Efficiency assessment of public higher education with the application of Data Envelopment Analysis: The evidence from Poland

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Abstract

Higher education is a form of a merit good. This is why governments usually support the delivery of this good. However, one could doubt the efficiency of such solution. How well do public higher education institutions (HEIs) do their job? How to measure their performance? This paper discusses these issues. First, we discuss the problem of defining and measuring efficiency in the case of publicly held HEIs with particular emphasis put on the Data Envelopment Analysis (DEA) method. Secondly, we present the results of our empirical investigation of efficiency assessed using the DEA method conducted on the sample of 33 Poland faculties specialized in social sciences . We use Charnes-Cooper-Rhodes *(CCR) output oriented model with two inputs and three outputs. Next, we present some important differences in efficiency of those faculties. We also define benchmarks for inefficient HEIs and quantify the gaps to be fulfilled by them in order to become efficient. Finally, we pinpoint the directions of further research.*

Keywords: higher education institutions, efficiency, Data Envelopment Analysis (DEA), public sector

Introduction

The education system, particularly on the highest level, is an important source of knowledge in developed countries. Delivering higher education creates positive externalities, which means that it offers benefits to the economy that exceed those to any individual who consumes it. Benefits from education go not only to a graduate and their family, but also to third parties: through higher productivity, greater satisfaction of living in a society with democratic institutions, lower crime rates, lower unemployment compensation and public health costs and many others (Begg Fischer, & Dornbusch, 2014, McMahon, 1982). This is why the governments are often engaged in the higher education sector. However, the engagement of a government in the higher education differs across regions and countries. In the USA, higher education is financed in prevailing proportions privately, but in European countries the proportions are reverse – higher education institutions (HEIs) are financed mainly (80 to 95%) publicly from governmental budgets (Paliszkiewicz, 2010).

The scale of governmental engagement in higher education is an interesting issue. On the one hand, such educational services are considered merit goods which create externalities, but on the other hand, the public sector does not produce better or more efficient goods (Bowden & Bowden 2002). Indeed, public bureaus or agencies are usually seen as achieving inferior

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performance in comparison to the business sector. The contemporary societies create an increasing pressure on public organizations to be more elastic, entrepreneurial, and parsimonial entities (Ansoff, 1979). This pressure is embodied in the New Public Management (NPM) concept. According to NPM, the public sector organizations have to strive for the efficiency analogous to the business counterparts, particularly by implementing competitive mechanisms, customer orientation, decentralization, performance measurement and strategic management. The NPM has been applied recently to higher education institutions, mainly in European countries (Schimank, 2005; Tahar, 2013; Wilkesman & Schmid, 2012). Consequently, the methods and techniques such as: setting targets of efficiency and effectiveness, benchmarking, performance measurement etc. are growing in popularity with higher education institutions (Parker, 2012).

The purpose of this paper is twofold. The first one is to discuss the problem of the efficiency of public universities and to present how it can be measured. The second one is to empirically verify the differences in efficiency of faculties of social sciences in Poland and to identify possible improvements.

The problem of efficiency measurement in the public higher education

Ansoff (1979) made a distinction between two types of environment serving organizations: firms and not profit-oriented organizations, which differ in strategic behaviour. The latter could by further divided into public not-for-profit organizations (government bureaus and agencies) and private not-for-profit organizations i.e. nonprofits (Carroll, 2004). One can find every of these three types of organizations engaged in the higher education, however in this paper we are concerned with publicly held institutions. Recently, there has been an increasing interest in performance measurement in public bureaus and agencies (Byrson, J. M., & Alston, F. K. 2011; Niven, 2008).

But what does efficiency really mean in the case of the public sector, particularly the public universities? How could it be measured? What are the objectives and the efficiency criteria? Who defines the objectives and the criteria? Who is the owner of a bureau or an agency? According to Carroll (2004), in the general sense, taxpayers should be considered as the owner of public organizations. Legislators are the taxpayers' representatives. Legislators could defend the interest of the latter through their decisions on the amount of funds to allocate for projects and programs of each public organization (Carroll, 2004). As Taylor and Baines (2012) observed, the universities in the UK have become increasingly interested in performance management methods, for example in the Balanced Scorecard. Pietrzak (2014) and Pietrzak Paliszkiewicz, & Klepacki (2015) gave an evidence of how the Balanced Scorecard could be used in strategy communication and in performance management at the example of one of the big Polish universities. Balanced Scorecard is a very useful method of translating a strategy into measurable targets and actionable initiatives (Kaplan & Norton, 2008). However, this role implies that it should be specifically designed for every individual case, because the strategy should be unique for any organization. Consequently, the Balanced Scorecard based on many uniquely dedicated metrics and indicators is a helpful tool for the strategic management for the executives of a higher education institution, but it does not seem to be very helpful for the legislators in performance controlling of a number of universities. In this case, a method that allows a direct efficiency comparison between public organizations could be more useful.

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Considering the functionality of public bureaus and agencies' benchmarking, it is worth paying attention to the Data Envelopment Analysis (DEA) method. This is because DEA allows for a relative appraisal of the efficiency of studied objects. Thus, efficient benchmarks for inefficient entities can be defined. Accordingly, gaps are identified in a quantitative manner. These gaps should be fulfilled if any inefficient object wants to become efficient. Another advantage of the DEA method is its ability to take into account many outputs and inputs simultaneously. This functionality is very important in universities assessment because of many desirable results and multiple production factors engaged.

The DEA occupies an important place in the comparative efficiency studies in the public sector worldwide, for example in the health care (Färe, Grosskopf, Lindgren, & Roos, 1992; Hollingsworth, Dawson, & Maniadakis, 1999; Jacobs, 2001), in the military entities (Sun, 2004) and, last but not least, in higher education institutions (Bates, 1993; Thanassoulis & Dunstan, 1994). Examples of DEA application around the world are described in literature by Worthington (2001), Taylor and Harris (2004), Baran, Pietrzak, M., & Pietrzak, P., (2015), and Mikušová (2015). The existing studies on the efficiency of higher education institutions have been based mainly on country-specific data (Wolszczak-Derlacz & Parteka, 2011). Table 1 provides a summary of selected empirical studies from the last two decades, which are based on the DEA methodology in assessing higher education efficiency.

In the UK, the issues of higher education efficiency receive a lot of attention, thus providing many instances of DEA application for the assessment of higher education productivity (Nazarko & Šaparauskas, 2014). Athanassopoulos and Shale (1997) proposed the concepts of cost and outcome efficiency. DEA was used in their research to assess these two types of efficiency. Their study of 45 universities in the UK revealed a subset of six organizations that showed satisfactory performance across alternative efficiency tests (Athanassopoulos & Shale, 1997). Another British example of DEA application is Johnes (2006) examination of the efficiency of more than 100 universities in the period 2000-2001 According to Johnes (2006), the technical and scale efficiency in the UK higher education sector appeared to be high on average. The quality and the quantity of undergraduate degrees, the quantity of postgraduate degrees and research were significant outputs in the UK higher education production process (Johnes, 2006).

From 1997-1999, Warning (2004) examined the efficiency of 73 universities in Germany using the DEA method. Warning (2004) results indicated that universities were better in teaching than in research, and they were also better in natural sciences than in social sciences. The results also provided evidence that universities in Germany differed regarding their level of efficiency and the underlying effects (Warning, 2004).

Abramo, D'Angelo and Pugini (2008) presented a methodology of measuring the technical efficiency of research activities. It was based on the application of DEA to bibliometric data on the Italian university system. Different input values (research personnel by level and extra funding) and output values (quantity, quality and level of contribution to actual scientific publications) were considered (Abramo, D'Angelo, & Pugini 2008).

In Thailand, the relative efficiency in the production of research and teaching from 2003-2006 was analysed. Kantabutra and Tang (2010) xamined the difference in performance between two types of public universities: the government universities and the autonomous universities. The results indicated that the autonomous universities outperformed the government universities in terms of research efficiency (Kantabutra & Tang, 2010).

Table 1. Selective empirical studies using DEA to evaluate the efficiency of higher education institutions

Reference*	Country/ Sample of HEIs/ Period of study	Inputs	Outputs
Athanassopoulos and Shale (1997)	UK (45 universities) 1992-93	number of undergraduates, postgraduates and academic staff, mean A-level entry score over the last three years, research income, expenditure on library and computing services	number of successful leavers, number of higher degrees awarded, weighted research rating
Warning (2004)	Germany (73 universities) 1997-99	expenditure on personnel, other expenditures	SSCI (Social Science Citation Index) publications, SCI (Science Citation Index) publications, SSCI graduates, SCI graduates
Johnes (2006)	England (109 universities) 2000-01	number of FTE (Full Time Equivalent) undergraduate students studying for a first degree multiplied by the average A-level points for first year full-time undergraduate students, number of FTE postgraduate students, number of full-time academic staff, expenditure on central libraries and information services, and on central computer and computer networks, expenditure on central administration and central services	number of first degrees awarded weighted by degree classification, number of higher degrees awarded, value of recurrent grant for research awarded by the Higher Education Funding Council for England
Abramo, D'Angelo and Pugini (2008)	Italy (64 universities) 2001-03	number of full professors, number of associate professors number of research scientists, PRIN funding for research	number of publications, contribution to publications scientific strength
Kantabutra and Tang (2010)	Thailand (267 faculties) 2003-06	For TEM (Teaching Efficiency Model): annual operating budget, number of academic staff, number of non-academic staff For REM (Research Efficiency Model): amount of internal and external research found	For TEM (Teaching Efficiency Model): number of graduates at the undergraduate/ master degree levels, employment rate For REM (Research Efficiency Model): number of publications in internationally/ nationally refereed journals, number of PhD degrees
Monafared and Safi (2011)	Iran (27 universities) 1999	For TEM and CEM (Teaching Efficiency Model, Cost Efficiency Model): staff per student, faculty members per major, faculty members' positions, books per student material procurement cost, capital expenditure For REM (Research Efficiency Model): staff per student, faculty members per major, faculty members' positions, teaching load, books per student, material procurement cost, capital expenditure	For TEM (Teaching Efficiency Model): students per faculty, teaching load, faculty receivable from extra lecturing hours For REM (Research Efficiency Model): external contracts to total, For CEM (Cost Efficiency Model): students per faculty, teaching load, external contracts to total
Wolszczak-Derlacz and Parteka (2011)	Austria, Finland, Germany, Italy, Poland, UK and Switzerland (259 universities) 2001-05	total academic staff, total number of students, total revenues	number of graduations, number of scientific publications

*Studies are presented in chronological order.
Source: own elaboration based on the referred literature.

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In 1999, 27 Iran universities were studied from the perspective of their efficiency. Monafared and Safi (2011) provided an analysis on the importance of the stakeholder's perspective on the structure of DEA and the variations of efficiency results. They examined efficiency from three different perspectives of importance, i.e. teaching quality, research productivity, and cost efficiency by using available data. Monafared and Safi (2011) noted that the data used in their experiments was over 10 years old, whereas in recent years, the higher education institutions in Iran had undergone dramatic changes (Monafared & Safi, 2011).

Wolszczak-Derlacz and Parteka (2011) examined efficiency and its determinants in a set of universities from several European countries. Their analysis was based on a sample of 259 HEIs from 7 European countries across the period of 2001-2005. They conducted a two-stage DEA analysis. The main conclusion was that only 5% of HEIs were fully-efficient. Universities from Switzerland obtained the best efficiency scores (Wolszczak-Derlacz & Parteka, 2011). Overall, the literature confirmed that technical inefficiency is a common phenomenon in higher education all over the world (Cunha & Rocha, 2012).

Method

We decided to take a slightly different approach than most of the literature previously mentioned, that treated a university as a basic analytical unit. However, one could doubt the uniformity of production technology at a university with many different faculties. Such uniformity is an important assumption in using DEA, which drew its origins from the economic concept of production function, in which production technology means the relationship between inputs and outputs (Fried, Lovell, & Schmidt 1993). Carlton and Perloff (2005) noted that, "knowing the cost function of a firm and knowing its technology are equivalent" (p. 32). For example, in the case of the Warsaw University, the costs of teaching one student at the Faculty of Physics is 11-times higher than at the Faculty of Journalism and Political Sciences (Wilkin, 2009). Thus, it is clear for us, that efficiency should be measured rather on the faculty than on the whole university level.

After the political and economic transition, the Polish higher education system faced a rapid growth measured by the number of students (about 450% growth during the first two decades after transition). It was forecasted that until 2020, the number of students will be reduced by 35%. Privately held higher education institutions established after transition, which achieve about one third share in total students' number in Poland, played an important role in this growth (Pietrzak, 2013). The areas of teaching at private universities are dominated by social sciences (economics, management, law, political sciences, sociology etc.). Thus, social sciences are the main field of rivalry between privately and publicly held HEIs. This competition should be growing because of the predicted falls in demand. It seems interesting to assess the efficiency of social sciences faculties affiliated at public higher education institutions. There are 150 such faculties in Poland. The data from 33 of them could be collected. We investigated their efficiency using the DEA method.

DEA is a non-parametric mathematical programming approach for measuring relative efficiencies of comparable Decision Making Units (DMUs) with respect to multiple inputs and outputs. Charnes, Cooper, and Rhodes (1978) described DEA as a "mathematical programming

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model applied to observational data that provides a new way of obtaining empirical estimates of relations, such as the production functions and/or efficient production possibility surfaces, that are cornerstones of modern economics" (p. 429-444). The DEA model may be presented mathematically in the following manner (Cooper Seiford, & Tone, 2007, p. 23):

$$\max \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \qquad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1$$

$$u_r, v_i \geq 0$$

where:

s – quantity of outputs, m – quantity of inputs, u_r – weights denoting the significance of respective outputs, v_i – weights denoting the significance of respective inputs, y_{rj} – amount of output of r-th type ($r = 1,...,R$) in j-th object, x_{ij} – amount of input of i-th type ($i = 1,...,I$) in j-th object; ($j = 1,...,J$).

In the DEA model m of inputs and s of diverse outputs come down to single figures of "synthetic" input and "synthetic" output, which are subsequently used for calculating the object efficiency index. The quotient of synthetic output and synthetic input is an objective function, which is solved in linear programming. Optimized variables include u_r and v_i coefficients, which represent weights of input and output amounts, and the output and input amounts are empirical data (Cooper et al., 2007).

By solving the objective function using linear programming it is possible to determine the efficiency curve called also the production frontier, which covers all the most efficient units of the focus group. The graphical presentation of the efficiency curve is possible for models: 1 input and 1 output, 2 inputs and 1 output, or 1 input and 2 outputs. In the case of multidimensional models the curve equivalent incorporates a few fragments of different hyperplanes linked to each other. Objects are believed to be technically efficient if they are located on the efficiency curve. Objects technically efficient achieve the best possible combination of their effects (production) to the input. In other words, their efficiency index equals 1, which means that for example in the model focused on input minimization, there is not any other more favourable combination of inputs allowing to achieve the same outputs (Coelli, Prasada Rao, O'Donnell, & Battese 2005). However, if they are beyond the efficiency curve, they are technically inefficient (their efficiency index is below 1). The efficiency of the object is measured against other objects from the studied group and is assigned values from the range (0, 1). The DEA models measure the efficiency of a Decision Making Unit relative to similar DMUs in order to estimate a 'best practice' frontier. It means that the DEA method measures relative efficiency (Charnes et al., 1978).

The DEA models may be categorized based on two criteria: orientation and type of returns to scale. Depending on the model orientation, the calculations of efficiency focused either on the input minimization or on the output maximization are made. Taking into account the type of

returns to scale, the two models are distinguished: the Charnes-Cooper-Rhodes (CCR) model (Charnes, Banker, & Rhodes, 1978) and the Banker-Charnes-Cooper (BCC) model (Banker, Charnes, & Cooper, 1984). The CCR model is built on the assumption of constant returns to scale: this means that inputs and outputs are linked in a strictly proportional manner. The CCR efficiency scores measure the overall technical efficiency (Technical Efficiency - TE), where TE for P object = AP_C/AP (Figure 1). The BCC model is an extension of the CCR model and allows for the fact that the productivity at the most productive scale size may not be attainable for other scale sizes at which a given Decision Making Unit is operating. Therefore, the BCC model estimates the pure technical efficiency of a DMU at a given scale of operation (Pure Technical Efficiency - PTE), where PTE for P object = AP_V/AP (Figure 1). The only difference between the CCR and BCC models is the convexity condition of the BCC model, which means that the frontiers of the BCC model have piecewise linear and concave characteristics, which lead to variable returns-to-scale (Coelli et al., 2005).
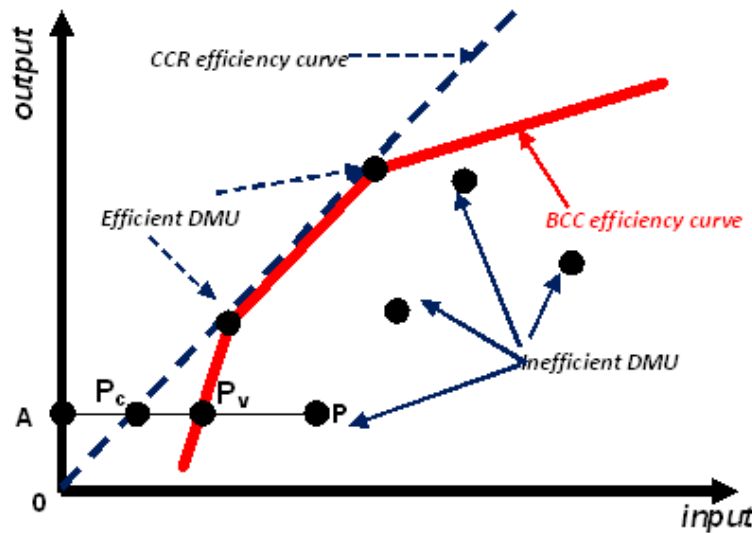
Figure 1. Efficiency according to the DEA method (model: 1 output and 1 input)

Source: Coelli et al., 2005, p. 61

The key issue in our research study was the selection of inputs and outputs. As one can find in our review of efficiency studies of the higher education, the variables that are typically used as inputs are: the number of academic staff, the non-academic staff, the financial resources of the institutions, as well as their major expenditures. We followed these proposals and selected two variables as inputs:

- input 1: total number of researchers (i.e. academic staff),
- input 2: statutory grant (i.e. core financial resources received from governmental budget).

The variables usually used as outputs in literature are: the total number of successful leavers (graduates), the number of publications in internationally/ nationally referred journals or number of PhD degrees. This research study partially followed those approaches. They generally mirrored the traditional view of the university and its role in the society, namely conducting scientific research and academic teaching. In literature such a view is called the Humboldtian or liberal model of the university (Leja, 2013). However, contemporarily an evolution towards the entrepreneurial model of the university can be observed. In such a model, the general mission of the university is enlarged and consists of three pillars not only research and teaching but also supporting the economic and social development (Leja, 2013). Such a view of the role of public higher education institutions is also emphasized in recent reforms of the law, which regulates public universities in Poland (Pietrzak, 2013). Thus, defining outputs we tried to take into account such an extended view of the public university mission:

- output 1: total number of students (reflecting the activity in teaching)

- output 2: total value of externally acquired funds like funds for R&D work etc., as well as externally granted research projects (reflecting the activity in supporting the development of university's environment)

- output 3: number of publications (reflecting the activity in scientific work)

It is not common in Poland to fire academic staff except for immoral acts, the loss of mental competence etc. and as there is not a government strategy to reduce financing of universities, we assumed that the output-oriented model would be more appropriate than an input-oriented model. As the number of studied objects (faculties) was not high, we decided to use the CCR model (in the BCC model the number of efficient units is always higher than in the CCR model). In summary, this research study used the CCR output-oriented model and MS Excel 2007 and DEASolverPro were used to perform the calculations .

Results

The results of relative efficiency for 33 Faculties of Social Sciences are presented in Table 2. In the academic year 2013/2014, the analyzed Faculties of Social Sciences in Poland experienced the efficiency index from 0.41 to 1 (average 0.72). Nine faculties were fully efficient. The group of efficient Decision Making Units covered the following faculties: WZ(PCz), WNPiDz(UAMP), WSE(UAMP), WAiNS(PW), WNE(UW), WZ(PL), WPiA(UW), WPsycho(UW), WEiZ(UZ). Among the inefficient faculties the lowest rate of efficiency was observed in: WZ(PRIL) and WP-A(UAMP) (see Table 2).

Table 2. Ranking of faculties

ID	Faculty	DEA score
WEiZ(UZ)	Faculty of Economics and Management (University of Zielona Góra)	1,000
WPsycho(UW)	Faculty of Psychology (Warsaw University)	1,000
WPiA(UW)	Faculty of Law and Administration (Warsaw University)	1,000
WZ(PL)	Faculty of Management (Lublin University of Technology)	1,000
WNE(UW)	Faculty of Economic Sciences (Warsaw University)	1,000
WAiNS(PW)	Faculty of Administration and Social Sciences (Warsaw University of Technology)	1,000
WSE(UAMP)	Faculty of Educational Studies (Adam Mickiewicz University in Poznań)	1,000
WNPiDz(UAMP)	Faculty of Political Science and Journalism (Adam Mickiewicz University in Poznań)	1,000
WZ(PCz)	Faculty of Management (Częstochowa University of Technology)	1,000
WNE(SGGW)	Faculty of Economic Sciences (Warsaw University of Life Sciences)	0,882
WPiA(USK)	Faculty of Law and Administration (University of Silesia in Katowice)	0,853
WPiA(UWMO)	Faculty of Law and Administration (Warmian and Mazurian University in Olsztyn)	0,825
WNE(UWMO)	Faculty of Economics (Warmian and Mazurian University in Olsztyn)	0,810
WZ(UW)	Faculty of Management (Warsaw University)	0,774
WPiA(UJK)	Faculty of Law and Administration (Jagiellonian University in Kraków)	0,724
WNS(USK)	Faculty of Social Science (University of Silesia in Katowice)	0,672
WZiKS(UJK)	Faculty of Management and Social Communication (Jagiellonian University in Kraków)	0,667
WOiZ(PSG)	Faculty of Organization and Management (Silesian University of Technology)	0,610
WSNSiR(UW)	Faculty of Applied Social Sciences and Resocialisation (Warsaw University)	0,593
WEiNoE(USK)	Faculty of Ethnology and Educational Science (University of Silesia in Katowice)	0,593
WDziNP(UW)	Faculty of Journalism and Political Science (Warsaw University)	0,591
WPiP(USK)	Faculty of Pedagogy and Psychology (University of Silesia in Katowice)	0,588
WP(UW)	Faculty of Education (Warsaw University)	0,577
WRiT(USK)	Faculty of Radio and Television (University of Silesia in Katowice)	0,562
WZ(PW)	Faculty of Management (Warsaw University of Technology)	0,554
WNS(SGGW)	Faculty of Social Sciences (Warsaw University of Life Sciences)	0,536
WPiA(UAMP)	Faculty of Law and Administration (Adam Mickiewicz University in Poznań)	0,518
WSMiP(UJK)	Faculty of International and Political Studies (Jagiellonian University in Kraków)	0,499
WNS(UAMP)	Faculty of Social Sciences (Adam Mickiewicz University in Poznań)	0,493
WNS(UWMO)	Faculty of Social Sciences (Warmian and Mazurian University in Olsztyn)	0,473
WPSiNoZ(UZ)	Faculty of Education, Psychology and Sociology (University of Zielona Góra)	0,427
WP-A(UAMP)	Faculty of Pedagogy and Fine Arts (Adam Mickiewicz University in Poznań)	0,418
WZ(PRIL)	Faculty of Management (Rzeszów University of Technology)	0,407

Source: own calculations based on: universities' annual reports

Based on the DEA method, benchmarks were defined for the inefficient faculties. On the basis of these benchmarks for inefficient faculties (Decision Making Units), it is possible to determine a combination of technologies that allows more results to be achieved with the same inputs. Calculations were made based on the values of coefficients of the linear combination of common technology. Based on these coefficients, it is possible to construct an optimal technology modelled on the inefficient faculties by defining benchmarks for them. For example, for WNE(SGGW) benchmarks would consist of WZ(PL), WSE(UAMP) and WEiZ(UZ). For WNE(SGGW) the following combination of technology is therefore optimal: 17,3% WZ(PL) technology, 30,9% WSE(UAMP) technology and 115,3% WEiZ(UZ) technology. In order to be efficient, WNE(SGGW) should achieve the level of outputs shown in Table 3.

Table 3. The results of the benchmarking analysis for Faculty of Economic Sciences at Warsaw University of Life Sciences - WNE(SGGW)

	Benchmarks for WNE(SGGW)			Projected output for WNE(SGGW)	Present level of WNE(SGGW) outputs	Estimated percentage increase in the outputs of WNE(SGGW)
	WZ (PL)	WSE (UAMP)	WEiZ (UZ)			
Output 1 - number of students	1246	7917	2723	$0,173 \times 1246 + 0,309 \times 7917 + 1,153 \times 2723 = 5798$	5117	13,32%
Output 2 - externally acquired funds	824937	611480	163440	$0,173 \times 824937 + 0,309 \times 611480 + 1,153 \times 163440 = 519915$	458790	13,32%
Output 3 - number of publications	258	371	286	$0,173 \times 258 + 0,309 \times 371 + 1,153 \times 286 = 489$	356	37,32%
The values of coefficients of the linear combination of common technology for inefficient WNE (SGGW)	0,173	0,309	1,153			

Source: Calculations based on universities' annual reports

The resulting outputs are far above those achieved in the WNE(SGGW). As a result, the faculty could be classified as efficient by achieving 13% more students, increasing externally acquired funds by 13%, and publishing 37% more papers. Table 4 shows potential changes in outputs in the set of inefficient faculties. The results suggest that inefficient faculties could improve their efficiency in all output variables. Thus, deans should concentrate their efforts on enhancing the performance by reaching the indicated growth effects (Table 4), while using the existing level of inputs (academic staff and statutory grant) to reach a maximum of "production capacity".

Table 4. Estimated percentage increase in the outputs of individual departments, which would improve the efficiency of departments using current inputs such as academic staff and statutory grant

DMU	Projections		
	Output 1 **(number of students)**	**Output 2** **(externally acquired funds)**	**Output 3** **(number of publications)**
WNE(SGGW)	13,32%	13,32%	37,32%
WNS(SGGW)	86,42%	889,27%	162,71%
WOiZ(PSG)	64,01%	64,01%	64,01%
WZ(PW)	80,51%	999,90%	406,17%
WZ(PRIL)	145,51%	145,51%	145,51%
WNS(UAMP)	102,76%	102,76%	102,76%
WP-A(UAMP)	139,33%	999,90%	139,33%
WPiA(UAMP)	93,04%	93,04%	93,04%
WPiA(UJK)	38,10%	38,10%	38,10%
WZiKS(UJK)	49,95%	76,71%	49,95%
WSMiP(UJK)	100,56%	100,56%	100,56%
WEiNoE(USK)	68,71%	68,71%	68,71%
WNS(USK)	48,91%	48,91%	48,91%
WPiP(USK)	70,06%	70,06%	70,06%
WPiA(USK)	17,22%	17,22%	17,22%
WRiT(USK)	77,98%	999,90%	77,98%
WNE(UWMO)	23,44%	615,53%	239,52%
WNS(UWMO)	111,59%	999,90%	261,74%
WPiA(UWMO)	21,20%	110,48%	410,74%
WDziNP(UW)	69,31%	69,31%	69,31%
WP(UW)	73,33%	73,33%	73,33%
WSNSiR(UW)	73,71%	68,57%	68,57%
WZ(UW)	29,13%	47,49%	74,45%
WPSiNoZ(UZ)	134,30%	352,46%	134,30%

Source: Calculations based on universities' annual reports

Concluding remarks

Governments typically support higher education services because they are merit goods, which create positive externalities. Particularly in Europe, governments often fund public universities. One of the interesting methods of assessment of their efficiency is the Data Envelopment Analysis (DEA), which is growing in popularity in the research of public sector performance. Typically, the DEA studies in the higher education are concerned with a whole university as a Decision Making Unit (DMU), however, we believe that the proper unit of such an analysis should be a faculty. This empirical investigation of efficiency was conducted on the sample of 33

faculties specialized in social sciences across many public HEIs in Poland. This research study based on the CCR output-oriented model noted that there are substantial differences in efficiency between analysed entities. Important inefficiencies were identified. Their elimination could contribute to the enhancement of the social welfare. We also defined benchmarks for inefficient HEIs and quantified the necessary gaps to be fulfilled in order to become fully efficient.

However, one should be aware of the limitations of our research study. Firstly, the selection of inputs and outputs to control performance at the universities is very difficult (McCormick & Meiners, 1988). Secondly, we used one input and one output, which are expressed in value terms. The DEA method concerns technical efficiency, so inputs and outputs should be preferably expressed in natural/ technical terms. Nevertheless, our inputs and outputs set does not diverge from the sets used by many other authors in similar studies. Moreover, the DEA method has some limitations itself: the sensitivity of extreme observations or failures in the units referred as efficient, the sensitivity of the total number of inputs and outputs (the greater it is, the greater the probability to be efficient is). The last one was the reason why in the case of limited number of faculties in the sample, we decided to use the CCR model. Finally, one should be aware that DEA defines efficiency in a relative manner, so it could be the case that a unit on the frontier of efficiency is not very efficient, but others conduct even worse.

Thus, further studies are welcome. We suggest to follow our approach and to investigate efficiency at a faculty level rather than a university level. It would be interesting to make comparisons between faculties at public and private universities. Comparisons between faculties from different countries could be very fruitful as well. Finding another and a better set of inputs and outputs for efficiency models would be also highly desirable.

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