Socio-Economic Planning Sciences 55 (2016) 47–58

Contents lists available at ScienceDirect

Socio-Economic Planning Sciences

journal homepage: www.elsevier.com/locate/seps

Evaluating the efficiency of Italian public universities (2008–2011) in presence of (unobserved) heterogeneity

Tommaso Agasisti [a], Cristian Barra [b], Roberto Zotti [b, *]

[a] Department of Management, Economics & Industrial Engineering, Politecnico di Milano, P.za Leonardo da Vinci, 32, 20133, Milano, MI, Italy
[b] Department of Economics and Statistics, University of Salerno, Via Giovanni Paolo II, 132, 84084, Fisciano, SA, Italy

ARTICLE INFO

Article history:
Received 30 October 2015
Accepted 22 June 2016
Available online 1 July 2016

JEL codes:
I24
I23
C14
C67

Keywords:
Efficiency
Unobserved heterogeneity
Higher education

ABSTRACT

In assessing the performance of universities, the most recent literature underlined that the efficiency scores may suffer from the presence of incidental parameters or time-invariant, often unobservable, effects that lead to biased efficiency estimates. To deal with this problem, we apply a procedure developed by [67]; for estimating the efficiency in Italian higher education through a multi-output parametric distance function. We show that models which do not consider unobservable heterogeneity tend to estimate divergent efficiency scores. We also study the determinants of efficiency; the findings provide a clue towards the expansion of pro-competitive policies in the Italian higher education sector, consistently with the interpretation that when market forces operate, there are benefits for university efficiency. When exploring differences in the performance of universities, by geographical areas, we claim that maintaining State-level policies can be detrimental for overall efficiency, and instead special interventions for universities in the South should be designed.

1. Motivation and objectives

The analysis of university costs is at the heart of institutional and academic debates since when [29] identified these organizations as multi-output, thus posing the challenge of measuring their scale and scope effects. Following this seminal study, several papers attempted at measuring the productivity of Higher Education Institutions (HEIs) – defined as the ratio between costs and output – in the USA (see, for instance [16,30], and Europe (especially in UK, see Refs. [37,42,64]. As widely discussed by Refs. [46]; the problem of assessing economic performances of HEIs is also exacerbated by inefficiency in production; then, when modeling production and cost functions, it must be kept in mind that HEIs are likely to produce using their inputs in a suboptimal way.

The statistical approach for incorporating inefficiency into the estimation of production is the method named Stochastic Frontier Analysis (SFA), proposed by Refs. [13,56]. SFA has been extensively applied in the literature for measuring efficiency in the higher education environment. Operationally, the method assumes that the error term is composed of two components with different distributions: the first component, regarding the "inefficiency", is asymmetrically distributed (typically as a semi-normal), while the second component, concerning the "error", is distributed as white noise. On methodological grounds, the most recent literature, which deals with panel data, emphasized the importance of separating inefficiency and fixed individual effects. As [67] have underlined: "(…) *stochastic frontier models do not distinguish between unobserved individual heterogeneity and inefficiency", forcing "all time-invariant individual heterogeneity into the estimated inefficiency*". For instance, in the field of higher education, (average) innate ability of students or researchers may be an important determinant of their individual academic achievement and thus account for an important share of the heterogeneity in data, when evaluating the efficiency of the institution in which they are studying or working.

In the context of the use of efficiency models for policy-making, or managerial considerations, the problem of separating the three elements: (i) unobserved structural differences in underlying inputs, (ii) inefficiency and (iii) heterogeneous production processes is of crucial importance. Indeed, the lack of judgment about the

* Corresponding author.
E-mail addresses: tommaso.agasisti@polimi.it (T. Agasisti), cbarra@unisa.it (C. Barra), rzotti@unisa.it (R. Zotti).

http://dx.doi.org/10.1016/j.seps.2016.06.002
0038-0121/

various parts would lead to a misleading evaluation of estimated inefficiency[1]. An approach to this end is promoted by Ref. [67] who show, in the context of panel data, that first-difference and within transformation can be analytically performed to remove the fixed individual effects, and thus the estimator (of efficiency) is immune to the incidental parameters problem. In other words, after transforming the model, the fixed effects are removed before the estimation.

This paper main objective is to apply the procedure developed by Ref. [67] for estimating the efficiency of Italian HEIs through a multi-output, parametric distance function, using data over the four-years 2008–2011; this way, the estimated efficiency is net of the influence of unobserved heterogeneity. To the best of authors knowledge, this is the first paper that attempts at separating inefficiency from heterogeneity when assessing the performances of Italian universities, with the only notable exception of [10]; who however used the [38] method for this purpose.

This paper is innovative because of two other reasons. Firstly, it tests the effects of assuming different functional forms of university production functions. While the theoretical problem of identifying the "correct" functional form of HEIs' production processes is discussed in the literature (see, for instance [28,43], the empirical tests about how different forms affect estimations are quite sparse. The topic itself is important in a managerial perspective; indeed, it is important to check whether the judgment about efficiency is affected by the assumptions behind the production process or not. In this paper, we conduct such tests systematically: we start the empirical analysis assuming a translog functional form for the output distance function, with and without input-output separability property. Furthermore, we also consider a Cobb-Douglas formulation (see Section 2 for a discussion of the different assumptions concerning the production process). To anticipate the findings, the functional form chosen seems to have a minor impact on main estimates, therefore we consider them empirically robust. Secondly, this paper directly investigates whether the efficiency of universities is influenced by some characteristics of the market structure in which they operate. More specifically, we look at the effect of variables like an indicator of market share (MK), the level of fees (FPS), and wealth – as measured through added value per capita (AV) - in the areas (Regions) where universities operate. This policy-oriented analysis is particularly relevant given that since the 1990s the Italian university system has been characterized by policy interventions that stimulate competition between universities [5].[2]

The paper is organized as follows. In the Section 2, we present the methodological approach; Section 3 illustrates the data, production set and model specification for the empirical analysis; Section 4 contains the main results. Finally, Section 5 discusses the managerial and policy implications of the main findings, together with concluding remarks.

2. Empirical methodology

The presence of a multidimensional nature of the production (i.e. multiple outputs and multiple inputs) may represent a problem when estimating stochastic production models. To solve this issue, a distance function approach has been considered [27,53]. Moreover, this technique is particularly useful when no price information regarding inputs and outputs is available [26]. Specifically, and following [1] and [48]; we choose to model the production set through an output distance function in a panel context.

Furthermore, as already mentioned before, we are aware that the estimates of the frontier and then, consequently, the efficiency scores suffer by the presence of incidental parameters or time-invariant effects that may distort the estimates. In order to deal with this problem and to estimate the technical efficiency, we apply a procedure developed by Refs. [67]; according to whom after transforming the model by either first-difference or within-transformation, the fixed effects are removed before estimation. More specifically, we impose on the data a within transformation. As [67] specified, "*by within-transformation, the sample mean of each panel is subtracted from every observation in the panel. The transformation thus removes the time-invariant individual effect from the model*". Following the notation in Refs. [67]; the transformation employed in our model is (being*w*, for instance, any input or output to be transformed):

$$w_{i.} = (1/T)\sum_{t=1}^{T} w_{it},\ w_{it.} = w_{it} - w_{i.} \tag{1}$$

The stacked vector of $w_{it.}$ for a given i is:

$$\tilde{w}_{i.} = (w_{i1.}, w_{i2.}, \ldots, w_{iT.})' \tag{2}$$

For simplicity, hereafter in our formulation does not include a subscript t.[3] The baseline model associated to distance function after the transformation can be written as:

$$f(\tilde{y}_{i.}) = f(\tilde{x}_{1.}, \ldots \tilde{x}_{n.}) + \tilde{\varepsilon}_{i.} \tag{3}$$

where $\tilde{y}$ represents the conventional outputs, $\tilde{x}$ denotes the conventional inputs and $\tilde{\varepsilon}$ denotes the disturbance term.

With stochastic frontier analysis, a frontier is estimated on the relation between inputs and outputs. This can be, for example, a linear function, a quadratic function or a translog function. This paper uses both translog and a Cobb-Douglas function. However, there is no general consensus about which one has to be adopted in the higher education environment (for a discussion on the different function forms, see Refs. [28] and [9]. Firstly, concerning the structure of production possibilities, a more general functional form, that is, the transcendental logarithmic, or "translog", could be considered for the frontier production function. The translog functional form may be preferred to the Cobb–Douglas form because of the latter restrictive elasticity of substitution and scale properties, and it allows for non-linear causalities, compared with the more simple Cobb-Douglas function (see Refs. [11]; who use a translog function in order to compare the efficiency of public universities among European countries). On the other hand, the assumptions behind the use of Cobb–Douglas production function are also plausible in view of the theoretical model which describes the human capital formation in the university system. It allows overcoming the multicollinearity problem associated to the estimation of a few number of parameters with respect to the translog function; therefore it is less susceptible to multicollinearity and degrees of freedom problems than the translog function (see Refs. [52]; who uses a Cobb-Douglas function in order to model exogenous variables in human

[1] Such a topic has been systematically investigated by Refs. [38]; who examined different ways to incorporate heterogeneity; his findings demonstrate that different models produce very different results. In particular, he analyses several extensions of the stochastic frontier that account for unmeasured heterogeneity as well as firm inefficiency (an application of these methods when analyzing the efficiency of universities is in Refs. [45]; and [10].

[2] See Refs. [5,20,60] and [23] for a brief review of the university system in Italy.

[3] Even though the formulation does not include a subscript *t*, the inefficiency component is time varying in order to examine how the (in)efficiency changes over time.