Socio-Economic Planning Sciences 48 (2014) 4–9

Contents lists available at ScienceDirect

Socio-Economic Planning Sciences

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

Measuring efficiency in Australian Schools: A preliminary analysis

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ARTICLE INFO

Article history:
Available online 29 August 2013

Keywords:
Efficiency
Nondiscretionary inputs
Data envelopment analysis

ABSTRACT

In this paper, we apply a public sector Data Envelopment Analysis model to estimate the efficiency of Australian primary and secondary schools. Standard microeconomic production theory showing the transformation of inputs into outputs is extended to allow nondiscretionary environmental variables characteristic of educational production. Failure to properly control for the socioeconomic environment leads to inappropriate comparisons and biased efficiency estimates. We employ a conditional estimator that does not allow a school with a better environment to serve as a benchmark for a school with a worse environment. The results suggest that Australian schools are moderately inefficient and that efficiency increases for the quintile of schools with the most favorable environment. Further, efficiency gains are realized with increasing enrollment.

1. Introduction

The Australian Federal Government has recently articulated that the major focus of their future school funding reforms will focus on reducing the achievement gaps between rich and poor students on the one hand, and between indigenous and non-indigenous students on the other [15]. Most often these groups are overlapping. Recent studies have found that these gaps are being exacerbated by increasing social segregation between schools in Australia. The Census data show that the number of students from low income families is increasing in Government schools relative to Catholic and Independent schools. Researchers have also found that both the family socioeconomic status (SES) and the socioeconomic composition of the school impacts student achievement. A recently published report by Murdoch University found students from low income families in low SES schools are nearly four years behind students from high income families in high SES schools in reading, math, and science [27]. Also the results from PISA 2006 show that the difference between the average low SES student in a low SES school and the average high SES student in similar schools is 60 points in maths and 68 points in science, a difference of two years in learning. The difference between the low and high SES students in high SES schools is 52 points in maths and 67 points in science.

A study by Cobbold [7] finds 41 percent of students from low SES families fail to complete Year-12 compared to 22 percent of students from high SES families, and 60 percent of indigenous students who start secondary schooling do not go on to Year-12 compared to 25 percent of all students. Some Australian researchers suggest increased funding for disadvantaged schools should be the major policy priority for educational administrators and policymakers. McMorrow [25] adds that differences among the Commonwealth and the States in assumptions and presentations: calendar and financial years; constant and current prices; and opaqueness obfuscates funding comparisons between sectors and over time. Redmond [31] argues that the best way to tackle the disparities effectively is that the resource allocations to students need to be closely monitored, “at present it is not possible” (p.53). Utilising Sen’s [36] capability approach Redmond asserts that governments should not only be concerned with outcomes (‘how well did the child do?’), but also need to address the issue of inputs invested (‘what resources were invested?’). Australian Governments have recently started to measure students’ educational outcomes. This also needs to be directed toward a disaggregation of resource inputs to enhance accountability. Utilising a school site expenditure data set for New South Wales government schools such accountability studies can now be undertaken. This paper is an initial step in a proposed wider range of studies into School efficiency to be completed in the near future for all Australian schools, in both the government and non-government school sectors.

Although some researchers suggest that availability of more resources for low SES schools would promote social justice and equity no effort has been made to examine how if any, additional resources would increase student achievement for Australian schools. We argue that before any additional funding is committed

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http://dx.doi.org/10.1016/j.seps.2013.08.002

to low SES and low performing schools the policymakers should seek answers to two fundamental questions: (1) are these low SES low performing schools utilizing their existing resources efficiently while providing quality education to its students? And, (2) what are the factors primarily responsible for the low efficiency for these schools?

This study attempts to answer these two questions by measuring an efficiency index for all public schools in New South Wales (NSW) and by investigating the relationship between school inefficiency and its environmental factors. The empirical analysis uses a 2010 cross section data set of 1415 primary schools and 381 secondary schools in the largest state of NSW in Australia. This study is the first attempt to assess the relative efficiency of government schools in NSW using the most comprehensive school site data set and modern nonparametric tools. We believe the empirical results from this study will contribute to the existing body of knowledge in the public education literature and provide valuable information to Commonwealth and State legislatures, education-researchers, and policymakers for informed decision making on school funding issues.

One popular model for measuring efficiency is data envelopment analysis (DEA), a nonparametric linear programming approach that evaluates each observed production unit relative to the estimated production frontier. Building on the work of Farrell [14] and Afriat [2], Charnes et al. [5] introduced DEA for multiple input and multiple output production correspondences assuming constant returns to scale. Cooper [4] extended the model to allow variable returns to scale. Using standard axioms including convexity and monotonicity, the frontier is estimated by enveloping data with piecewise linear hyperplanes. The frontier is used to estimate relative efficiency of observed production units based on distance functions.

Ruggiero [32] extended the DEA model to the public sector where production is characterized by nondiscretionary socioeconomic factors. In education, for example, schools that have a lower percentage of students in poverty can achieve higher outcomes than schools with higher percentages holding school resources fixed. This suggests that frontier production depends on the operating environment that a given school faces. Ruggiero [32] provided a conditional estimator for technical efficiency by projecting inefficient schools to the appropriate frontier by not allowing schools with a more favorable environment to serve as benchmarks for the school under analysis.[1] DEA applications to education have a long tradition, beginning with [6]. Recent applications include Refs. [10,16,17,21,22,24,29,30,37,38]. These papers, among others, focus on the importance of measuring efficiency in education.

This study evaluates the relative performance of the primary and secondary schools in NSW providing quality education to NSW K-12 students. Lamb et al. [23] using education data from Victorian schools found schools perform better when more students are from advantaged backgrounds and that schools with higher per capita funding achieve better outcomes for their students. However there is a lack of empirical studies in Australia measuring the impact of FOEI on students' achievement scores using modern nonparametric models.

The remainder of this paper is organized as follows. In Section 2, we present the technology for education production where discretionary inputs are transformed into educational outcomes for a given environment. This technology allows us to measure efficiency and the effect that the environment has on educational costs using public sector DEA models. In Section 3, we analyze educational production and efficiency of Australian primary and secondary schools using DEA. In anticipation of the results, we find a moderate degree of inefficiency. In general, the results are similar across quintiles of socioeconomic status. However, we find that schools with the most favorable operating environment tend to provide the highest level of output and are the most efficient. The last section concludes with directions for future research.

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 represented by an exogenous (nondiscretionary) variable z.[2] Individual school production data for school $X_j \equiv (x_{1j}, \ldots, x_{mj})j$ $(j = 1, \ldots, n)$ are given by , $Y_j = (y_{1j}, \ldots, y_{sj})$, and z_j. The empirical production possibility set is given as:

$$T\left(z\right) = \left\{ \left(Y,X,z\right) : \sum_{j=1}^{n} \lambda_j y_{kj} \geq y_k,\ k = 1,\ldots,s;\ \sum_{j=1}^{n} \lambda_j x_{lj}, \leq x_l,\ l = 1,\ldots,m;\ \sum_{j=1}^{n} \lambda_j = 1;\ \lambda_j = 0 \text{ if } z_j > z, j = 1,\ldots,n;\ \lambda_j \geq 0, j = 1,\ldots,n \right\} \quad (1)$$

The technology in (1) allows variable returns to scale for any given level of the nondiscretionary variable in the standard sense of changing the scale of operation with respect to the discretionary inputs via the convexity constraint.[3] It is assumed that larger values of z imply a more favorable operating environment where the school should produce at least as much output for any given mix of discretionary inputs. This is shown with the constraint on the nondiscretionary variable z: units with a more favorable environment are not included in the conditional production set.

Following Ruggiero [32], the technical efficiency of school i $(i = 1, \ldots, n)$ is estimated relative to the technology in (1) as the solution to the following linear program:

$$\begin{aligned} \mathrm{TE}_i = \min\ & \theta \\ \text{s.t.}\ & \sum_{j=1}^{n} \lambda_j y_{kj} \geq y_{ki},\ \ k = 1,\ldots,s; \quad \sum_{j=1}^{n} \lambda_j x_{hj}, \leq \theta x_{hi} \\ & h = 1,\ldots,m; \quad \sum_{j=1}^{n} \lambda_j = 1; \quad \lambda_j = 0 \text{ if } z_j > z_i, \\ & j = 1,\ldots,n; \quad \lambda_j \geq 0,\ j = 1,\ldots,n \end{aligned} \quad (2)$$

Here, the frontier is defined for each level of the nondiscretionary input; if school j $(j = 1, \ldots, n)$ has a more favorable environment as indicated by $z_j > z_i$ it is not allowed to serve as a benchmark in the solution of (2).[4]

[1] De Witte and Kortelainen [9] provide a robust nonparametric analysis to test the significance of continuous and discrete exogenous factors influencing educational production. The authors relax the assumption of how the exogenous variables enter the production process. See also Ref. [35].

[2] In our empirical application, we use only one nondiscretionary input to represent the environment. Ruggiero [33] showed how to extend this to a three-stage model to handle multiple nondiscretionary inputs.

[3] Our choice of VRS technology is consistent with our choice of volume unrelated outputs. See Ref. [20] for a discussion.

[4] Essentially, this model, due to Ruggiero [32], assumes selective convexity for a given level of nondiscretionary input. See Ref. [28] for further discussion. Alternative models exist to control for the environment; see Banker and Morey (1986) [3] and Estelle, Johnson and Ruggiero (2010) [13]. This model has been shown to work well. See Ref. [26] for a discussion.