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Estimating technical and allocative efficiency in the public sector: A nonparametric analysis of Dutch schools

Carla Haelermans [a,b,*], John Ruggiero [c]

[a] Top Institute for Evidence-Based Education Research (TIER), Maastricht University, Netherlands
[b] IPSE Studies, Delft University of Technology, Netherlands
[c] University of Dayton, United States

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ABSTRACT

Public sector output provision is influenced not only by discretionary inputs but also by exogenous environmental factors. In this paper, we extended the literature by developing a conditional DEA estimator of allocative efficiency that allows a decomposition of overall cost efficiency into allocative and technical components while simultaneously controlling for the environment. We apply the model to analyze technical and allocative efficiency of Dutch secondary schools. The results reveal that allocative efficiency represents a significant 37 percent of overall cost efficiency on average, although technical inefficiency is still the dominant part. Furthermore, the results show that the impact of environment largely differs between schools and that having a more unfavorable environment is very expensive to schools. These results highlight the importance of including environmental variables in both technical and allocative efficiency analysis.

1. Introduction

Productivity and efficiency of education are topics of intense debate among politicians, teachers, and trade unions and employers in education. Until recently, there was little political discussion on productivity and efficiency in education. However, the EU Lisbon goal of becoming a competitive knowledge economy has put productivity and efficiency high on the political agenda of most countries. In the face of the current economic crisis and the austerity measures and budget cuts that come with that, this goal has become even more of a challenge than before. The challenge is to improve educational output with less or equal money. This puts the productivity and efficiency of education on the agenda.

Responsibility, accountability, and transparency are more and more becoming the norm in education and, therefore, it is important to gain insight in educational productivity and efficiency. First of all, in order to fulfil these requirements, but also because schools are evaluated based on the indicators that are used to measure productivity and efficiency. Schools need to start acting based on the information they get from these indicators in order to be prepared for these assessments. Furthermore, as we want the resources invested in education to be well spent, it is important to operate as efficient as possible, and to generate the highest possible educational output with the given budget.

Lastly, the increasing requirements for schools (e.g., more pupil counseling, additional extra-curriculum activities, use of school buildings during weekends and summer holidays) induce pressure on the resources which are already in place. Productivity is not only a political issue anymore, but has also become an issue in the schools themselves (see Ball and Goldman, 1997; Ministry of Education, 2011a, p. 98).

In this paper, we extend a theoretical framework on technical efficiency and apply it to Dutch secondary schools. Studying Dutch schools is attractive and insightful for three reasons. First, standardized performance measures of Dutch students make educational attainments well comparable. Second, there is information on student achievement, which compares the educational career of a student (both in terms of school track and retentions) with the education track predicted for a student at the end of primary education. Third, Dutch schools receive a yearly lump sum budget from the government, which is at the discretion of the school such that, within the existing legal framework, the allocation of this budget among the several resources is the decision of the school. Therefore, a significant heterogeneity in hired resources, in terms of management, teachers, supporting personnel and material use, is observed.

In the literature, there are many studies on the efficiency of education in which the (average) efficiency scores of the studied schools are presented (e.g. Borge and Naper, 2006; Chakraborty

* Corresponding author. Address: PO Box 616, 6200 MD Maastricht, Netherlands. Tel.: +31 433884458.
E-mail address: Carla.Haelermans@maastrichtuniversity.nl (C. Haelermans).

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et al., 2001; Cordero-Ferrera et al., 2008; Grosskopf et al., 2009; Korhonen et al., 2011; Ouellette and Vierstraete, 2005). Some authors make a comparison between two groups of institutions, e.g. from different countries, and draw a conclusion related to the difference in efficiency scores between these groups (e.g. Barbetta and Turati, 2003; Grosskopf et al., 2009). However, most of the efficiency studies look at different units of observation, and conclude that efficiency scores vary greatly among the units of observation (Barbetta and Turati, 2003).

These studies on efficiency in education differ widely, both with respect to content and methodology. The content differs mostly in the types of inputs and outputs used in the measurement of productivity. With respect to outputs, some studies use only the number of students of certain years (e.g. Ouellette and Vierstraete, 2005), whereas other studies use the number of students and the subsequent student performance (e.g. Blank et al., 2007). There are also studies that use only the student performance or changes in student performance as an output measure (e.g. Afonso and St. Aubyn, 2006; Conroy and Arguea, 2008; Korhonen et al., 2011; Millimet and Collier, 2008). Studies using at least student performance, that can be independently compared and cannot be influenced by the schools, as output measure, are preferable over studies using, for example, only student numbers as output. One reason is that in most countries schools are evaluated based on student performance and not on the number of students. Another reason is that such an independent performance measure is comparable and cannot be influenced.

With respect to inputs, studies use costs of personnel or materials (e.g. Grosskopf et al., 1997), costs per student (e.g. Chakraborty et al., 2000; Haelermans and De Witte, 2012; Ruggiero, 2007), total costs of a school (e.g. Aaltonen et al., 2006), or costs including prices (e.g. Haelermans and Blank, 2012; Haelermans et al., 2012). Other studies do not use costs as inputs, but use, for example, the number of teachers (e.g. Barbetta and Turati, 2003), teacher characteristics (such as experience, Conroy and Arguea, 2008), school characteristics, parental information (such as income level, educational facilities at home and contribution of the parents towards to school programs Korhonen et al., 2011), or student characteristics. Studies using costs and prices combined with the number of students and teachers as inputs are preferable over studies that use other inputs. A reason for the preference for including costs and prices is that in many countries schools receive a lump sum payment and are evaluated based on their performance. Another reason is that a combined input of both costs and prices and number of students or teachers provides more information than using only costs.

Besides differences in content, there are methodological differences between efficiency studies. These methodological differences between efficiency studies do not necessarily influence the quality of the studies, but do influence the outcomes and interpretation of the results. The most important methodological distinction is the difference between studies using parametric methods, such as stochastic frontier analysis (e.g. De Witte et al., 2010; Grosskopf et al., 2009) and studies using nonparametric methods, such as data envelopment analysis or free disposal hull (e.g. Haelermans and De Witte, 2012). There is also a methodological difference between studies using a cost function or input oriented analysis (e.g. Denaux, 2009), and studies using a production function or output oriented analysis (e.g. Haelermans and Blank, 2012; Haelermans et al., 2012).

The measure of allocative efficiency yields insights in the under- or over-utilization of school resources. Allocative efficiency in primary or secondary education has been largely overlooked. The available allocative efficiency studies mostly consider higher education (Cherchye and Vanden Abeele, 2005; Johnes and Johnes, 2009; Soares de Mello et al., 2006; Tauer et al., 2007). Some rare exceptions are Banker et al. (2004) and Grosskopf et al. (1997, 2001) both of which study school districts in Texas.

However, in many cases the environment plays a large role in the performance of the school, but this is often ignored. This paper contributes to the literature by extending the theoretical model and explicitly taking into account an (un)favorable environment to the school, which influences its technical and allocative efficiency. We use a nonparametric analysis, with costs and FTEs (Full Time Equivalents) per personnel group as inputs and three types of student performance as outputs. The share of students from a disadvantaged area is used as the environmental variable.

The remainder of this paper is organized as follows. In the next section, we present the public sector DEA model that properly controls for nondiscretionary inputs. In this section we also develop a new model to allow estimation of cost efficiency in the presence of these exogenous factors and provide a decomposition of overall cost inefficiency into technical and allocative components while controlling for the operating environment. In Section 3, we apply our model to analyze technical, allocative and cost efficiency of Dutch schools using 2007 data. The results indicate that although technical inefficiency is the dominant type of inefficiency, allocative inefficiency is a significant component of overall inefficiency. The last section concludes the paper.

2. Public sector production and costs

We assume that each of n schools uses a vector $X = (x_1, \ldots, x_m)$ of m discretionary inputs to produce a vector $Y = (y_1, \ldots, y_s)$ of s outputs while facing an environment characterized by index z and exogenous input prices $P = (p_1, \ldots, p_m)$. Observed production and price data for school $j (j = 1, \ldots, n)$ are given by $X_j \equiv (x_{1j}, \ldots, x_{mj})$, $Y_j = (y_{1j}, \ldots, y_{sj})$, $P_j = (p_{1j}, \ldots, p_{mj})$ and z_j.[1] Given observed inputs and prices, observed expenditures (E_j) for school $j (j = 1, \ldots, n)$ is $E_j = \sum_{l=1}^{m} p_{lj} x_{lj}$. We specify the empirical production possibility set as:

$$\begin{aligned} T(z) = \{Y, X, z\} : & \sum_{j=1}^{n} \lambda_j y_{kj} \geqslant y_k \geqslant 0, \quad k = 1, \ldots, s; \\ & \sum_{j=1}^{n} \lambda_j x_{lj} \leqslant x_l, \quad l = 1, \ldots, m; \\ & \sum_{j=1}^{n} \lambda_j = 1; \\ & \lambda_j = 0 \text{ if } z_j > z \geqslant 0, \quad j = 1, \ldots, n, \\ & \lambda_j \geqslant 0, \quad j = 1, \ldots, n. \end{aligned} \tag{1}$$

The technology in (1) allows variable returns to scale for any given level of the environmental variable in the standard sense of changing the scale of operation with respect to the discretionary inputs. Also, we assume that output is monotonic with respect to the environmental index; larger values of z imply a favorable operating environment where the school should produce at least as much output for any given mix of discretionary inputs.[2]

Based on (1), Ruggiero (1996) developed a DEA model to estimate technical efficiency of school $i (i = 1, \ldots, n)$ as the solution to the following linear program:

[1] Here, we simply exposition to assume there is only one nondiscretionary factor. In the case of multiple nondiscretionary variables, we can employ a multiple stage model to construct an index of environmental influence. See the Appendix for discussion. Our technology description is consistent with our empirical analysis, which uses only one nondiscretionary input.

[2] An anonymous referee correctly points out that our modeling works if we have resource prices for all discretionary inputs. In the case when some discretionary input does not have a price and a shadow price cannot be imputed, we are left with measuring only technical efficiency unless we make additional assumptions. This is consistent with the motivation of Charnes et al. (1978) who argue for using technical efficiency in the public sector where prices might not be available.