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**Article**

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# Position of Chosen European Union Countries in Respect of Financial Efficiency of Higher Education in the Area of Didactics

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**Abstract:** This article is continuation of the authors' research on financial efficiency evaluation in higher education in the area of didactics in countries that belong to European Union. On the basis of the results of researches, in which a non-parametric approach was used, a classification of member countries into uniform groups has been conducted with reference to researched feature.

**Keywords:** financial efficiency, didactical process, non-parametric methods, Ward method, European Union higher education

**JEL codes:** C14, C38, I21, I23

## 1. Introduction

Measuring financial efficiency is justified not only in terms of commercial units, for which generating income is the main objective, it also refers to public units. A significant indicator of financial efficiency is rational, in other words efficient, usage of sources by the units. Public universities act in specific economic conditions – in educational service market. On the one

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hand they receive public sources for realization of their tasks in the area of education and scientific research, on the other they are obliged to use it in a rational way and even to multiply it.

People in charge of universities, in their process of management, should follow information about efficiency measurement of source usage. The solution to this problem is not easy because these are areas (education, science) where expenses are not vulnerable to the usage of effects measuring tools. It is worth mentioning that it is not easy to specify dependency between the amount of expenses and gained results because the latter are very often difficult to measure and they appear with delay.

Typical index analysis do not solve this problem. It happens because it is impossible to determine the size of input of given type that was directly used to gain a specific result or results. In practice this kind of calculations are based on very detailed material which is uneasy to organize.

That is why it is justified to use DEA method in researches on efficiency which uses multidimensional data classifications both on input and output side. It is interesting whether such results give an opportunity to group these units due to their similarity of gained outcomes.

The aim of this article is to classify European Union countries according to their financial efficiency relating to didactical activity of universities with the usage of hierarchical agglomerative procedures on the basis of vector results with the usage of non- parametric DEA method. In the same way this work is a continuation of the authors' works in the area of efficiency evaluation of Polish higher education system against such background as European Union countries.

## **2. DEA method as a method of financial efficiency evaluation of business entities**

This method was presented by Charnes, Cooper and Rhodes in 1978 for the first time. By using tools of linear programming they have created (CCR) model in which they have made the assumption about constant returns-to-scale. With time new models have appeared however they were modifications of the former CCR model. Another model which is very often used is the one presented by Banker, Charnes and Cooper (BBC) in 1984. The difference between the

models concerns the returns-to-scale. Namely in the first model the assumption is made that the returns-to-scale are constant while the second one allows for determining the efficiency of scale.

From 1978 there have been thousands of articles on DEA method. The wealth of these models allows to group them in many various ways. Different types of classifications of these objects were presented in works of L.M.Seiford (1996: 99-137), and S.Gattoufi, M.Oral and A.Reisman (2004: 141-158).

The most often used division of models are models not oriented and oriented. The basic orientated DEA models may appear as those expenditure models – the assumption of minimalization of expenditure with low limitation on the results or as results oriented – an assumption of maximalization of results with high limitation on expenditures (Guzik, 2009: 55-75). In oriented models efficiency results shows the change in expenditures or results which indicates that a given unit is becoming effective. The choice of orientation has a practical meaning. Namely the choice of orientation covers inefficiency in other areas and may give various results in a ranking. If a unit mainly controls expenditures and the results are treated in an exogenic way expenditure oriented models should be used. If a unit mainly influences results then an orientation on the area of results should be used (Małys, Nowak, 2009).

The basis for DEA method is a Debreu-Farell productivity factor which is determined by one expenditure to one result ratio (Basso, Funari, 2001: 477-492). This factor was generalised in case of multidimensional situation (a lot of expenditure and many results). A subject of an analysis in this method is determined by a level of efficiency of a unit that makes a decision to transform expenditure into results. By the usage of DEA method the limit of set of production possibilities efficiency is determined. Objects that are on this limit line take the value of efficiency factor equal to 1. The value of this factor for objects that are under this line is lower than 1. The difference of the values of this factor in regard to 1 determines a size of inefficiency of a single object because a DEA method allows to determine what is a level of efficiency of a chosen object in regard to remaining objects in an analysed attempt (Zamojska, 2009: 51-66).

A theory concerning efficiency measures was included in the previous article of the authors (Małys, Mościbrodzka, 2016), that is why it will not be presented in this part of the article.

### 3. Ward method as a method of hierarchical objects grouping

An analysis of financial efficiency similarities in a scope of a didactic activity of universities in a spatial conceptualization has been conducted with the usage of hierarchical agglomerative methods. Although these grouping methods differs from each other in a way of determining distances between groups (Wishart, 1969: 165-170), all the agglomerative procedures can be described with the usage of one general scheme that is considered as a central agglomerative procedure (Nowak, 1990: 80-81). It is based on distance matrix between researched objects.

A general formula that serves to convert distance matrix while  $A_p$  and  $A_q$  group combining into a new  $A_r$  group for hierarchical agglomerative methods is the following:

$$d_{ir} = a_p \cdot d_{ip} + a_q \cdot d_{iq} + b \cdot d_{pq} + c \cdot |d_{ip} - d_{iq}|$$

where  $d_{ir}$  – is a distance between  $A_i$  and  $A_r$  groups,  $d_{ip}$  – is a distance between  $A_i$  and  $A_p$  groups,  $d_{iq}$  – is a distance between  $A_i$  and  $A_q$  groups,  $d_{pq}$  – is a distance between  $A_p$  and  $A_q$  groups,  $a_p$ ,  $a_q$ ,  $b$ ,  $c$  – parameters of transformation characteristic for different methods of group forming.

As to conduct spatial grouping, comparison and analysis of higher education in member countries, a Ward method was used which was presented in a work of J.H. Ward (1963). In this method parameters to a formula of distance matrix transformation, distances have the following values:

$$a_p = \frac{N_i + N_p}{N_i + N_r}, a_q = \frac{N_i + N_q}{N_i + N_r}, b = -\frac{N_i}{N_i + N_r}, c = 0,$$

where  $N_i$ ,  $N_p$ ,  $N_q$  and  $N_r$  show the number of elements in groups  $A_i$ ,  $A_p$ ,  $A_q$  and  $A_r$  (Nowak, 1990: 81).

Ward method joins such clusters that give minimum sum of squares of distances from a centre of gravity of a new cluster that they create. As a result in each group there are such objects that are the least differentiated due to describing variables (EUROSTAT). Consequently, due to analysis we receive dendrogram which is a graphic interpretation of results.

### 4. Results of researches

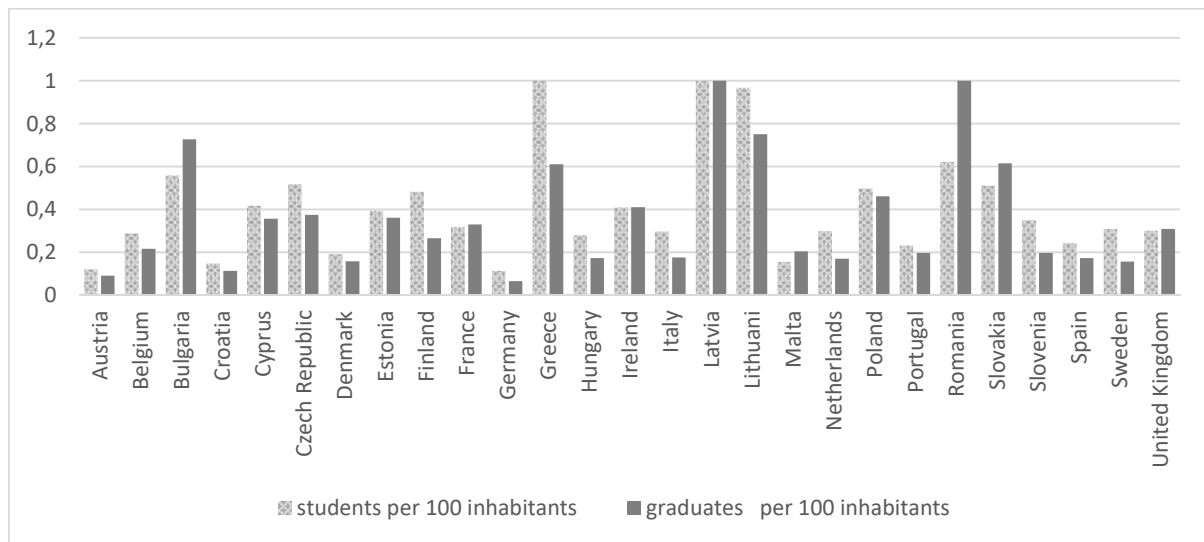
The research involved 27 countries from European Union. Luxembourg was excluded from this trial because of totally different politics and specificity of a country against a background of

POSITION OF CHOSEN EUROPEAN UNION COUNTRIES IN RESPECT OF FINANCIAL EFFICIENCY OF  
HIGHER EDUCATION IN THE AREA OF DIDACTICS

remaining member countries. Financial efficiency was researched on the basis of data provided by Eurostat (<http://ec.europa.eu/eurostat/data/database>) including data from 2013 and 2014. A detailed description of the research and data are available in the previous work of the authors (Małysz, Mościbrodzka, 2016).

Figure 1 and 2 show results of efficiency evaluation from European Union countries in 2013 and 2014.

**Figure 1. Collective results of efficiency evaluation for 27 European Union countries with constant returns to scale in 2013**

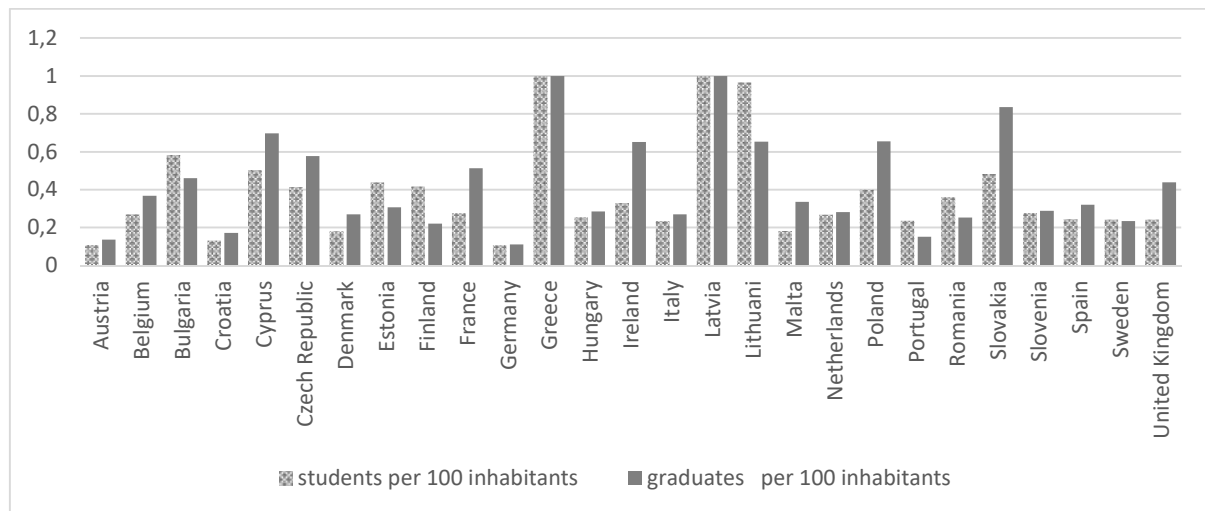


Source: Self - study.

Researches in 2013 on financial efficiency in the area of didactics of universities in member countries show results measures in number of students that implicate average efficiency higher than in cases with results in number of graduates. The opposite situation was observed in 2014. It is worth mentioning that average efficiency for European Union countries was higher in 2013 than in 2014 reaching 41% in a situation when the outcomes showed the number of students. In a situation when the outcomes showed the number of graduates financial efficiency of European Union countries was higher in 2014 reaching 43%.

The most effective countries according to the usage of public sources and didactic staff were Greece and Latvia, when the outcomes showed the number of students and Latvia when the outcomes reflected the number of graduates.

**Figure 2. Collective results of efficiency measurement for 27 European Union countries with constant returns to scale in 2014**

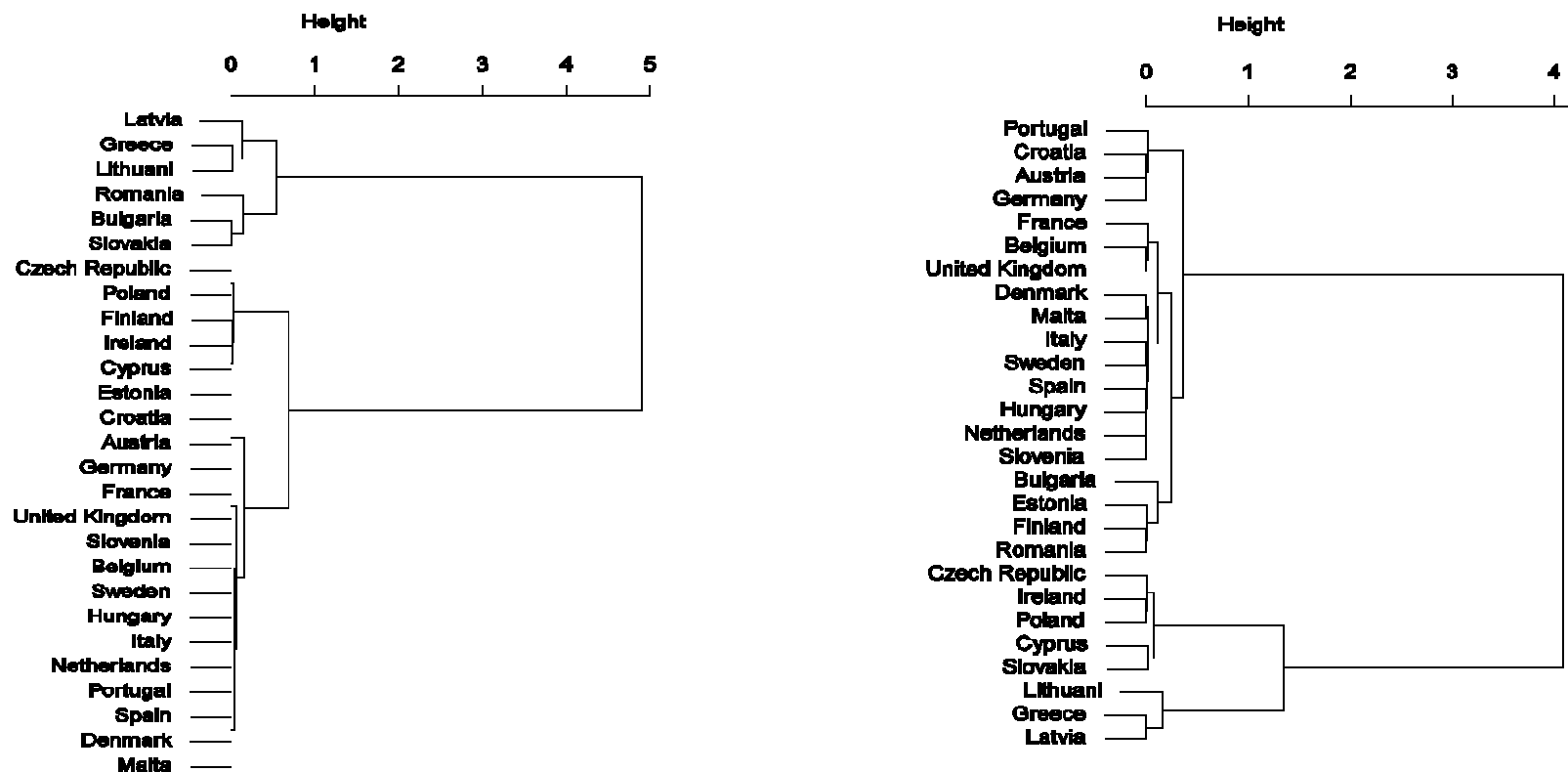


Source: Self - study.

These results should be interpreted very carefully because in cases of chosen models only financial efficiency based on quantitative data was analysed. Qualitative factor was missing and this one determines complete evaluation of financial outcomes in higher education.

In the following step, on the basis of gained financial efficiency results in the area of didactics, on the basis of distance matrices normalized values, a division was made concerning member countries according to their similarities in 2013 and in 2014. The results of procedure usage were presented in figure 3.

**Figure 3. Hierarchical arrangement of European Union countries on the basis of Ward method according to financial efficiency in didactics in 2013 and 2014**



Source: Self – study with the usage of R package.



On the basis of figure 3 it can be noticed that the number of groups, in case of European Union countries division, should be between 4 and 7. Determining an optimal number of groups and evaluation of gained classification was based on Silhouette index that was introduced in Kaufman (Kaufman, Rousseeuw, 1990) and Rousseeuw's works (1987: 53-65).

The value of Silhouette for fixed number of groups is estimated on the basis of the following pattern:

$$S(u) = \frac{1}{n} \sum_{i=1}^n \frac{b(i) - a(i)}{\max\{a(i); b(i)\}},$$

where  $u$  is a number of groups,  $n$  a number of objects,  $i$  is an object number ( $i=1, \dots, n$ ),  $a(i)$  average distance of  $i$ - object from the remaining objects that belong to the same group that an object  $i$  and  $b(i)$  average distance of  $i$  object from objects that belong to the closest group of object  $i$ .

The value of considered index is in an interval  $[-1, 1]$ . A maximizing argument of a value of Silhouette gives an optimal, in respect of evaluation of classification quality, number of groups due to its content and separability. Additionally, this value allows for a subjective evaluation of quality of a classification (Gatnar, Walesiak, 2012: 420).

**Table 1. Hierarchical arrangement of European Union countries on the basis of Ward method according to financial efficiency in didactics in 2013**

Group	Countries	Average efficiency	
		Number of students	Number of graduates
1	Croatia, Germany	0,1310	0,0900
2	Belgium, Denmark, France, Hungary, Italy, Malta, Netherlands, Portugal, Slovenia, Spain, Sweden, United Kingdom	0,2721	0,2056
3	Bulgaria, Slovakia	0,5345	0,6720
4	Cyprus, Czech Republic, Estonia, Finland, Ireland, Poland	0,4533	0,3720
5	Greece, Lithuania	0,9840	0,6810
6	Latvia	1,0000	1,0000
7	Romania	0,6210	1,0000

Source: Self – study with the usage of R package.

The best division according to efficiency of higher education in the area of didactics was a division into 7 groups, which is indicated by a high level of Silhouette index value (reaching 0,873 in 2013

and 0,885 in 2014). Results of a classification with an average level of efficiency were included in Table 1 and 2.

**Table 2. Hierarchical arrangement of European Union countries on the basis of Ward method according to financial efficiency in didactics in 2014**

Group	Countries	Average efficiency	
		Number of students	Number of graduates
1	Austria, Croatia, Germany, Portugal	0,1448	0,1428
2	Belgium, Denmark, France, Hungary, Italy, Malta, Netherlands, Slovenia, Spain, Sweden, United Kingdom	0,2422	0,3275
3	Bulgaria	0,5820	0,4610
4	Cyprus, Czech Republic, Ireland, Poland, Slovakia	0,4254	0,6834
5	Estonia, Finland, Romania	0,4050	0,2603
6	Greece, Latvia	1,0000	1,0000
7	Lithuania	0,9660	0,6530

Source: Self – study with the usage of R package.

## 5. Conclusion

All financial efficiency analyses are in broadly defined politics of rational public sources spending. What becomes vital is creating ranking lists on the basis of this criterion. They induce an analysis of a state and a position on the list. This kind of action is appropriate because it induces the necessity to take actions, for instance fixing ones. However, when it comes to research results and final conclusions it is advisable to be careful while interpreting them because in case of chosen models only financial efficiency was analysed and this was formed by measurable data in a quantity conceptualization. This does not mean that qualitative outcomes of education process do not exist. They exist and are unusually vital. However, their measurement is more difficult, even impossible, and outcomes of education process referring to, for instance, an attitude and students behaviour and a value system, can only be estimated.

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***Klasyfikacja wybranych krajów Unii Europejskiej pod względem efektywności finansowej szkolnictwa wyższego w zakresie dydaktyki***

***Streszczenie***

Artykuł ten jest kontynuacją badań autorek w tematyce oceny efektywności finansowej w szkolnictwie wyższym w zakresie dydaktyki w krajach, które należą do Unii Europejskiej. W artykule, na podstawie uzyskanych wyników podejścia nieparametrycznego metodą DEA, dokonano klasyfikacji krajów członkowskich w jednorodnej grupie pod względem ich efektywności finansowej szkolnictwa wyższego w zakresie dydaktyki .

***Słowa kluczowe:*** efektywność finansowa, szkolnictwo wyższe, metody nieparametryczne, metoda Warde European Union, higher education.