9511	0.6480	0.5648	0.7707
67	Tuscia	0.4801	0.4273	0.6911	05168	0.4539	0.6681
68	Udine	0.5152	0.5248	0.7168	0.5018	0.4659	0.6950
69	Urbino Carlo Bo	0.9971	0.9980	0.9988	0.7595	0.7417	0.8918
70	Venezia Cà Foscari	0.6905	0.7519	0.8617	0.6775	0.6717	0.8465
71	Venezia Iuav	1.0000	1.0000	0.9769	0.9512	0.9546	0.8598
72	Verona	0.5763	0.6256	0.7192	0.5198	0.5466	0.6888

6. Sensitivity analysis

In order to take into account the possible evidence of variation in the universities' performances by subject of study, for robustness check, we replicate the analysis performed so far using only the Faculties of Economics. The basic idea is to check whether the results are still consistent comparing universities within subject rather than across subjects (i.e. faculties). We again focus the attention on technical efficiency using a VRS method, according to the Kruskal-Wallis test results which suggest to reject the null hypothesis that the sample means of the efficiency scores by models (VRS vs CRS) are the same (see Table 7 below) and along with same motivation already discussed in section 5.1.

The results (see Table 8, below) confirm that the private sector is more efficient then the public sector in all Models (thus independently from the specification of the outputs used). Moreover, the empirical evidence also supports the presence of some regional effects with the Southern area being still less efficient than the other areas. Interestingly, when we consider only the Faculties of Economics, the North-Eastern and the Central areas outperform the North-Western area in Models 1, 2 and 3. It is also confirmed that, switching to Models 4, 5 and 6 (when GRAD_TIME instead of GRAD_MARKS is used as one of the outputs), the North-Western and the North-Eastern areas outperform the Central and the Southern areas. Again, the use of different models allows us to analyse whether the results obtained are sensitive to the change in the output specification. The estimates as well as the Kruskal-Wallis test (see Tables 8 and 9 below), confirm, in most of the years, that the number of enrolments that did not take any exam at the end of the 1st year (INACT_ENR) might be a good proxy of the students who did not renew the enrolment in the 2nd year (DROU). Moreover it is also confirmed that measuring the universities' performances by taking into account, separately, the number of graduates weighted by their degree marks and the number of graduates weighted by the time to get the degree leads to different results, suggesting that a measure which takes into account both the quality of the graduates and the time to get the degree would be probably a preferred outcome.

Figure 2, below, graphically summarizes the results obtained grouping the universities according to the different regions in which they are located[30]. Interestingly, according to the first three models none of the regions perform lower than 0.5 (most of the regions have instead the efficiency score greater than 0.7 and lower or equal than 0.9) while according to the last three models almost all the Southern regions perform very low (lower than 0.5).

Finally, Table 10, below, summarizes the estimates for each university in the sample. Confirming the previous results, among the private universities, Milano Bocconi, Milano Cattolica and Roma LUISS still perform very well. Among the public institutions, instead, the university of Bologna, Padova, Parma, Tuscia and Venezia are particularly efficient. The estimates still show that there are some universities (Bari, Cassino, Firenze, Lecce, L'Aquila, Macerata, Marche, Messina and Roma La Sapienza) performing particularly well in the first three models (when GRAD_MARKS, DROU, INACT_ENR and INACT_STUD have been used as outputs) while their efficiency estimates decrease substantially in Models 4, 5, and 6 (where GRAD_TIME, DROU, INACT_ENR and INACT_STUD have been used as outputs). Again, it seems that some universities perform better if the quality of the graduates is taken into account instead of the time is which the graduation is obtained.

Table 7 - Kruskal-Wallis test. Variable return to scale versus constant return to scale efficiency scores (only Faculty of Economics)

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
2003/2004	*0.0441*	*0.0950*	*0.0413*	*0.0714*	*0.2574*	*0.0931*
2004/2005	*0.0091*	*0.0812*	*0.0007*	*0.1555*	*0.6400*	*0.0890*
2005/2006	*0.0000*	*0.0021*	*0.0000*	*0.0164*	*0.1312*	*0.0081*
2006/2007	*0.0014*	*0.0037*	*0.0000*	*0.1458*	*0.0590*	*0.0014*
2007/2008	*0.0000*	*0.0015*	*0.0000*	*0.0065*	*0.2384*	*0.0000*

[30] We again divide the regions in 4 groups as follow: low (mean university efficiency score lower or equal than 0.5), medium (mean university efficiency score greater than 0.5 and lower or equal than 0.7), medium-high (mean university efficiency score higher than 0.7 and lower or equal than 0.9) and high (mean university efficiency score higher than 0.9).

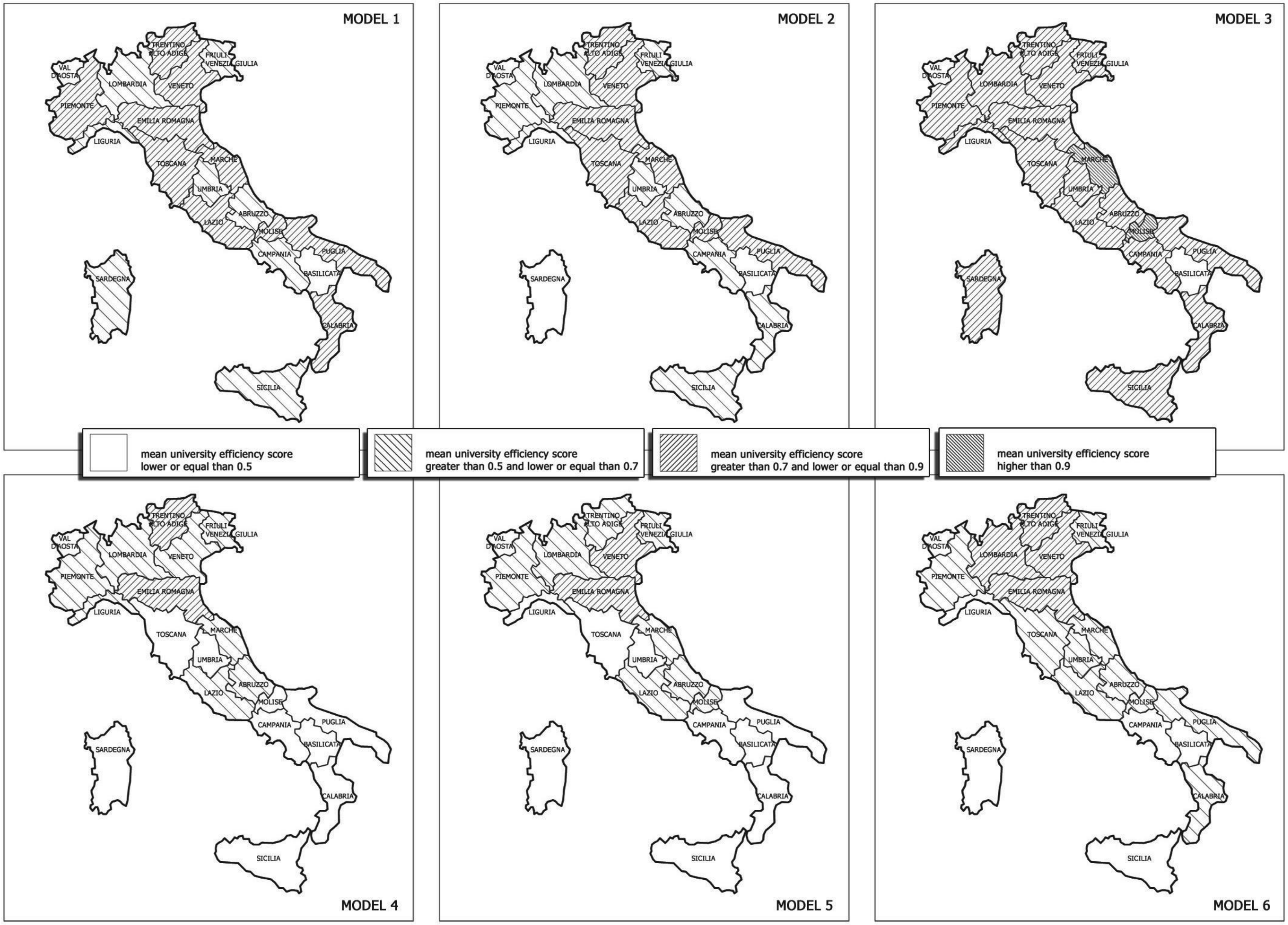
Table 8 - Technical Efficiency – Directional distance efficiency scores by geographical areas and by ownership (only Faculty of Economics)

	Model 1					*Model 2*					***Model 3***				
	2003/2004	*2004/2005*	*2005/2006*	*2006/2007*	*2007/2008*	*2003/2004*	*2004/2005*	*2005/2006*	*2006/2007*	*2007/2008*	*2003/2004*	*2004/2005*	*2005/2006*	*2006/2007*	*2007/2008*
Geographical areas															
North-Western	*0.7603*	*0.6732*	*0.6911*	*0.6524*	*0.6410*	*0.7422*	*0.5957*	*0.6588*	*0.6440*	*0.6325*	*0.8687*	*0.7685*	*0.8122*	*0.7648*	*0.7513*
North-Eastern	*0.8669*	*0.8252*	*0.7099*	*0.7525*	*0.6306*	*0.8757*	*0.7220*	*0.6742*	*0.6734*	*0.6279*	*0.9142*	*0.8070*	*0.8055*	*0.7592*	*0.7335*
Central	*0.8677*	*0.7772*	*0.7992*	*0.8237*	*0.6751*	*0.8497*	*0.6911*	*0.7922*	*0.8305*	*0.6167*	*0.9166*	*0.8280*	*0.8610*	*0.8868*	*0.8027*
Southern	*0.6726*	*0.6043*	*0.5950*	*0.6477*	*0.5520*	*0.6452*	*0.5150*	*0.5598*	*0.6661*	*0.5180*	*0.8023*	*0.6892*	*0.7580*	*0.8070*	*0.706*
Ownership															
Public	*0.7620*	*0.6709*	*0.6452*	*0.6733*	*0.5694*	*0.7500*	*0.5808*	*0.6148*	*0.6779*	*0.5424*	*0.8531*	*0.7348*	*0.7798*	*0.7937*	*0.7196*
Private	*0.9121*	*0.9582*	*0.9980*	*1.0000*	*0.9449*	*0.9122*	*0.9083*	*0.9942*	*0.9023*	*0.9524*	*0.9794*	*0.9940*	*0.9970*	*0.9193*	*0.9599*
	Model 4					*Model 5*					***Model 6***				
	2003/2004	*2004/2005*	*2005/2006*	*2006/2007*	*2007/2008*	*2003/2004*	*2004/2005*	*2005/2006*	*2006/2007*	*2007/2008*	*2003/2004*	*2004/2005*	*2005/2006*	*2006/2007*	*2007/2008*
Geographical areas															
North-Western	*0.6712*	*0.6100*	*0.6532*	*0.6367*	*0.6300*	*0.6405*	*0.5409*	*0.6311*	*0.5817*	*0.6010*	*0.7500*	*0.6167*	*0.7382*	*0.6756*	*0.6763*
North-Eastern	*0.7604*	*0.7542*	*0.7167*	*0.7775*	*0.6318*	*0.7885*	*0.6422*	*0.7061*	*0.6783*	*0.6286*	*0.7899*	*0.6763*	*0.7834*	*0.6905*	*0.6766*
Central	*0.5243*	*0.5385*	*0.5548*	*0.6168*	*0.5914*	*0.5373*	*0.4546*	*0.5251*	*0.5399*	*0.5044*	*0.6523*	*0.5615*	*0.6357*	*0.6479*	*0.5762*
Southern	*0.3722*	*0.3766*	*0.4584*	*0.4915*	*0.4288*	*0.3343*	*0.3245*	*0.4164*	*0.4650*	*0.4054*	*0.5124*	*0.3933*	*0.5696*	*0.5494*	*0.4965*
Ownership															
Public	*0.5061*	*0.4803*	*0.5207*	*0.5576*	*0.4972*	*0.5098*	*0.4223*	*0.4985*	*0.5203*	*0.4598*	*0.6149*	*0.4868*	*0.6264*	*0.5968*	*0.5394*
Private	*0.9125*	*0.9642*	*0.9448*	*0.9762*	*0.9299*	*0.8853*	*0.8192*	*0.9291*	*0.7986*	*0.9614*	*0.9572*	*0.9535*	*0.9688*	*0.8815*	*0.9333*

Table 9 - Kruskal-Wallis test. Sample means comparison of the efficiency scores among all the models (only Faculty of Economics)

	Model 2 vs Model 1	*Model 3 vs Model 1*	*Model 5 vs Model 4*	*Model 6 vs Model 4*	*Model 4 vs Model 1*	*Model 5 vs Model 2*	*Model 6 vs Model 3*
2003/2004	*0.8342*	*0.1195*	*0.9284*	*0.0248*	*0.0000*	*0.0000*	*0.0000*
2004/2005	*0.0553*	*0.2986*	*0.0970*	*0.8321*	*0.0005*	*0.0007*	*0.0000*
2005/2006	*0.3276*	*0.0039*	*0.3294*	*0.0206*	*0.0073*	*0.0157*	*0.0002*
2006/2007	*0.7151*	*0.0242*	*0.1505*	*0.3391*	*0.0101*	*0.0003*	*0.0000*
2007/2008	*0.3853*	*0.0002*	*0.2614*	*0.1840*	*0.0655*	*0.0412*	*0.0000*

Figure 2 - Technical Efficiency – Directional distance efficiency scores by regions (only Faculty of Economics)



Note: Val d'Aosta and Basilicata regions are not represented by any university in the analysis.

Table 10 - Technical Efficiency – Directional distance efficiency scores by university (only Faculty of Economics)

		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1	Bari	0.9717	0.9603	0.9693	0.4343	0.4202	0.6173
2	Bergamo	0.4827	0.4516	0.6416	0.5010	0.4636	0.6048
3	Bologna	0.9641	0.9555	0.9884	0.9484	0.9535	0.9668
4	Bolzano	0.9232	0.8197	0.8481	0.9485	0.8610	0.8599
5	Brescia	0.5432	0.5224	0.6898	0.4966	0.4659	0.5463
6	Cagliari	0.6467	0.5845	0.7918	0.3885	0.3793	0.4972
7	Calabria	0.7060	0.6866	0.8299	0.4661	0.4400	0.5513
8	Casamassima - J.Monnet	0.8986	0.8759	0.9636	0.9511	0.8694	0.9525
9	Cassino	0.7790	0.7434	0.8823	0.4545	0.4131	0.6647
10	Castellanza LIUC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	Catania	0.3966	0.3476	0.6444	0.2873	0.2698	0.3581
12	Chieti e Pescara	0.5663	0.4863	0.7009	0.8398	0.7674	0.8615
13	Ferrara	0.6016	0.5285	0.5922	0.5868	0.5179	0.5333
14	Firenze	0.7110	0.6660	0.8207	0.4529	0.4205	0.5092
15	Foggia	0.5551	0.5776	0.7311	0.2753	0.3340	0.4082
16	Genova	0.6710	0.5899	0.8032	0.5005	0.4270	0.4975
17	Insubria	0.4933	0.4906	0.5907	0.4949	0.4909	0.5295
18	Lecce	0.6716	0.6720	0.8273	0.3360	0.3046	0.5099
19	L'Aquila	0.6093	0.6105	0.7142	0.4829	0.4469	0.3765
20	Macerata	0.8615	0.8265	0.8958	0.5663	0.4945	0.6410
21	Marche	0.8073	0.8322	0.8853	0.5530	0.5561	0.6140
22	Messina	0.82783	0.8298	0.9102	0.3946	0.3332	0.5580
23	Milano Bicocca	0.4454	0.4308	0.6675	0.3773	0.3512	0.50323
24	Milano Bocconi	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	Milano Cattolica	0.9345	0.9004	1.0000	0.9287	0.8042	1.0000
26	Modena e Reggio Emilia	0.7238	0.6429	0.7644	0.7985	0.7455	0.7881
27	Molise	0.8845	0.8621	0.9351	0.6129	0.5787	0.6970
28	Napoli Federico II	0.5495	0.5490	0.7608	0.3328	0.3068	0.4260
29	Napoli II	0.3939	0.3698	0.5605	0.3450	0.3208	0.3435
30	Napoli Parthenope	0.7127	0.6116	0.8127	0.3560	0.3386	0.5005
31	Padova	0.8096	0.7698	0.7639	0.8501	0.8414	0.8098
32	Palermo	0.3712	0.3470	0.6015	0.1922	0.1894	0.3192
33	Parma	0.9416	0.9322	0.9658	0.8599	0.8021	0.8196
34	Pavia	0.6900	0.6526	0.7670	0.6851	0.6351	0.6764
35	Perugia	0.6317	0.5690	0.7751	0.4847	0.4384	0.5615
36	Piemonte Orientale	0.5582	0.4879	0.7020	0.4969	0.4215	0.5503
37	Pisa	0.8869	0.8494	0.9233	0.5352	0.4542	0.6407
38	Roma LUISS	1.0000	1.0000	1.0000	0.8080	0.6681	0.8077
39	Roma La Sapienza	0.8861	0.8730	0.9436	0.4018	0.3936	0.5167
40	Roma San Pio V	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
41	Roma Tor Vergata	0.3361	0.2984	0.4794	0.2844	0.2629	0.3210
42	Roma Tre	0.6043	0.5970	0.7826	0.4038	0.3847	0.4613
43	Salerno	0.4480	0.4014	0.6137	0.3475	0.3068	0.3848
44	Sannio	0.3895	0.3216	0.6060	0.3103	0.2338	0.3540
45	Sassari	0.4593	0.4069	0.6248	0.3066	0.2714	0.3604
46	Siena	0.6983	0.7173	0.8419	0.4146	0.5223	0.5143
47	Torino	0.7017	0.6749	0.8624	0.5614	0.5301	0.6975
48	Trento	0.7241	0.6342	0.8019	0.6147	0.5195	0.6340
49	Trieste	0.6702	0.6585	0.7485	0.6509	0.5734	0.5582
50	Tuscia	0.9252	1.0000	0.9423	0.8888	1.0000	0.9181
51	Udine	0.6499	0.5772	0.7586	0.5726	0.4961	0.6486
52	Urbino Carlo Bo	0.9396	0.8980	0.9554	0.7589	0.6797	0.7366
53	Venezia Cà Foscari	0.7768	0.7903	0.8878	0.7715	0.7712	0.8213
54	Verona	0.5423	0.5521	0.7229	0.4075	0.4956	0.5170

7. Conclusion

This paper applies a DEA methodology in order to analyse the performances (i.e. efficiency) of 72, both public and private, universities in Italy using a panel from academic year 2003/2004 to 2007/2008. Moving from the traditional context according to which DEA assumes non-negativity of inputs and outputs, a directional distance function approach has been used with the aim of assessing efficiency in the presence of negative data. This is mostly due to the need of evaluating the higher education institutions also according to a parameter such as the number of leavers. The problem of interrupted careers in tertiary education has become an increasing concern in OECD countries. Moreover, Italy is a particularly interesting case for our aim, as the transition between the first and the second year has been considered one of the weaknesses of the higher education system, and the universities have started to be funded according to several indicators among which the number of leavers plays an important role. In other words the quality of the education provided by the universities was meant to increase also by reducing the number of students who drop out.

The empirical findings suggest that private universities are more efficient than public universities and that the Central-North area of the country outperforms the Southern area (confirming what has been found by Agasisti and Dal Bianco, 2009). Thus ownership and geographical location seem to explain part of the differences in technical efficiency scores. Several quality and quantity proxies have also been used in order to check whether the estimates are sensible to the output specification. With regard to the dropout phenomenon, the results suggest that using the number of enrolments who do not renew the enrolment at the 2nd year or the number of enrolments who do not pass any exam at the end of the 1st year lead to similar results. They both might be good proxies of the university leavers in the first part of the career. An important hint could be also taken from the use of the number of graduates. There is still discussion in the literature on whether and how this variable should be used as outcome in the educational process (see for instance Madden et al. 1997; Abbot and Doucouliagos, 2003). We used the number of graduates weighted firstly by their degree marks and secondly by the time to get the degree. The empirical evidence suggests that, for some universities, the efficiency scores decline when the number of graduates weighted by the time to get the degree is used as output rather than the number of graduates weighted by their degree marks. This suggests that a measure which takes into account both the quality of the graduates and the time to get the degree would be probably a better outcome, in order to, at least partially, take into account what Abbott and Doucouliagos (2003) pointed out such as that “a high rate of graduation might just as well be an indication of low standards of education in an institution as it is of output”.

The aim of our analysis is to give a contribution to the literature that attempts to evaluate the efficiency of HEIs. Even though more empirical evidence has to be provided, the use of a directional distance function approach might be useful in order to get more information on what the efficiency scores of HEIs tell us, when universities’ performances are evaluated also according to a negative output such as the number of students who drop out. We are aware that the problem of student attrition is not related to a single aspect and that economic, sociological and psychological factors have to be considered; moreover data on students who leave the university are difficult to collect. But, considering that on average about 20% of the tertiary education students in Italy dropped out from the university in the last years, taking into account this aspect does offer useful insights on how efficiency can be improved.

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