EFFICIENCY OF PUBLIC SPENDING ON HIGHER EDUCATION: A DATA ENVELOPMENT ANALYSIS FOR EU-28

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Abstract

One of the main goals of education policy is to enhance educational outcomes. If resources are used inefficiently, they will fail to maximise those outcomes. Data Envelopment Analysis was used to calculate technical efficiency of public spending on education for EU-28 using the latest higher education statistics available. Focusing on European higher education, conceptual and methodological issues related to the measurement and analysis of efficiency were discussed. The most efficient countries are identified and also countries for which real efficiency improvements are possible. A novel set of variables is used to highlight more appropriately the distinctiveness of the higher education sector and the relationship between input and outputs. The advantage of using Data Envelopment Analysis is that it identifies the best performing decision, making units and not the averages. This type of information about the efficiency of public spending on education is of importance to many parties. It can be used to promote 'yardstick' competition in the areas of education where the lack of market mechanisms is apparent, guide policy proposals, and to enhance the monitoring of education.
Key words: e*fficiency in education, higher education, public spending, data envelopment analysis, European Union.*

Introduction

Higher education (HE) plays an essential role in an economy, by promoting economic growth, increasing productivity and contributing to social cohesion. Many countries in the world finance their higher education systems from public funds and the European Union (EU) is not an exception. In the interest of accountability and in light of the economic crisis of 2008 it is becoming crucial to evaluate the efficiency with which these funds are being utilised. Efficiency concerns are even more serious when looking at some of the trends in European HE.

In the EU-28 there has been a steady increase in the number of students in tertiary education. According to Eurostat (2017) in 2015 there were 19.5 million students in tertiary programmes and around 4.7 million students graduating from tertiary education. The share of persons aged 30-34 with completed tertiary education increased, from 23.6% in 2002, to 39.1% in 2016 in EU-28 (Eurostat, 2017). Germany had the highest number of tertiary education student in 2015, about 3 million, or 15.2% of EU-28 total. Following Germany is France with 12.4% of EU-28 total, the United Kingdom (11.95%), Spain (10.1%), Italy (9.4%) and Poland (8.5%). In all EU countries the majority of students were enrolled on Bachelor's degrees. This is especially the case for Greece where 84.4% of students were studying for Bachelor's degrees. One of the targets of the Europe 2020 strategy is to have at least 40% of persons aged 30-34 with completed higher education by 2020.

Most of the EU countries have a significant share of their HE financed from public sources. In the EU-28 (excluding Greece and Croatia), public expenditure on tertiary education

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was corresponding to 1.3% of GDP in 2014 (Eurostat, 2017). This ranged from 0.5% of GDP in Luxembourg, to 1.3% in Germany and 2.4% in Denmark in 2014. With above mentioned increases in the number of people participating in HE and the already stretched out public resources, the issues of efficiency, effectiveness and accountability are being evoked more often in discussions and national planning documents.

In many EU Member States there is a growing sentiment that the existing systems of higher education are not organized efficiently and a large number of empirical studies to date have attempted to define and measure this (in)efficiency in an HE framework. These studies used a variety of techniques to identify 'efficient' decision-making units (DMU) (students, HEIs, departments, universities, countries) and compare them with 'inefficient' ones.

The efficiency concepts currently dominant in economics originate from engineering relations where a technical process is considered efficient when the desired mix of outputs is maximised for a given level of inputs or when inputs are minimised for a desired mix of outputs. When transposed to the field of economics (of education) it seems there is no general consensus about how to define and measure efficiency. The foundation of the theory of efficiency and its measurement was laid out by Farrell (1957) who used three main measures of efficiency (overall, technical and price efficiency). Technical efficiency was defined as the ability of a firm to achieve maximum output from a given set of inputs. Fried, Lovell and Schmidt (2008) provided a more detailed analysis of the efficiency concepts in neoclassical economics.

With the development of non-parametric techniques in the 1970s such as Data Envelopment Analysis (DEA) (Banker, Charnes, & Cooper, 1984; Charnes, Cooper, & Rhodes, 1978), Stochastic Frontier Analysis (SFA) (Aigner, Lovell, & Schmidt, 1977), and others there has been a thriving literature on efficiency across various settings, including education. A recent survey of this general literature focusing on the most widely used method, DEA, can be found in Emrouznejad and Yang (2017). Surprisingly, only about 3.5% of studies using Data Envelopment Analysis were dedicated to the higher education issues and even smaller share is dedicated to cross-country comparisons (noted in Thanassoulis et al., 2016).

Research Problem

Given the importance of higher education and the limited research in this area, the focus is the analysis of efficiency in the context of higher education. Using the non-parametric technique of Data Envelopment Analysis and the latest available data, technical efficiency of public spending on higher education was estimated for EU-28. A novel set of variables was used to highlight more appropriately the distinctiveness of the HE sector and the link between input and outputs. The advantage of using DEA is that it identifies the best performing DMUs and not the averages. In today's competitive economies, countries cannot afford to have average education systems. Technical efficiency estimates serve to inform education policy-makers about the effects of changes in the production of educational services on outputs, hence they can learn more about the consequences of different procedures and methods in education. Without such information they would solely rely on past practices and traditional approaches. As emphasised in Pausits and Pellert (2007), with the increasing size of HE the complexity of the system increases and HEIs are themselves becoming more performance oriented and specifying goals and strategies to achieve them. Hence, examining the efficiency of an HE system is of great importance as a means of obtaining relevant information about the way HE functions.

Research Methodology

Measuring Efficiency in Higher Education: General Background

The higher education system has important characteristics separating it from other levels of education. In HE there are multiple stakeholders, multiple objectives and multiple outputs (Dixit, 2002). Contemporary HEIs are diverse, have multiple inputs and carry out a number of activities sometimes extending further than the teaching and research work (Cohn & Cooper, 2004). Furthermore, most educational outcomes are not sold at market prices, thus making it difficult to attach a market value to these outcomes. These distinguishing features of HE need to be taken into consideration when estimating the production function and measuring its efficiency. An overview of literature on the efficiency of various levels of education can be found in Johnes, Portela and Thanassoulis (2017) and a focus on efficiency in HE in Mihaljevic Kosor (2013).

The term production function can simply be defined as producing the maximum output feasible with given inputs. In a mathematical form a production function illustrates how a DMU generates a vector of outputs using a flow of inputs and some available technology. When estimating efficiency in HE, several distinctive techniques have developed in the literature. Their main features are briefly discussed, and the main approach is introduced. Three most widely used approaches in efficiency estimation are the statistical, econometric approach that mostly uses regression analysis, the Stochastic Frontier Estimation and the DEA.

A statistical approach is often parametric and assesses how DMUs produce educational outcomes analogous to firms producing outputs. Economic criteria from the neoclassical theory of the firm (Baumol, Panzar, & Willig, 1982) are applied to model educational production. This method provides estimates of parameters whose significance can be tested. However, there are problems with model misspecification and, more importantly, this approach cannot handle multiple inputs and outputs. That is a serious shortcoming when estimating HE efficiency.

The Stochastic Frontier Analysis was pioneered by Aigner et al. (1977). Here a functional form is established between the set of explanatory variables and the dependent variable. The analysis provides parametric estimates of efficiency. The main difference between SFA and the traditional parametric regression is that the error term in SFA consists of two parts: a normally distributed error term, and a second term capturing the remaining error (i.e. technical inefficiency). Given the presence of normally distributed error terms, the tools of statistical inference can be employed which is seen as an advantage of this approach. However, a particular distributional form for the error terms needs to be imposed by the researcher that gives rise to misspecifications in the efficiency measure. Additionally, SFA uses data on costs and prices according to which may introduce additional measurement errors (Worthington, 2001). Finally, SFA is not easily extended for multiple input and output settings.

The third approach in estimating efficiency is the DEA. It was originally developed for efficiency evaluation of 'not-for-profit entities participating in public programs' where prices are not clearly observed (Charnes et al., 1978). It is a non-parametric method which assigns a set of weights to selected outputs and inputs. Efficiency estimates are then obtained as the maximum of a ratio of weighted outputs to weighted inputs, subject to certain restrictions such as monotonicity and convexity. This approach amounts to constructing an efficiency frontier over the data so that the actual input/output quantities are either on or in the interior of this frontier. The efficiency frontier outlines the maximum combinations of outputs that can be produced by a given set of inputs. DEA assigns a score of 1 to a DMU which lies on the frontier. That unit in comparison with other units shows no evidence of inefficiency. An efficiency score less than 1 implies that a linear combination of other DMUs from the sample could generate the same output using less inputs. However, the method does have some downsides.

Being a nonparametric technique, statistical inference cannot be used to examine the possible bias resulting from measurement error or omitted variables. Furthermore, DEA only estimates relative efficiency scores but cannot offer insights on the performance of DMUs in comparison to the global best-practice. Some of the advantages of DEA are that it can handle multiple inputs and multiple outputs, it requires no assumptions on the functional form linking inputs to outputs and the DMUs are directly compared to one another. All of this makes it an appealing choice for measuring the efficiency in HE. Comparing these three different approaches, DEA stands out as a valuable tool in measuring efficiency in an HE setting as can be noted from the following research on efficiency in HE.

Sample

Existing studies on efficiency in HE have focused mostly on specific countries and their HEIs as the main DMUs (some of the exceptions are Johnes 2006a; Barra & Zotti 2016; Thanassoulis et al. 2017). The UK has a remarkably long tradition in the efficiency analysis of HE. See, among other studies, Athanassopoulos and Shale (1997), Glass, McKillop and Hyndman (1995), Johnes (2006), Sarrico, Hogan, Dyson and Athanassopoulos (1997), Sarrico and Dyson (2000). Most of these studies have shown the efficiency of the UK's HEIs to be quite high. Australian HE system and its universities have also been widely examined (see in Abbott & Doucouliagos, 2003; Worthington & Lee, 2008). Studies on efficiency in HE can also be found for Italy (Abramo, D'Angelo, & Pugini 2008; Agasisti & Dal Bianco, 2006), Germany (Kempkes & Pohl, 2010) and more recently for Greece (in Thanassoulis, Kumar, Petridis, Goniadis, & Georgiou, 2017).

Only a small number of studies analyses HE efficiency for several European countries. Some of the examples are Joumady and Ris (2005) for 209 HEIs in eight European countries, Bonaccorsi, Daraio & Simar (2007) for six European countries (Italy, Spain, Portugal, Norway, Switzerland, and the UK), Agasisti and Johnes (2009) for Italy and England, Agasisti (2011) for 18 countries, and finally, Wolszczak-Derlacz and Parteka (2011) for seven European countries (Austria, Finland, Germany, Italy, Poland, Switzerland and the UK).

All of the above studies focus either on country specific data or use a small sample of DMUs in cross-country comparisons. This is understandable given the problem of obtaining micro data on HE that can then be used for country comparison. The DMUs are mostly universities or HE staff and not the whole country. The exception is the study by Agasisti (2011) who used countries as DMUs enabling an assessment of the overall performance of the HE system and their cross-country comparison. Some of the variables used in that research are the total resources for HEIs as a percentage of GDP – this is the input variable. And for the outputs, the author used employment rates for the population aged 25-64 and tertiary graduation rates (which were later dropped from the model due to missing data). The variables for DEA are for a selection of European countries in the period from 2000-2003. A similar approach is followed here.

Instruments and Procedures

DEA is used in measuring the efficiency of public spending on higher education. It identifies optimally performing DMUs and assigns them a score of one (or 100). These DMUs serve to identify an efficiency frontier against which all other DMUs are compared. A fundamental step in DEA is the selection of appropriate inputs and outputs (Thanassoulis, 2001). These variables need to satisfy the condition of exclusivity and exhaustiveness i.e. the inputs and they alone must influence the output levels, and only of the outputs used in estimation. Furthermore, to have sufficient discriminatory power, the number of DMUs should exceed the number of inputs and outputs by more than a few times in the DEA model (Cohn & Cooper, 2004). The DMU's used in this research are the 28 countries of the European Union.

The efficiency frontier in DEA will vary conditional on the scale assumptions of the model. Two scale assumptions are commonly used in DEA: constant returns to scale (CRS) and variable returns to scale (VRS).

Variable returns to scale assumption allows the production technology to exhibit increasing, decreasing and constant returns to scale. Given the nature of HE, i.e. that outputs will not change by the same proportion as inputs, VRS is better suited to examining the efficiency. Furthermore, an output orientation approach is used which is also common when examining efficiency in education. The output orientation is a logical choice given the nature of higher education financing. The objective is to maximise the output production while not exceeding the actual input level.

Data Analysis

One input and two outputs related to country's higher education system are used (Table 1). The input used is the public expenditures on tertiary education as a percentage of GDP. This serves as a proxy for all inputs in public HE and allows easier cross-country comparisons as discussed in the research by Afonso and St Aubyn (2005, 2006). This indicator is available for all countries in the sample. However, countries may still have a different education production technology that is not best expressed through the use of public expenditures. However, given to data limitations on the more precise indicators of education production in each country this indicator was used as an input, hence focusing on EU-28 there is a collection of countries with similar policy objectives in HE.

The two outputs are the share of graduates in HE per 1000 inhabitants and the employment rates of people aged 20-34 with completed tertiary education. In comparison to the work by Agasisti (2011) this is a valuable improvement in data availability. The output variable on employment rates is available for population aged 20-34, which gives a better indication of the short-term effects of HE. These two indicators serve as a proxy for the quality of HE delivered and capture, to some, extent, private returns to HE.

Table 1. Variable names and definitions.

Variable	Category	Description	Year
Public expenditures (%GDP)*	Input	Public expenditures on tertiary education as a percentage of GDP	2012
Graduates in HE (per 1000 of population)	Output	Graduates in tertiary education per 1000 of population	2015
Employment rates (%)	Output	Employment rates of young people not in education and training with completed tertiary education level one to three years beforehand aged 20 to 34	2016

The data is from Eurostat. For the two outputs the latest data available is used. This allowed a fresh perspective to be taken on the efficiency of European HE. For the share of graduates the latest data available was for the year 2015, and for employment rates the data is for 2016.

For the input variable, public expenditures, the data is for 2012. The motivation is the following. Public expenditures being spent on HE (including students) in one year are assumed to have a full effect when that cohort of students graduates or looks for employment several years after. Here the same cohort of student is followed, as they progress through their studies towards graduation and employment. In all EU countries in 2015, the majority of students were enrolled in Bachelor's degrees (Eurostat, 2017). The term cohort is used loosely; it actually follows the whole HE system being funded in one year and its outputs several years later. This approach is drawing some of its insight from the window analysis technique in DEA pioneered by Charnes et al. (1997) which measured efficiency changes over time. Given the characteristics of variables that change very slowly over time, the above mentioned approach was used. This allows a stronger functional link to be established in the model between the input and the outputs.

Research Results

The model was estimated using the Performance Improvement Management Software (PIMDEA). Summary statistics for variables is presented in Table 2.

Table 2. Summary statistics.

	Mean	Sum	St.dev.	Variance	Min	Max	Range
Public expenditures (%GDP)	1.26	35.22	0.44	0.2	0.45	2.25	1.8
Graduates in HE (per 1000 pop)	72.5	2030	19.22	369.4	27.4	126.8	99.4
Employment rates (%)	82.62	2313.3	9.39	88.18	55	97	42

The highest share of public expenditures on HE was recorded in Denmark (2.5% GDP), followed closely by Finland (2.13%) and Sweden (2.01%). These are the only countries with public expenditures on HE over 2% of GDP. The lowest public expenditures are in Luxembourg (0.45%) and a fairly better situation is in Bulgaria (0.66%), Romania (0.78%), Hungary (0.82%), Italy (0.83%) and Portugal (0.85%). The latter group is formed of countries with public expenditures less than 1% of GDP. The average public expenditures on HE in the EU in 2012 are 1.26%.

The greatest number of graduates from tertiary education per 1000 of population is in Ireland (126.8), followed by Denmark (102.9), France (96.5) and Poland (96). However, if only the data on the number of graduates from tertiary education is used, Ireland and Denmark are not the leading countries. The greatest population of tertiary graduates is in France (752,068 graduates), the UK (740,276) and Poland (516,675). The smallest number of graduates per 1000 inhabitants is in Luxembourg.

The employment rates for recent graduates are calculated for the age group 20–34. It captures those who had successfully completed their highest level of education one to three years previously. The minimal employment rate is in Greece (55%) and the highest in Malta (97%), followed by the Netherlands (94.2) and Germany (93.1).

The results of the DEA model are in Table 3.

Table 3. DEA results.

Country	Technical efficiency
Austria	95.62
Belgium	93.78
Bulgaria	100
Croatia	85.3
Cyprus	82.53
Czech Republic	95.72
Denmark	96.03
Estonia	82.9
Finland	87.46
France	87.51
Germany	90.14
Greece	59.5
Hungary	100
Ireland	100
Italy	73.39
Latvia	96.78
Lithuania	97.37
Luxembourg	100
Malta	100
Netherlands	98.24
Poland	98.17
Portugal	89.35
Romania	90.37
Slovakia	93.89
Slovenia	88.27
Spain	87.42
Sweden	94.23
United Kingdom	94.61

The average technical efficiency of public expenditures on HE for EU-28 was 91.4%. Five countries stand out as 100% efficient. These are Bulgaria, Hungary, Ireland, Luxembourg and Malta. It might be argued that Luxemburg and Malta stand out as efficient because of their size and that perhaps they should be dropped from the analysis. It was decided not to remove them from the sample to report a complete picture of efficiency in public spending for EU-28. The Netherlands, Poland, Latvia, Lithuania and Denmark are close to the efficiency frontier with an efficiency score over 96%.

The least efficient country was Greece (59.5). Given the recent economic crisis in Greece this inefficiency in public spending was an expected result. As previously mentioned, to achieve full efficiency in an output-oriented model, an inefficient unit may focus on an increase in its outputs while the input proportions remain the same. For Greece this would imply an increase in the share of graduates and an improvement in the employment rates.

These results of DEA provided a form of ranking for countries, from best to worst. This ranking is easier for inefficient countries. However, the countries on the efficiency frontier all have the same efficiency score equal to 1 (or 100) and it is difficult to establish which countries stand out as best examples.

In the next section the benchmarks were considered for each of the individual countries. These are the countries that can potentially serve as role models for inefficient countries. These results are in Table 4.

Table 4. Benchmarks.

Name	Bulgaria	Hungary	Ireland	Luxembourg	Malta
(Frequencies)	5	12	22	7	18
Austria	0	0	1	0	1
Belgium	0	0	1	0	1
Bulgaria	1	0	0	0	0
Croatia	1	0	1	1	0
Cyprus	0	1	1	0	1
Czech Republic	0	1	1	0	1
Denmark	0	0	1	0	1
Estonia	0	1	1	0	1
Finland	0	0	1	0	1
France	0	1	1	0	1
Germany	0	1	0	1	1
Greece	0	0	1	0	1
Hungary	0	1	0	0	0
Ireland	0	0	1	0	0
Italy	1	0	1	1	0
Latvia	0	1	1	0	1
Lithuania	0	1	1	0	1
Luxembourg	0	0	0	1	0
Malta	0	0	0	0	1
Netherlands	0	0	1	0	1
Poland	0	1	1	0	1
Portugal	1	0	1	1	0
Romania	0	1	1	1	0
Slovakia	0	1	1	1	0
Slovenia	0	1	1	0	1
Spain	1	0	1	0	0
Sweden	0	0	0	0	1
United Kingdom	0	0	1	0	1

The efficient countries are in the first row and all of the other countries are compared to them. Efficient countries are their own “benchmarks” while inefficient countries have several benchmarks. For example, Romania has Hungary, Ireland and Luxembourg as benchmarks, while Austria has Ireland and Malta as best practice examples or peers. This means, to become efficient Austria must use a combination from both Ireland and Malta. Those two countries have the highest frequencies in the table as they are peers to 22 and 18 countries respectively (including themselves).

The next issue is how to calculate what combination of efficient peers must an inefficient country use to become efficient. So, for Austria the question would be, should it attempt to ‘become more’ like Ireland or more like Malta. The answer is in the λ (lambda) weights. For example, Austria should look up more to Malta (λ=0.77) than to Ireland (λ=0.23). These results uncovered interesting connections between countries that would merit a more detailed analysis. That is, however, out of scope, hence these results can be obtained from the authors.

The next goal was the estimation of efficient targets for input and outputs. In Table 6 target input and output levels are suggested for each country. These targets would allow countries to gain full efficiency. However, some of these target values and improvement options may not be practical for policy makers in HE. They are presented here only to offer more insight into the efficiency of public spending on HE and as a source for potential future research in the area.

Table 5. Efficient targets for input and outputs.

	Input			Output			Output		
	Public spending			Graduates in HE			Employment rates		
	Value	Target	Gain (%)	Value	Target	Gain (%)	Value	Target	Gain (%)
Austria	1.88	1.46	-22.4	75.6	79.06	4.58	90.5	94.64	4.58
Belgium	1.48	1.44	-2.51	79.3	84.56	6.63	87.9	93.73	6.63
Bulgaria	0.66	0.66	0	70.3	70.3	0	78.5	78.5	0
Croatia	0.93	0.93	0	70.4	82.54	17.24	74.7	87.58	17.24
Cyprus	1.17	1.17	0	57.6	69.79	21.17	76.4	92.57	21.17
Czech Republic	1.05	1.05	0	74.3	77.62	4.47	86.3	90.16	4.47
Denmark	2.25	1.38	-38.79	102.9	107.15	4.13	86.4	89.97	4.13
Estonia	1.06	1.06	0	59.4	71.65	20.62	75.5	91.07	20.62
Finland	2.13	1.41	-33.74	83.4	95.36	14.34	80.4	91.93	14.34
France	1.27	1.27	0	96.5	110.27	14.27	77.3	88.33	14.27
Germany	1.37	1.37	0	55.9	62.02	10.94	86.4	95.85	10.94
Greece	1.48	1.42	-4.03	54.9	92.28	68.08	55	92.44	68.08
Hungary	0.82	0.82	0	55.3	55.3	0	90.5	90.5	0
Ireland	1.32	1.32	0	126.8	126.8	0	86.7	86.7	0
Italy	0.83	0.83	0	58.2	79.31	36.26	61.3	83.53	36.26
Latvia	1.01	1.01	0	63.2	65.3	3.33	88.4	91.34	3.33
Lithuania	1.4	1.4	0	80	82.16	2.7	91.1	93.56	2.7
Luxembourg	0.45	0.45	0	27.4	27.4	0	89	89	0
Malta	1.5	1.5	0	64.9	64.9	0	97	97	0
Netherlands	1.7	1.48	-12.9	70.3	71.56	1.8	94.2	95.89	1.8

Poland	1.15	1.15	0	96	97.79	1.86	87	88.62	1.86
Portugal	0.85	0.85	0	66.8	74.76	11.92	77.8	87.07	11.92
Romania	0.78	0.78	0	52.7	58.31	10.65	80.7	89.3	10.65
Slovakia	0.95	0.95	0	78.3	83.4	6.51	82.5	87.87	6.51
Slovenia	1.23	1.23	0	77.5	87.8	13.29	80.2	90.86	13.29
Spain	1.02	1.02	0	88.4	101.12	14.39	72.3	82.97	14.76
Sweden	2.01	1.5	-25.37	59	64.9	10	91.4	97	6.13
United Kingdom	1.47	1.43	-2.83	84.7	89.52	5.69	87.9	92.9	5.69

In a VRS, output-oriented model the objective was to maximize the output production (tertiary graduates and employment rates) while not exceeding the actual input level (public spending). DEA calculated for each country the amount and category that needs to change in order for country to reach efficiency frontier. For inefficient countries an increase in outputs is suggested. In some cases, a decrease in public spending is also an option. All the efficient countries have the same targets and values for input and outputs and gain equal to zero. Countries that were far from the efficiency frontier (Greece, Italy, Cyprus, Estonia, Croatia) have to make substantial changes in their outputs in order to become efficient. For example, Greece will need to increase graduates and employment rates by 68 percentage points and Italy by 36 percentage points. Countries which were close to the frontier (e.g. Netherlands, Poland, Lithuania, Latvia) have a smaller magnitude of changes suggested. Only 1.9 percentage point increase in outputs is suggested for Poland, and a 2.7 percentage points increase in outputs for Lithuania.

Discussion

Although there is a growing research on efficiency of public spending on HE there are not many comparable approaches in estimating it. The basis for this analysis, as clarified in the section on methodology, was the empirical work found in Agasisti (2011) who used countries of the EU as the decision making units. The obtained results are similar to the ones obtained in that research. However, it should be noted that the variables used in DEA are not the same i.e. there is a slight difference in the outputs used and the time period. Furthermore, the estimation by Agasisti was performed for 18 countries of the EU. Therefore, any similarities should be discussed with caution as the DEA is very sensitive to the selection of inputs and outputs (Thanasoulis et al., 2016).

In general, the technical efficiency of public expenditures on HE is high (91.4%), however there are noticeable differences among countries as in the research by Agasisti (2011). The least efficient country is Greece. This is in line with the expectations given the external context i.e. the economic situation and the financial crisis, including Greece in the model reduced the overall efficiency score when compared to the results in Agasisti (2011).

When efficient targets for inputs and outputs are considered a decrease in public spending is suggested for eight countries (Austria, Belgium, Denmark, Finland, Greece, Netherlands, Sweden and the UK). A detailed formulation for the calculation of these target values can be found in Thanassoulis and Dyson (1992). An interesting example was Denmark; with a cut in public spending of almost 40 percent and an increase of 4 percentage points in employment rates and share of graduates, it could achieve full efficiency. Bearing in mind the limitations of DEA, in the time of economic crisis this might present an interesting issue for further investigation. As Monk (1992) argues, the production function can be viewed as a model which connects theoretically and mathematically outcomes, inputs, and the processes that convert the latter into the former in educational institutions, thus, production functions can be important as a means of identifying ways of improving both technical and allocative efficiencies. With more information on performance and efficiency, policymakers can be in a better position to develop effective HE strategies. Nevertheless, the key responsibility for generating reforms in HE lies with individual Member States.

Conclusions

From the overview of the research in this area there is still a lot of room for improvement. There are often data limitations preventing researchers from making functional cross-country comparisons. There are also well-documented limitations of methods being used to calculate efficiency i.e. DEA is good at estimating relative efficiency of DMUs, but it converges slowly to total efficiency, it is also very sensitive to changes in the data, and the hypotheses testing is still not available. Although great care was taken in the selection of variables, and current literature was consulted, measuring the efficiency of public spending on HE is still a challenging undertaking. Results in this research need to be interpreted with caution.

Using DEA and the latest data available, this research compared the efficiency of public spending for 28 European countries. The average efficiency in spending is high, although there are stark differences among countries in their efficiency scores. Five most efficient countries were identified (Bulgaria, Hungary, Ireland, Luxembourg and Malta) and also countries for which real efficiency improvements were possible. Benchmark countries and target values also revealed new approaches to deal with the inefficiencies.

Efficiency analysis is valuable in informing policy makers and providing a better understanding of the education system. Although there are severe problems in estimating efficiency in an HE system, it remains important to develop reliable estimates, especially considering the emphasis currently given to issues of accountability, quality and costs. European HE system needs to contribute to Europe's prosperity. Finding the most productive benchmarks and eliminating waste in resources dedicated to HE represents a good starting point.

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