RELATIVE EFFICIENCY OF PRIMARY EDUCATION: AN INTERNATIONAL COMPARISON

Aleksander Aristovnik

University of Ljubljana, Faculty of Administration, Gosarjeva 5, 1000 Ljubljana, Slovenia

Abstract
The paper joins the efforts of other scholars in investigating education efficiency by applying a non-parametric methodology. Most importantly, Data Envelopment Analysis (DEA) technique is presented and then applied to the wide range of the EU and OECD countries to evaluate technical efficiency within the selected education sector in 1999-2008 period. The empirical results show that within a selected group of EU member states Denmark, Hungary and Portugal are seen as most efficient in primary education sector. In addition, some countries come very close to the frontier (e.g. Czech R. and Italy), while the other countries are further away and therefore less efficient (e.g. Turkey). On the other hand, the least efficient countries are Belgium, Sweden and Croatia. The empirical findings also point out that the new EU member states are relatively more efficient than non-EU countries in the sample, however, they show relatively low efficiency against the old EU-member states.

Key words: *Efficiency, Primary Education, DEA, EU Member States, OECD*

1. INTRODUCTION

Each nation's future wealth and competitive position in the globalised world depends increasingly on its ability to create and absorb knowledge. An essential feature of knowledge is that it requires human capital (educated persons) for both its production and its application. Indeed, long-term economic growth of the economy rests with its capacity to increase productivity through rapid technological progress. Therefore, the national system of education is the quintessential tool for the creation and application of knowledge. However, as most of the countries are faced with increasing demands on their limited (public) resources, there is an increasing pressure to improve resource allocation and utilisation. Accordingly, policy makers in a number of countries became increasingly concerned with measuring efficiency. With education expenditures comprising a relatively important amount of national income, the interest in examining whether such expenditures are cost-effective has increased, recently.

The purpose of the paper is to present and apply Data Envelopment Analysis (DEA) technique to the wide range of the EU and OECD countries to evaluate technical efficiency of the primary education. The importance of examining public sector expenditure efficiency is particularly pronounced for emerging market economies where public resources are normally insufficient. When services are publicly provided, performance measurement becomes an inevitable management tool because when inefficiency continues, the constituents of that inefficient unit suffer. The government needs benchmarking tools to provide incentives to good performing sectors and to induce inefficient sectors to perform better. However, the focus of the paper is not on how to cut (public) expenditures, but rather more on investigating potential reserves to increase the value for money of public spending, i.e. how to make the most of limited public (and private) resources.

The paper is organized as follows. In the next section we present a brief literature review of measuring public education expenditure efficiency. Section 3 shows a theoretical background of non-parametric methodologies with special focus on Data Envelopment Analysis (DEA) and the specifications of the models. Section 4 outlines the results of the non-parametric efficiency analysis of primary education sector. The final section provides concluding remarks.

2. LITERATURE REVIEW

Previous studies on the performance and efficiency of the public sector (at national level) that applied non-parametric methods find significant divergence of efficiency across countries. Studies include notably Fakin and Crombrugghe (1997) for the public sector, Gupta and Verhoeven (2001) for education and health in Africa, Clements (2002) for education in Europe, St. Aubyn (2003) for education spending in the OECD, Afonso et al. (2005, 2006) for public sector performance expenditure in the OECD and in emerging markets, Afonso and St. Aubyn (2005, 2006a, 2006b) for efficiency in providing health and education in OECD countries. De Borger and Kerstens (1996), and Afonso and Fernandes (2006) find evidence of spending inefficiencies for the local government sector. Additionally, Afonso et al. (2008) assess the efficiency of public spending in redistributing income. Most studies apply the Data Envelopment Analysis (DEA) method while Afonso and St. Aubyn (2006a) undertook a two-step DEA/Tobit analysis, in the context of a cross-country analysis of secondary education efficiency.

Other authors (e.g. Mandl et al., 2008 ; Jafarov and Gunnarsson, 2008) have tried to improve on the work by Afonso et al. (2005). The country-clusters resulted are very similar. Southern European countries present low general and educational performance, the CEE countries show low general performance but high educational one, and the Northern European and Anglo-Saxon countries with high scores in both items (although the differences among countries in the educational performance are high; e.g. Luxembourg with a high macroeconomic score but fairly poor results for the effectiveness of its education system). Additionally, a number of studies examine technical efficiency in education (see also Castano and Cabanda, 2007; Grosskopf and Mourtray, 2001; Johnes, 1996, 2006; Johnes and Johnes, 1995; Ng and Li, 2000; Cherchye et al., 2010).

3. METHODOLOGY AND DATA

A common approach to measure efficiency is based on the concept of efficiency frontier (productivity possibility frontier). There are multiple techniques to calculate or estimate the shape of the efficiency frontier. Most investigations aimed at measuring efficiency are based either on parametric or non-parametric methods. The main difference between the parametric and the non-parametric approach is that parametric frontier functions require the ex-ante definition of the functional form of the efficiency frontier. While a parametric approach assumes a specific functional form for the relationship between input and output, a non-parametric approach constructs an efficiency frontier using input/output data for the whole sample following a mathematical programming method.[1] A calculated frontier provides a benchmark by which the efficiency performance can be judged. This technique is therefore primary data-driven. Among the different non-parametric methods the Free Disposal Hull (FDH) technique imposes the fewest restrictions.[2] It follows a stepwise approach to construct the efficiency frontier. Along this production possibility frontier one can observe the highest possible level of output/outcome for a given level of input. Conversely, it is possible to determine the lowest level of input necessary to attain a given level of output/outcome. This allows identifying inefficient producers both in terms of input efficiency and in terms of output/outcome efficiency (Afonso et al., 2005).

An alternative non-parametric technique that has recently started to be commonly applied to (public) expenditure analysis is Data Envelopment Analysis (DEA).[3] DEA is a non-parametric frontier estimation methodology originally introduced by Charnes, Cooper, and Rhodes in 1978 that compares functionally similar entities described by a common set of multiple numerical attributes. DEA classifies the entities into “efficient” or “performers” versus “inefficient” or “non-performers.” According to DEA framework, the inefficiencies are the degrees of deviance from the frontier. Input inefficiencies show the degree to which inputs must be reduced for the inefficient country to lie on the

[1] For an overview of non-parametric techniques see Simar and Wilson (2003).
[2] FDH analysis was first proposed by Deprins et al. (1984).
[3] DEA analysis, originating from Farrell’s (1957) seminal work was originally developed and applied to firms that convert inputs into outputs (see Coelli et al. (2002) for a number of applications).

efficient practice frontier. Output inefficiencies are the needed increase in outputs for the country to become efficient. If a particular country either reduces its inputs by the inefficiency values or increases its outputs by the amount of inefficiency, it could become efficient; that is, it could obtain an efficiency score of one. The criterion for classification is determined by the location of the entities' data point with respect to the efficient frontier of the production possibility set. The classification of any particular entity can be achieved by solving a linear program (LP).

Various types of DEA models can be used, depending upon the problem at hand. The DEA model we use can be distinguished by the scale and orientation of the model. If one cannot assume that economies of scale do not change, then a variable returns- to-scale (VRS) type of DEA model, the one selected here, is an appropriate choice (as opposed to a constant-returns-to-scale, (CRS) model). Furthermore, if in order to achieve better efficiency, governments' priorities are to adjust their outputs (before inputs), then an output-oriented DEA model rather than an input-oriented model is appropriate. The way in which the DEA program computes efficiency scores can be explained briefly using mathematical notation (adapted from Ozcan, 2007). The VRS envelopment formulation is expressed as follows:

$$\mathbf{VRS_p}\ (\mathbf{Y_l}, \mathbf{X_l}, \mathbf{u^l}, \mathbf{v^l}):\ \min\text{-}(\mathbf{u^l s} + \mathbf{v^l e})$$

$$\mathbf{Y\lambda} - \mathbf{s} = \mathbf{Y_1}$$

$$-\mathbf{X\lambda} - \mathbf{e} = -\mathbf{X_l}$$

$$\mathbf{1\lambda} = 1$$

$$\boldsymbol{\lambda \geq 0},\ \mathbf{e} \geq 0,\ \mathbf{s} \geq 0$$

For decision making unit 1, $x_{i1} \geq 0$ denotes the ith input value, and $y_{i1} \geq 0$ denotes the rth output value. X_1 and Y_1denote, respectively, the vectors of input and output values. Units that lie on (determine) the surface are deemed *efficient* in DEA terminology. Units that do not lie on the surface are termed *inefficient.* Optimal values of variables for decision making unit 1 are denoted by the s-vector s^1, the m-vector e^1, and the n-vector λ^1.

Although DEA is a powerful optimization technique that can assess the performance of each country, it has certain limitations. When one has to deal with large numbers of inputs and outputs, and a small number of countries are under evaluation, the discriminatory power of the DEA is limited. However, analysts can overcome this limitation by including only those factors (input and output) that provide the essential components of "production", thus avoiding distortion of the DEA results. This is usually done by eliminating one of a pair of factors that are strongly positively correlated with each other.

The specification of the outputs and inputs is a crucial first step in DEA, since the larger the number of outputs and inputs included in any DEA, the higher will be the expected proportion of efficient DMUs, and the greater will be the expected overall average efficiency (Chalos, 1997). Common measures of teaching output in education used in previous studies are based on graduation and/or completion rates (see Johnes, 1996; Jafarov and Gunnarsson, 2008), PISA scores (see Afonso and Aubyn, 2005; Jafarov and Gunnarsson, 2008) pupil-teacher ratio and enrolment rate (see Jafarov and Gunnarsson, 2008).

In the majority of studies using DEA, the data are analyzed cross-sectionally, with each decision making unit (DMU) – in this case the country – being observed only once. Nevertheless, data on DMUs are often available over multiple time periods. In such cases, it is possible to perform DEA over time, where each DMU in each time period is treated as if it were a distinct DMU. However, similar to the former empirical literature in this empirical analysis the data set to evaluate education sector efficency (at different levels) includes input data, i.e. (public) expenditure per student, primary (% of GDP per capita) and output/outcome data, i.e. school enrolment, primary (% gross), teacher/pupil ratio in primary education and primary completion rate, total (% of relevant age group).

There are up to thirty countries included in the analysis (selected EU and OECD countries). In our case the data set for all the tests in the study includes an average data for the 1999-2008 period (including PISA 2006 average scores) in order to evaluate long-term efficiency measures as education process is characterized by time lags in selected countries. The program used for calculating the technical efficiencies is the DEA*Frontier* software. The data are provided by Eurostat, OECD, UNESCO and the World Bank's World Development Indicators database.

4. EMPIRICAL RESULTS

When looking at the education results and applying the DEA efficiency frontier technique within a selected group of EU/OECD countries and Croatia to measure efficiency of primary education, Denmark, Hungary and Portugal are seen as most efficient. The efficient countries are also Greece, Iceland and Romania, however, their primary expenditures per student (in % of GDP) is very low and have averaged less than 12% (the EU/OECD average is 18.7% in the considered period). One can also see that some countries come very close to the frontier (e.g. Czech R. and Italy), while the other countries are further away and therefore less efficient (e.g. Turkey and Croatia) (see Table). Some less efficient countries should significantly decrease their input (primary expenditure per student) (e.g. Slovenia from 27.0% to 22.0%) and/or increase their outputs, i.e. school enrolment (e.g. Ireland and Poland), primary completion rate (Belgium) and teacher-pupil ratio (Turkey and Ireland) in order to become efficient.[4] Interestingly, the CEE countries are, in general, relatively more efficient than non-EU countries in the sample, however, they show relatively low efficiency against the old EU-member states.

Further empirical analysis, testing the efficiency of the total expenditure on education (in DEA model: as input – average public expenditure and as output – average PISA test) shows that the worse efficiency performers are Bulgaria, Romania and Portugal (see Table 2). Indeed, if these countries would employ the resources in efficient manner, they could increase their PISA scores by 19.5%, 15.6% and 13.6%, respectively. The main reason for the education inefficiency in these countries lies in transforming intermediate education outputs into real outcomes (see IMF, 2008) (same problems have some other CEE countries, particularly Latvia, Lithuania and Hungary). The results also show that the best performers (in terms of efficiency) seem to be Finland and Japan, while Greece presents a good efficiency result due the lowest education spending (averaged only 3.6% of GDP in 1999-2008). Interestingly, output-oriented DEA results confirm that Scandinavian countries could attain the same result with lowering their education expenditure by up to 2.3 percentage points (in Denmark). However, the new EU member states, in general, show the same efficiency as the old EU member states (both groups could increase their PISA scores by around 10% on average).

[4] The average output efficiency score for primary education is 1.050, which means that the average country could increase the outputs/outcomes for about 5.0% if it were efficient. The results also confirm our expectations, that larger public sector increases the inefficiency in a primary education.

Table 1. The Relative Efficiency of the EU Member States and OECD Countries in Education

(Distribution by quartiles of the ranking of efficiency scores)

I. quartile	*II. quartile*	*III. quartile*	*IV. quartile*
Denmark	Spain	Lithuania	Slovenia
Greece	Slovakia	Netherlands	Poland
Hungary	Germany	Ireland	Latvia
Iceland	Norway	France	Turkey
Portugal	Austria	Bulgaria	Croatia
Romania	Finland	Cyprus	Sweden
Czech Republic		Estonia	Belgium
Italy		United States	

Notes: Twenty-nine countries are included in the analysis (EU-27, OECD and Croatia).

Sources: World Bank, 2011; UNESCO, 2011; own calculations.

Table 2. The Relative Efficiency of the selected EU Member States and OECD Countries in Education

(Distribution by quartiles of the ranking of efficiency scores)

Country	*Output-Oriented VRS Efficiency*	*Rank*	*Benchmarks*
Finland	1.00000	1	
Greece	1.00000	1	
Japan	1.00000	1	
Czech R.	1.01370	4	Greece, Japan
Netherlands	1.01971	5	Finland, Japan
Slovakia	1.04248	6	Greece, Japan
Estonia	1.04817	7	Finland, Japan
Germany	1.05221	8	Finland, Japan
Iceland	1.05541	9	Finland, Japan
Switzerland	1.07374	10	Finland, Japan
Croatia	1.07427	11	Greece, Japan
Poland	1.07577	12	Finland, Japan
Spain	1.07915	13	Greece, Japan
Belgium	1.08288	14	Finland
Ireland	1.08607	15	Finland
Austria	1.08700	16	Finland, Japan
United Kingdom	1.08986	17	Finland, Japan

Slovenia	1.09281	18	Finland
Hungary	1.09307	19	Finland, Japan
Sweden	1.09620	20	Finland
Denmark	1.10320	21	Finland
Italy	1.10961	22	Finland, Japan
Turkey	1.11606	23	Greece, Japan
France	1.11721	24	Finland, Japan
Lithuania	1.12536	25	Finland, Japan
Latvia	1.13250	26	Finland, Japan
Norway	1.13547	27	Finland
Portugal	1.13607	28	Finland, Japan
Romania	1.15600	29	Greece, Japan
Bulgaria	1.19523	30	Greece, Japan
Mean	1.082974		
Std. Dev.	0.046890		

Notes: Thirty countries are included in the analysis (EU-27, OECD and Croatia).

Sources: World Bank, 2011; UNESCO, 2011; OECD, 2011; own calculations.

5. CONCLUSION

Spending on primary education system represents an important tax burden on taxpayers. The efficiency with which inputs produce the desired outputs is thus an important public policy issue. In this study, an attempt was made to measure the relative efficiency of primary education across selected OECD and EU countries by using data envelopment analysis (DEA) in a VRS framework. The research results suggest that Denmark, Hungary and Portugal are seen as most efficient countires and can serve as benchmarks for their efficient use of primary education resources.On the other hand, Belgium, Sweden and Croatia are the worse efficiency performes among the selected EU and OECD countries. The empirical results also suggest that, in general, new EU member states are relatively more efficient than non-EU countries in the sample, however, they show relatively low efficiency against the old EU-member states.

However, a few limitation of the presented empirical study should be pointed out. Firstly, the applications of presented techniques are hampered by lack of suitable data to apply those techniques. Quality data are needed because the techniques available to measure efficiency are sensitive to outliers and may be influenced by exogenous factors. Indeed, substantial inefficiency may be simply a reflection of environmental factors (such as climate, socio-economic background, etc.). This also suggests applying a combination of techniques to measure efficiency. Secondly, the precise definition of inputs, outputs and outcomes may significantly influence the results. Finally, it seems important to bear in mind that by using a non-parametric approach, and in spite of DEA being an established and valid methodology, differences across countries are not statistically assessed, which can be considered as a limitation of such methodology. Hence, further research is clearly needed to eliminate the above deficiencies, in particular to test the influence of the environmental factors on education sector efficiency.

REFERENCES

1. Afonso, A., Schuknecht L. and Tanzi, V., (2005): Public Sector Efficiency: An International Comparison, *Public Choice*, 123 (3-4): 321-347.
2. Afonso, A. and Aubyn, St., (2005): Non-parametric Approaches to Education and Health Efficiency in OECD Countries, *Journal of Applied Economics*, 8 (2): 227-246.
3. Afonso, A. and Aubyn, St., (2006a): Cross-country Efficiency of Secondary Education Provision: a Semi-parametric Analysis with Non-discretionary Inputs, *Economic Modelling*, 23 (3): 476-491.
4. Afonso, A. and Aubyn, St., (2006b), Relative Efficiency of Health Provision: a DEA Approach with Non-discretionary Inputs, ISEG-UTL, Department of Economics Working Paper nº 33/2006.
5. Afonso, A., Schuknecht L. and Tanzi, V., (2006), Public Sector Efficiency: Evidence for New EU Member States and Emerging Markets, European Central Bank, Working Paper Series 581, European Central Bank: Frankfurt, 2006.
6. Afonso, A. and Fernandes, S., (2008): Assessing and Explaining the Relative Efficiency of Local Government, *Journal of Socio-Economics*, 37 (5), 1946-1979.
7. Afonso, A., Schuknecht L. and Tanzi, V. (2008), Income distribution determinants and public spending efficiency, Working Paper Series 861, European Central Bank: Frankfurt.
8. Castano MC, and Cabanda, E., (2007): Performance evaluation of the efficiency of Philippine Private Higher Educational Institutions: application of frontier approaches, *Int Trans Oper Res*, 14: 431-444.
9. Chalos, P., (1997): An Examination of Budgetary Inefficiency in Education Using Data Envelopment Analysis, *Financial Accountability & Management*, 13 (1): 55–69.
10. Cherchye, L., De Witte, K., Ooghe, E., and Nicaise, I. (2010): Efficiency and equity in private and public education: nonparametric comparison. *European Journal of Operational Research*, 202 (2): 563-573.
11. Clements, B., (2002): How Efficient is Education Spending in Europe?, *European Review of Economics and Finance*, 1: 3-26.
12. Coelli T., Rao, D. and Battese, G. (2002): An Introduction to Efficiency and Productivity Analysis (6th edition), Massachusetts: Kluwer Academic Publisher.
13. De Borger, B., and Kerstens, K., (1996): Cost efficiency of Belgian local governments: A comparative analysis of FDH, DEA, and econometric approaches. *Regional Science and Urban Economics*, 26: 145-170.
14. Deprins, D., Simar L. and Tulkens, H. (1984): Measuring labor-efficiency in post offices, in: *The performance of public enterprises: concepts and measurement*, Amsterdam: North-Holland.
15. Fakin. B. and de Crombrugghe, A., (1997), Fiscal adjustment in transition economies: social transfers and the efficiency of public spending: a comparison with OECD countries, Policy Research Working Paper 1803, Washington, DC: World Bank.
16. Farrell, M., (1957): The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society Series A (General)*, 120 (3): 253-281.
17. Grosskopf, S., and Mourtray, C., (2001): Evaluating performance in Chicago public high schools in the wake of decentralization, *Econ. Educ. Rev.*, 20: 1–14.
18. Gupta, S., and Verhoeven, M., (2001): The efficiency of government expenditure Experiences from Africa, *Journal of Policy Modelling*, 23: 433-467.

19. IMF (2008), Republic of Croatia: Selected Issues, IMF Publications, Washington.
20. Jafarov, E., and Gunnarsson, V., (2008), Government Spending on Health Care and Education in Croatia: Efficiency and Reform Options, International Monetary Fund, IMF Working Paper, WP/08/136.
21. Johnes, J., (1996): Performance assessment in higher education in Britain. *Eur. J. Oper. Res.*, 89: 18-33
22. Johnes, J., and Johnes, G., (1995): Research funding and performance in U.K. university departments of economics: a frontier analysis. *Econ Educ Rev*, 14: 301-314
23. Johnes, J., (2006): Data envelopment analysis and its application to the measurement of efficiency in higher education. *Economics of Education Review*, 25 (3): 273-288
24. Mandl, U., Dierx, A., and Ilzkovitz, F., (2008), The effectiveness and efficiency of public spending. European Commission, Economic Papers 31, Februar 2008.
25. Ng, Y. C., and Li, S. K., (2000): Measuring the research performance of Chinese higher education institutions: an application of data envelopment analysis, *Educ Econ*, 8: 2-139.
26. Ozcan, Y. A., (2007): Health Care Benchmarking and Performance Evaluation: An Assessment using Data Envelopment Analysis (DEA), New York: Springer.
27. Simar, L. and P. Wilson (2003): Efficiency analysis: the statistical approach, lecture notes.
28. St. Aubyn, M., (2003): Evaluating Efficiency in the Portuguese Education Sector, *Economia*, 26: 25-51
29. Unesco (2010) Data Centre, Montreal: UNESCO Institute for Statistics, *On-line*.
30. World Bank (2010) World Development Indicators, *On-line*.