

## An International Comparison of Higher Education Efficiency

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**Abstract.** The purpose of this study was to examine internationally the relative efficiency of higher education by using data envelopment analysis (DEA). DEA is known as a tool for measuring and analyzing the relative efficiency of non-profit organizations. For this study, the contraction model was established with three input variables and three output variables. Output maximization was used to analyze the model. Presupposing variable return to scale, the DEA efficiency value of twelve OECD countries was evaluated. The efficiency values of each country were very different.

**Keywords:** Data envelopment analysis, Efficiency, Input minimization, Output maximization.

### 1 Introduction

Higher education plays an increasingly crucial role in reinforcing knowledge-based society but also in strengthening a nation's competitiveness by creating national wealth. Since the advantage of the great economic powers came from higher education sectors, each government of leading countries are now seeking implementation of higher education reform [1, 2].

Efficiency is one of the most important variables that an individual university consistently pursues as an ultimate goal. Over the last 20 years, there have been various attempts to construct performance indicators for universities using a variety of approaches. One of the attempts is to construct performance indicators relied on university-level data and hence used non-parametric method such as data envelopment analysis (DEA) to construct the efficiency measures [3].

DEA is a non-parametric technique which uses linear programming methods to estimate a piecewise linear frontier around the data against which the efficiency of each decision-making unit (DMU) can be measured. DEA can easily accommodate multiple inputs and multiple outputs, taking up an advantage in the higher education

context where the university is known to produce teaching and research outputs [4]. This approach makes it possible to measure the degree of variation in efficiency across the university sector as a whole, and to identify possible sources of inefficiency. DEA constructs an 'efficiency frontier' with the most efficient organizations within a group being used to define the standard against which the performance of the other organizations is evaluated. Therefore, the concept of efficiency is relative [5].

This study aimed to measure and compare internationally the relative efficiency of higher education by using DEA, and to find implications for improvement of its efficiency scores.

## **2 Methodology**

### **2.1 Variables of the Study**

In this study, the following input variables were used in the DEA analysis: ratio of students to teaching staff in educational institutions (Ratio of Students); expenditure on educational institutions as a percentage of GDP (Expenditure); and percentage of GERD performed by the higher education sector (Percentage of GERD).

The core output variables were used in the DEA analysis: population that has attained tertiary education (PTE); university educational satisfaction (UES); and professor SCI per article number (Prof. SCI).

### **2.2 Data Collection and Analysis**

In conducting this study, the contraction model was employed as the methodology because the proper number of variables is twice of the total DMUs [6]. Several sources of data were used. The major source was 'Education at a Glance' and its DB run by OECD. The total number of universities from tertiary type A and type B were included for the study. The second source involved using data from the statistical publications of higher education published by Korea, America, and United Kingdom.

The Frontier Analyst 3.2 software, Excel 2002 and SPSS for Windows were used to analyze the DEA efficiency scores of twelve nations: America, Czech Republic, France, Germany, Hungary, Italy, Korea, Mexico, Poland, Spain, Sweden and UK.

## **3 Results**

### **3.1 Comparisons of the DEA Efficiency Scores**

The results from the comparison of the DEA efficiency scores under the condition of output maximization are displayed in Table 1. Note that the table reports the efficiency levels relative to their individual country. That is, the scores are relative scores. The efficiency scores of four nations (America, Spain, UK, and Korea) show an identical percentage of 100%. For Germany and Sweden, the efficiency scores

have increased, while Mexico, Czech Republic and Hungary have performed the lower efficiency scores, in comparison to the given year 2002 and 2002 to the year 2012 and 2014. Especially, the efficiency score of Mexico is the lowest (68.90%). The number of nations that are inefficient in the scores was five in the given year 2002, reduced to four in the year 2004; and increased to six in the compared year of 2012 and 2014.

**Table 1.** Comparison of DEA Efficiency Scores

Country	2000	2002	2012	2014
Germany	83.03	78.05	100.0	100.0
Mexico	100.0	100.0	65.07	68.90
America	100.0	100.0	100.0	100.0
Sweden	98.93	100.0	100.0	100.0
Spain	100.0	100.0	100.0	100.0
UK	100.0	100.0	100.0	100.0
Italy	100.0	96.30	100.0	100.0
Czech Republic	100.0	100.0	91.35	74.86
Poland	96.93	100.0	82.86	85.90
France	95.25	93.51	76.70	82.37
Hungary	100.0	100.0	76.41	70.12
Korea	100.0	100.0	100.0	100.0
Average	97.85	97.32	91.03	90.18
No. of country (inefficiency)	5	4	6	6

### 3.2 Analysis of Inefficient Variables

Table 2 demonstrates the scores of inefficient output variables in 2012 and 2014. As seen in Table 2, Mexico, Czech Republic, Poland and France should increase the levels of all the variables, PTE, UES and Prof. SCI, in order to improve the inefficiency scores of higher education. Especially, Czech Republic is in the lowest level (16.1% in 2014) in the variable of PTE, and Mexico is in the lowest inefficiency scores of UES and Prof. SCI variables.

**Table 2.** Inefficient Output Variables

DMU	2012			2014		
	PTE	UES	Prof. SCI	PTE	UES	Prof. SCI
Germany	0.0	0.0	0.0	0.0	0.0	0.0
Mexico	16.088	2.319	0.12	13.825	2.054	0.116
America	0.0	0.0	0.0	0.0	0.0	0.0
Sweden	0.0	0.0	0.0	0.0	0.0	0.0
Spain	0.0	0.0	0.0	0.0	0.0	0.0
UK	0.0	0.0	0.0	0.0	0.0	0.0

Italy	0.0	0.0	0.0	0.0	0.0	0.0
Czech Republic	16.516	1.392	0.03	16.063	1.672	0.109
Poland	13.736	1.123	0.067	4.102	0.914	0.057
France	8.807	1.626	0.083	6.635	1.305	0.061
Korea	0.0	0.0	0.0	0.0	0.0	0.0
Hungary	7.416	1.55	0.08	10.315	2.01	0.113

#### 4. Conclusions

The conclusions drawn from the study are as follows. First, there were differences of the DEA efficiency scores in accordance to both the given year and the variables. Four countries (America, Spain, UK, and Korea) had performed 100% in the efficiency scores regardless of the given years, while the efficiency scores of three countries (Mexico, Czech Republic, and Hungary) had been falling down. It is quite suggestive that the strategies improving the level of output should be developed based on input considering the limit of financial resources of each nation.

Second, the results of this study showed that Korea had maintained a 100% of the efficiency of higher education. It means that Korea is the nation which has maximized relatively output variables such as PTE, UES and Prof. SCI under the inputs of Ratio of Students, Expenditure, Percentage of GERD, and is the nation which is highly efficient by maintaining the efficiency. However, qualitative substantialization is to be needed rather than quantitative expansion of higher education.

Lastly, in searching for the inefficient variables in order to discover potential improvements, the results showed that the nations which were inefficient in the context of higher education should improve the output variables. In the case of the nations that were inefficient in the variables of PTE and UES, these nations should find the concrete inefficient factors from the inside of universities and make efforts to improve them in times of a nation's competitiveness.

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