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ARTYKUŁY

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MEASUREMENT OF EFFICIENCY EDUCATION IN PUBLIC HIGHER EDUCATION INSTITUTIONS NOT SUBJECT TO THE SUPERVISION OF THE MINISTRY OF SCIENCE AND HIGHER EDUCATION IN POLAND

POMIAR EFEKTYWNOŚCI DYDAKTYCZNEJ PUBLICZNYCH SZKÓŁ WYŻSZYCH NIEPODLEGAJĄCYCH MINISTERSTWU NAUKI I SZKOLNICTWA WYŻSZEGO W POLSCE

Streszczenie

Celem podejmowanych badań jest pomiar efektywności w zakresie działalności dydaktycznej publicznych szkół wyższych nadzorowanych przez inne ministerstwa niż Ministerstwo Nauki i Szkolnictwa Wyższego (MNiSW). Badaniem objęto łącznie 37 publicznych szkół wyższych podlegających pod pięć różnych ministerstw, sprawujących nadzór nad wyższymi szkołami morskimi, artystycznymi, wojskowymi, służb mundurowych oraz medycznymi. Do pomiaru efektywności działalności dydaktycznej szkolnictwa wyższego w 2015 r. wykorzystano model systemowy (SYS) należący do nieparametrycznej metody DEA. W zależności od wybranego modelu empirycznego do efektów przyjęto albo liczbę studentów, albo absolwentów. W obydwu modelach nakładami była liczba nauczycieli akademickich i pozostałych pracowników. Wyniki badania wskazują, że szkoły wyższe podlegające Ministerstwu Obrony Narodowej i Ministerstwu Spraw Wewnętrznych i Administracji charakteryzowały się najwyższą, a szkoły Ministerstwa Zdrowia i Ministerstwa Kultury i Dziedzictwa Narodowego najniższą efektywnością. Średni poziom efektywności badanej grupy szkół wyższych wynosił 0,83 w obydwu modelach.

Słowa kluczowe: szkolnictwo wyższe, efektywność, DEA

Introduction

Higher education plays an extremely important role in every country, as it covers both research and education, the effects of which affect

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above all the real sphere of the state economy. Therefore, since the introduction of the Consolidation Act and the unification of the higher education sector in 2005[1] as well as the simultaneous reform of the Polish system that made it compatible with the European requirements, a considerable debate on the shape and expected directions of development of academic education in Poland has begun. In recent years, the scientific-journalistic discourse has intensified due to the concerted attempts to introduce systemic changes and as a result of introducing subsequent amendments to the Higher Education Act and related executive acts every few years. At this juncture, it is worth citing dates of major system changes that were introduced in 2011, 2014, 2016, and 2018, which – it seems – indicate the evolutionary nature of holistic changes in Polish academic education. Correspondingly, it is worth emphasizing that the debate mainly concerns academic institutions, while higher vocational education is omitted, not to mention schools subject to the jurisdiction of other ministries than the Ministry of Science and Higher Education. Universities educating primarily for the needs of public administration are practically outside the mainstream public debate regarding the directions of development of this part of higher education, not to mention conducting scientific research on its functioning and assessing the efficiency of activities carried out in these educational units. According to Brzezicki (2018a), more than 80 studies of higher education under the Ministry of Science and Higher Education have been conducted so far and none in which universities under the supervision of other ministries were analysed. Due to the above, it should be noted that there is a need to examine this part of higher education. The article will measure the efficiency of parts of the higher education system in Poland, which has not been analysed so far, and not the whole system itself. Therefore, the present study will not include universities subject to the Ministry of Science and Higher Education, which have already been evaluated many times. An analysis of the efficiency of the overall higher education system in Poland exceeds the scope of this study.

The aim of the undertaken research is to measure efficiency in the field of teaching activities of public higher education institutions supervised by other ministries than the Ministry of Science and Higher Education. The implementation of the research objective will fill the gap in knowledge.

[1] Previously, the legal and organizational conditions of higher education institutions were contained in two legal acts, one of which concerned higher vocational schools, while the other dealt with academic schools.

The article consists of five parts. A review of the literature was made in the second part of the article. The methodology of the empirical study in the selection of the appropriate DEA model, variables and schools covered by the study was presented in the third, and the research results were included in the fourth. The article ends with conclusions and a proposal for further research in the subject matter described.

The review of the available literature on the subject

In the subject literature (Johnes 2015; De Witte, López-Torres 2017), it is indicated that two methods are most often used for studying the efficiency of education sector units, i.e. non-parametric DEA and parametric SFA, with the advantage of the former. Due to the above, the focus was on reviewing the literature. As Brzezicki (2017) notes, the majority of research in the field of efficiency of Polish higher education applies to academic institutions, and few studies include higher vocational schools. Heretofore, only four studies of this type have been published in Poland (Brzezicki 2016, Pasewicz, Wilczyński, Świtłyk 2012, Rządziński, Sworowska 2016, Świtłyk, Pasewicz 2009). From the query of the author of this article, it appears that similar relationships of scholarly under-representation are also present in foreign literature, because there are indeed very few papers in which higher vocational schools are the subject of research. For example, Liu and Zhang (2013) estimated the efficiency of Chinese, and Førsund and Kalhagen (1999) of Norwegian higher vocational schools.

In the world literature, there are even fewer studies devoted to the efficiency of another type of higher education, e.g. higher medical schools. The very few works in this field worth mentioning include: Delavari et al. (2013, 2016, 2018). Brzezicki (2018a) shows that in previous studies in Poland, the authors dealt only with academic and higher vocational schools supervised by the Ministry of Science and Higher Education. Therefore, the lack of research on the efficiency of other universities should be considered a research gap that requires academic attention.

Depending on the purpose of the research undertaken in the literature, the number of students or graduates (Ćwiąkała-Małys 2010) was most often taken as the effects of didactic activity. To a lesser extent, other variables were used, such as the value of funds raised for didactic activities or the assessment of employers' preferences in relation to higher education graduates. In the case of input, the authors used differentiated data, however, they can be divided into three groups: financial,

personal and material resources. The authors most often accepted the number of academic teachers as the basic input (Aleskerov, Belousova, Petrushchenko 2017). Sometimes the value of didactic revenues and fixed assets to illustrate the size of higher education institutions was also used.

The study of the efficiency of higher education is increasingly frequently carried out with the use of newer DEA models, which have more extensive analytical capabilities and enable estimation of various aspects of the entity's efficiency (Brzezicki 2018b). Nevertheless, most of the research carried out in the literature is based on two standard radial CCR and BCC models belonging to the DEA method (Brzezicki 2018b).

In the last few years, there has been an increased interest of authors involved in studying higher education with the non-radial SBM model and its subsequent modifications (Brzezicki, 2018b). It can therefore be assumed that the widespread use of the SBM model for research makes three models dominate in the analysis of higher education efficiency: CCR, BCC, and SBM. Although newer models or modifications of existing ones are emerging, not all analytical capabilities have been used to measure various aspects of higher education efficiency.

Research methodology

The DEA method is widely used to measure the efficiency of the education sector, as presented in the article above. The beginnings of the DEA method go back to the article by Charnes, Cooper and Rhodes (1978), who presented the first CCR model assuming constant return to scale. Next, the CCR model was modified by Banker, Charnes and Cooper (1984) to the BCC model, assuming a variable return to scale. It is assumed that the DEA method is the most suitable for estimating efficiency, taking into account the multidimensional situation, i.e. many inputs and many output. However, there are no methodological contraindications to use it with a smaller number of variables, which was, among others presented in the work of Cooper et al. (2007). In the literature (Domagała 2007; Guzik 2009), it is postulated that the adopted set of examined units within the DEA methodology should be homogeneous or at least almost homogeneous. However, in economic practice, it is not always possible to adopt an "ideal" group, which is characterized by homogeneity, e.g. due to organizational diversity, multitasking, etc. In classic DEA models, relatively homogeneous units, which, for example, belong to a given sector or industry, are admitted to the research sample, provided they do not stand out from other units. However, other entities that also belong to the same sector or industry, but additionally deal with

other activities or have different characteristics of functioning, financing, etc. should be excluded from the study, because the DEA method is characterized by a high sensitivity of results to atypical data (Guzik 2009: 30).

In the literature, many different models were created within the DEA methodology, so that an incomplete group of the studied units could be taken into account. One of the examples of solving the above problem is using the system model (SYS) DEA, which allows estimating the level of efficiency of units operating in different systems. Cooper et al. (2007: 231) cite an example of using the SYS model if the unit uses one type of an instrument to transform from the X1 edition to the Y1 output, and the second unit from the X2 input to the Y2 output the second instrument, then it cannot reasonably be assumed that there is any dependence between them or activity, despite the fact that they have the same nature of activity. In the case of higher education, these are schools subject to various ministries, which means that they have different legal and financial conditions. However, the authors point out that the assumptions of the SYS model can be applied to more general situations. Cooper et al. (2007: 220) indicate that the use of the SYS model not only allows for estimating the efficiency level of each unit, but also enables comparative assessment of the efficiency of different systems, observing the efficiency of DMU in each system. The SYS model uses a mixed assessment of the efficiency of individuals in different groups, it should be understood that each DMU is assessed on the basis of both its presence in a given group or its exclusion from the group under study (see: Cooper et al. 2007: 236). The DEA system model was proposed by Tone (1993), but only since the publication of Cooper et al. (2000) it has been widely disseminated in the literature on the subject. The next step as far as the study is concerned is to define the variables that will be used to assess the efficiency of higher education.

When selecting the variables for the study, the data used in the literature were applied. As noted in the previous part of the present article, in the case of studying the activities of higher education institutions, either the number of students or graduates was accepted, which is why their capture was an obvious choice. The literature on the subject emphasizes that "people are the key expenditure for higher education (…)" (Brzezicki, Prędki 2018: 17). Therefore, it was decided to accept two groups of employees, i.e. academic teachers and other employees. However, in order to correctly estimate the level of efficiency of two quantitative aspects of didactic activity in terms of the number of students and graduates, the two planes had to be separated from each other. Due to the

above, two empirical models (model 1 [M1] and model 2 [M2]) were included in the study, consisting of two inputs and one output in both cases (table 1). For the input in both models (M1 and M2), both the total number of academic teachers (full-time and part-time employees) expressed in posts (X1) and the total number of other employees (full-time and part-time), non-teachers also expressed in posts (X2) were assumed. As regards the output in the first model (M1), the total number of students was taken into account, while in the second M2, the total number of graduates was taken into account. The most current and available data from 2015 were adopted for the empirical study.

Table 1. Input and output adopted to study the efficiency of didactic public higher education in individual empirical models

	The name of the variable	M 1	M 2
Input	X_1 – number of academic teachers (full-time and part-time employed)	+	+
	X_2 – number of other employees (full-time and part-time employed)	+	+
Output	Y_1 – number of students (full-time and part-time)	+	-
	Y_2 – number of graduates (full-time and part-time)	-	+

Source: own study.

All data used in the study were taken from the "Higher education – basic data" information leaflet (MNiSW 2015), obtained from the Ministry of Science and Higher Education on the basis of the request for access to public information. Due to the small amount of available data on universities under the responsibility of other ministries, a limited set of variables was adopted, being guided by the research conducted in the field of educational efficiency of universities.

In 2015, there were 133 public higher education schools[2]. The majority of public universities (95) are under the supervision of the Ministry of Science and Higher Education, of which 59 were academic institutions and 36 were vocational schools. However, the remaining part of public higher education institutions (38) due to their nature or specificity of activity is subject to other ministries (table 2). The Ministry of Maritime Economy and Inland Navigation performs supervision over 2 schools, the Ministry of Culture and National Heritage over 19, the Ministry of National Defense over 5 schools, the Ministry of Interior and Administration over 2, and the Ministry of

[2] It is worth noting that in 2018 the Higher School of Criminology and Penitentiary in Warsaw was established, subject to the Ministry of Justice, which is a higher school of the prison service (Rozporządzenie Ministra Sprawiedliwości…., Dz.U. 2018 poz. 1461).

Health over 10 higher schools. The 37 (table 2) of 38 public higher education institutions subordinate to other ministries than the Ministry of Science and Higher Education were accepted for the study. Only the Medical Centre for Postgraduate Education in Warsaw is excluded from the study, which is subject to the Ministry of Health, because it does not provide education in the field of I, II or uniform master's studies, but only in the form of postgraduate studies. It was assumed that all higher education institutions included in the study belong to the public sector, because – firstly – they are supervised by the government public administration, and – secondly – they are financed from the state budget. The main purpose of their functioning is didactic activity, i.e. the 1st or 2nd degree studies or uniform master's studies. Despite the fact that the universities covered by them are subject to various ministries and comprise some kind of subsystems of academic education, all together with institutions supervised by the Ministry of Science and Higher Education form one formal system of higher education. Due to the above, the empirical model DEA system acceptance is substantiated.

After defining the units and variables for the study, as well as selecting the appropriate DEA model, one ought to work on an assumption regarding its orientation and scale effects. Higher schools differ in size and adopted variables are not indicative, therefore, according to recommendations in the literature (Cooper et al. 2007), it was decided to use a model with a variable return to scale. The main purpose of the various types of higher education institutions is primarily to educate students, and to a lesser extent, minimize the resources available to optimize them in relation to the generated business effects. In connection with the above, it was decided to apply the orientation on output, the aim of which is to maximize the effects.

Table 2. Public universities accepted for the study

Abbreviation	**Names of schools subordinate to individual ministries**
MGMiZS	**Ministry of Maritime Economy and Inland Navigation**
U1	Gdynia Maritime University
U2	Maritime University of Szczecin
MKiDN	**Ministry of Culture and National Heritage**
U3	Academy of Fine Arts in Gdansk
U4	Academy of Fine Arts in Katowice
U5	Jan Matejko Academy of Fine Arts in Krakow
U6	Wladyslaw Strzeminski Academy of Fine Arts in Lodz
U7	University of Arts in Poznan
U8	Academy of Art in Szczecin
U9	Academy of Fine Arts in Warsaw
U10	Eugeniusz Geppert Academy of Art and Design in Wroclaw

U11	Feliks Nowowiejski Music Academy in Bydgoszcz
U12	Stanislaw Moniuszko Academy of Music in Gdansk
U13	Karol Szymanowski Academy of Music in Katowice
U14	Music Academy in Krakow
U15	Grazyna and Kiejstut Bacewicz Music Academy in Lodz
U16	Ignacy Jan Paderewski Academy of Music in Poznan
U17	Fryderyk Chopin University of Music in Warsaw
U18	Academy of Music Karol Lipinski in Wroclaw
U19	Ludwik Solski State Theatre School in Krakow
U20	National Film School in Lodz
U21	Aleksander Zelwerowicz Theatre Academy in Warsaw
MON	**Ministry of National Defence**
U22	The College of Air Forces in Deblin
U23	Naval Academy of the Heroes of Westerplatte
U24	National Defence Academy in Warsaw
U25	Jaroslaw Dabrowski Military University of Technology in Warsaw
U26	General Tadeusz Kosciuszko Military University of Land Forces in Wroclaw
MSWiA	**Ministry of Internal Affairs and Administration**
U27	Police College in Szczytno
U28	The Main School of Fire Service in Warsaw
MZ	**Ministry of Health**
U29	Medical University of Bialystok
U30	Medical University of Gdansk
U31	Medical University of Silesia in Katowice
U32	Medical University of Lublin
U33	Medical University of Lodz
U34	Karol Marcinkowski Medical University in Poznan
U35	Pomeranian Medical University in Szczecin
U36	Medical University of Warsaw
U37	Medical University of Wroclaw

Source: own study based on the MNiSW 2015.

Finally, the systemic model with variable return to scale and output-oriented (SYS-O-V) was adopted for the empirical study.

Results of research on the efficiency of higher education

Figure 1 presents the frequency of occurrence of a given efficiency level in the studied group of higher education institutions in the form of a histogram. On the other hand, in Figure 2, the relationship between the level of efficiency in the M1 model and the M2 model for individual universities and groups of universities supervised by selected ministries is presented in graphic form. A detailed summary of performance of all

higher education institutions is included in table 3. The average level of efficiency of all higher education institutions in both empirical models is 0.83, and the standard deviation 0.15 in M1 and 0.16 in M2. Figure 1 shows that the largest group in both models were higher education institutions, which were fully efficient, with the fact that there were 17 in the M1 model and 15 in M2 that reached 100% efficiency. In the second largest group, the results varied and depended on the empirical model chosen. In the M1 model, 8 units with an efficiency level of (0.6-0.7], and in the M2 model, 9 higher education institutions with a score of (0.7-0.8] ranked second on the chart presented in Figure 1.

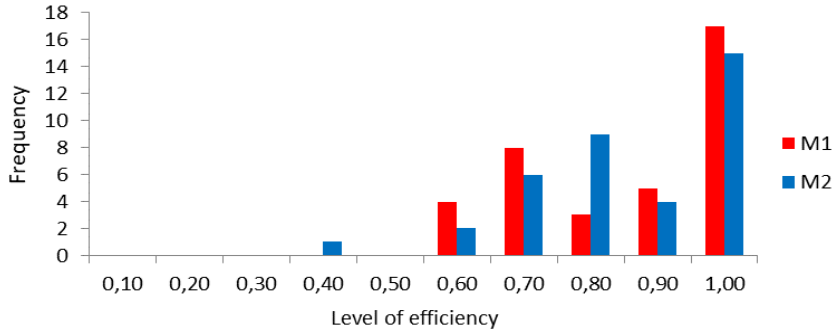


Figure 1. Histogram of performance indicators

Source: own study.

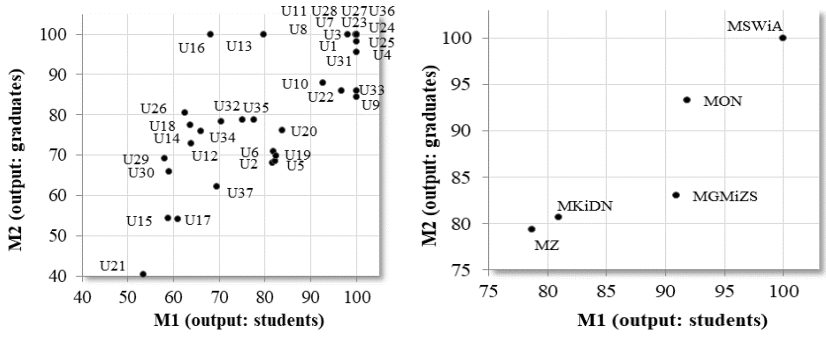
As evidenced by figure 2 and table 3, it appears that the lowest efficiency result in both models M1 and M2, amounting to 0.53 and 0.40 respectively, was obtained by the Aleksander Zelwerowicz Theatre Academy in Warsaw (U21). In the case of ten schools, they were 100% efficient in both models: Academy of Fine Arts in Gdansk (U3), Academy of Fine Arts in Katowice (U4), University of Arts in Poznan (U7), Academy of Arts in Szczecin (U8), Feliks Nowowiejski Academy of Music in Bydgoszcz (U11), Naval Academy of the Heroes of Westerplatte (U23), National Defense University (U24), Jaroslaw Dabrowski Military University of Technology (U25), College of Police in Szczytno (U27), Main School of Fire Service in Warsaw (U28). On the other hand, four schools achieved full 100% efficiency only in M1: Maritime University of Gdynia (U1), Academy of Fine Arts in Warsaw (U9), Medical University of Silesia in Katowice (U31), Medical University of Lodz (U33), and three in M2 : Karol Szymanowski Academy of Music in Katowice (U13), Ignacy Jan Paderewski Academy of Music in Poznan (U16), Medical University of Warsaw (U36).

In a few educational units, they were almost completely efficient in one model. In the case of M1, the situation concerned the following schools: Feliks Nowowiejski Academy of Music in Bydgoszcz (U10), Air Force Officers College in Deblin (U22), Medical University of Warsaw (U36), and for M2: Maritime University in Gdynia (U1), Medical University of Silesia in Katowice (U31). It means that, depending on the chosen school, it would be enough to increase the level of generating effects in the form of the number of students or graduates from 2% to 7% in order to get the full 100% efficiency in the given empirical model. Next, it was decided to check the correlation level between the M1 and M2 models, for this purpose the Spearman rank correlation coefficient was calculated. The results obtained indicate that there is a statistically significant positive correlation between the two empirical models at the level of 0.77.

Higher education institutions subject to the Ministry of Internal Affairs and Administration turned out to be fully efficient in both models, in contrast to centres supervised by the Ministry of Health, which obtained the worst result, and their level of efficiency fluctuated around 80% of efficiency. Interesting conclusions can be obtained by comparing extreme groups (min., max.) with the closest groups with similar levels of efficiency (Figure 2).

A group of units reporting to the Ministry of Interior and Administration obtained the highest efficiency, followed closely by schools supervised by the Ministry of National Defense. On the other hand, the schools subject to the Ministry of Health were characterised by the lowest efficiency, followed by the Ministry of Culture and National Heritage. The school supervised by Ministry of Maritime Economy and Inland Navigation was in between the two groups above.

Figure 2. The level of efficiency of public higher education in 2015



Source: own study.

The results indicate that schools of uniformed services characterized by highly specialized education for the needs of public administration, in which it is more difficult to study, obtain a higher level of efficiency than higher education institutions under other ministries. Probably the schools supervised by the Ministry of Culture and National Heritage as well as ones subordinate to by the Ministry of Health have a wider educational offer that can be used for both the public and private sectors. The second probable cause is the specificity of schools, as students of uniformed services already have a planned path of professional development in a given area coherent with the field of education. Also, even when they started learning, they have already worked in units for which academic education is dedicated, such as in schools subordinate to the Ministry of Defense or the Ministry of Interior and Administration.

Conclusions

The following conclusions can be drawn from the study. First of all, the average level of efficiency of higher education institutions subject to other ministries than the Ministry of Science and Higher Education amounted to 83%. Secondly, there is a high positive correlation between the efficiency of the M1 model, in which the number of students was adopted, and the M2 model characterizing the efficiency of higher education institutions in terms of the number of graduates. Thirdly, more often the surveyed units obtained higher values of the efficiency indicator in the M1 model than M2. This may indicate the focus of decision-makers on the appropriate adjustment of resources used in the education process in relation to the limits of admissions determined by ministers responsible for supervision on a given type of academic centres.

The author realizes that this research has been simplified, because as indicated in the literature (Brzezicki, Prędki 2018), apart from human resources, financial and material values in the educational process are also used. Therefore, in the future, the study is planned to be carried out, firstly, in the long-term, and secondly by means of other categories in terms of input and output and the use of alternative DEA models. In the future, the continuation of this research should be an analysis of the efficiency of the entire higher education system in Poland, including all universities subject to all ministries together with the analysis of determinants affecting their level of efficiency (two-stage analysis).

However, the added value of the article is, first of all, the estimation of the efficiency of higher education institutions supervised by various

ministries that have not been previously researched. Secondly, the use of the SYS model, which has not been applied to the study of the educational sphere, either in Poland or abroad.

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Annex

Table 3. Detailed results of efficiency for individual universities in 2015

DMU	M1	M2	DMU	M1	M2
U1	1,00	0,98	U21	0,53	0,40
U2	0,82	0,68	U22	0,97	0,86
U3	1,00	1,00	U23	1,00	1,00
U4	1,00	1,00	U24	1,00	1,00
U5	0,82	0,69	U25	1,00	1,00
U6	0,82	0,71	U26	0,63	0,80
U7	1,00	1,00	U27	1,00	1,00
U8	1,00	1,00	U28	1,00	1,00
U9	1,00	0,84	U29	0,58	0,69
U10	0,93	0,88	U30	0,59	0,66
U11	1,00	1,00	U31	1,00	0,95
U12	0,64	0,73	U32	0,75	0,79
U13	0,80	1,00	U33	1,00	0,86
U14	0,66	0,76	U34	0,70	0,78
U15	0,59	0,54	U35	0,78	0,79
U16	0,68	1,00	U36	0,98	1,00
U17	0,61	0,54	U37	0,69	0,62
U18	0,64	0,77	Minimum	0,59	0,54
U19	0,83	0,70	Average	0,83	0,83
U20	0,84	0,76	Stand. dev.	0,15	0,16

Source: own study.