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Teaching or research? An analysis of teaching and research efficiency in Polish public universities

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The article presents an efficiency evaluation for teaching and research in Polish institutions of higher education. Thirty one public universities in Poland were studied using the nonparametric DEA method from 2001 to 2008. Teaching outcomes were evaluated by the numbers of full-time and part-time graduates, while research activities were assessed by number of publications, citations and value of research grants. The scores for teaching and research efficiency were negatively correlated, which could indicate a trade-off between teaching and research activities.

Keywords: economics of education, efficiency, DEA, public higher education institutions.

Motivation for this study on the efficiency of Polish higher education institutions (HEIs) arose from work on the recent reform of the higher education sector. The reform came into effect in October 2011 and was largely intended, according to its authors, to contribute to improved efficiency of higher education institutions through better exploitation of the research and teaching potential of institutions (MNiSW, 2012).

In very general terms, efficiency in economics solves the problem of how to make the best use of existing resources (Samuelson and Nordhaus, 2002). Leja (2003) defined efficiency of institutions of higher education, adopting the teleological approach, in which efficiency assessment checks that a given institution performs the tasks it was established for.

The purpose of this study is to examine the efficiency of 31 Polish public HEIs over the period 2001–2008. Taking into account the double mission of HEIs, the analysis concentrates on the efficiency assessment of teaching and scientific research. Activity of institutions on their "third mission", that is co-operation with the local community and business, is not analysed due to serious difficulties in measuring the results of those efforts (c.f. Leja, 2011). The aim of this article is not only to determine the teaching and research efficiency in higher education, but also to investigate any relationship between these two activities: evidence of a potential trade-off between teaching and research.

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Measuring teaching and scientific efficiency in higher education institutions is burdened by the mode of operation of these institutions. HEIs are non-profit organisations, characterised by complex relations between inputs and outputs, which are influenced by both internal factors and the external environment. For example, the results of research activities in the form of publications can impact on future financial resources of the institution (a two-way relationship between the inputs and outputs). In Poland the allocation of public (governmental) funding for research activities of HEIs is based on the research assessment of units and the number of publications is one of the evaluated criteria (parametric evaluation). Further, because the HEIs are non-profit organisations, traditional indicators used to measure a firm's performance may not be justified. In addition, the number of tasks for HEIs is manifold. Following Article 13 of the Act of 27 July 2005 on higher education (Journal of Laws No. 164, item 1365, as amended), the tasks of HEIs in Poland include:

- teaching students with the aim to provide knowledge and skills necessary in a professional career;
- educating students in their sense of responsibility for the Polish State, for strengthening the principles of democracy and respect for human rights;
- conducting scientific research and development work, as well as provision of research services;
- training and promoting research staff;
- popularisation and increasing the achievements of science, national culture and technology, including by collecting and making available library and IT resources;
- provision of post-graduate studies, courses and training to develop new skills necessary for the labour market and in the system of lifelong learning;
- creation of the conditions for the development of students' physical culture;
- acting on behalf of local and regional communities;
- creating conditions for full participation in the process of education and scientific research for people with disabilities.

Considering the time constraints faced by academic staff, it may be asked if their responsibilities, in particular the teaching of students and conducting scientific research, are mutually supportive or mutually exclusive. Academics often face a dilemma: on one hand, they try to satisfy the expectations of institutional governing bodies, which emphasise scientific research, publishing and obtaining external grants, which can determine an individual's scientific career and promotion. On the other hand, academic staff are also obliged to deal with a considerable teaching load. The activities of individual members of academic staff are translated into the results obtained by the whole institution, since scientific activity affects the parametric evaluation, while the didactic grants coming from the government depend on the number of students. Authors of the Strategy for the development of higher education in Poland up to 2020 suggest that research activities are mainly concentrated in limited institutions, while units that provide mass studies usually limit their scientific activity (Ernst&Young and IBnGR, 2010). Therefore, the question remains of whether given HEIs should specialise in one task, or can they, in fact, obtain good results both in teaching and research?

Theoretically, conducting scientific research and teaching can be mutually supporting activities. A teacher may draw inspiration for research from work with students (especially final year or higher level students, e.g. doctoral students). In addition, scientific activities contribute to improvement of institutional financial standing, increasing prestige, growth of interest in doctoral studies and sometimes may lead to reduction of the teaching load, which is passed on to doctoral students (Marsh and Hattie, 2002; Baurelein, 2009).

In foreign literature, the problem of scientific and teaching efficiency of the higher education sector has clearly grown in importance over recent years. Undoubtedly, it is a consequence of several issues. Firstly, studies are justified by need to introduce change to the management of European HEIs, mainly due to limited public funding (Kwiek, 2009), and the need to assess their performance in the most objective way. Secondly, the development of studies on the topic became possible by implementation of non-parametric methods such as the Data Envelopment Analysis (DEA) in the evaluation of HEI performance. The complexity of scientific production and teaching suggests that a non-parametric approach may be particularly useful. Determination of interdependency between research and teaching is absolutely justified from the perspective of state higher education policy. Thus, should specialisation of HEIs be supported by promotion of units that concentrate on a selected activity (e.g. teaching), leaving scientific research to other, specialised entities, or should all tasks be equally supported?

The following paper is structured as follows: In Section 2 a concise non-parametric method is presented for estimation of technical efficiency, together with a review of relevant literature. In Section 3, the results are shown of the empirical analysis of teaching and research efficiency in 31 public HEIs in Poland in period 2001–2008. Additionally, the potential trade-off between teaching and research activities was examined. The article concludes with some comments and suggestions for further research on the topic.

Non-parametric method for efficiency measurement

To present an analysis, the non-parametric test of efficiency measurement, the data envelopment analysis (DEA) is applied. The concept of technical efficiency is a development of the work of Koopmans (1951), Debreu (1951) and Farell (1957). DEA in its current form was popularised by Charnes, Cooper and Rhodes (1978; 1981). Technical efficiency is understood as the efficiency of the transformation of inputs into outputs (Guzik, 2009). In comparison of decision making units (DMUs), e.g. HEIs, the more efficient is the one that obtains more outputs from a given number of inputs or one that obtains a given number of outputs from a smaller number of inputs.

Efficiency understood in this way is a relative concept. DMUs are compared to each other and a benchmark unit or units that have 100% efficiency determine the limits of productive capacity (represented by a frontier function). An efficient unit is determined by maximising outputs (output-oriented model) or by minimising inputs (input-oriented model). In practice, in DEA models, measuring the efficiency of a specific unit involves solving a decision-making task, based on a linear programming algorithm, which constructs an efficiency frontier from data on single DMU; in our case, universities. If technical efficiency is determined as the ratio of a weighed sum of outputs to the weighed sum of inputs, the task is to maximise the ratio of the outputs to inputs or minimise the ratio of inputs to outputs (Ćwiąkała-Małys and Nowak, 2009, pp. 206–209). There are several types of DEA models. The basic classification characterises the output-oriented and input-oriented models previously mentioned, as well as models with constant (constant returns to scale, CRS) or variable (variable returns to scale, VRS) scale effects. CRS models are based on the assumption that an increase in all production factors with a specific value will lead to proportional increase in the outputs of that production, whereas VRS models (increasing or decreasing) cover the situation in which an increase of all production inputs causes a higher or lower than proportional increase of the outputs.

In the literature on the subject (e.g. Ćwiąkała-Małys, 2010), many advantages of the DEA method as compared with traditional, parametric methods are identified. Most importantly, the DEA method does not impose an a priori function describing the relationship between the inputs and the outputs. In parametric methods, the interdependence between variables that describe inputs and outputs is identified by means of a regression function, which is established by satisfying some pre-established conditions, e.g. the ordinary least squares (OLS), which minimises the sum of squares of deviations of empirical values from theoretical ones. It is assumed (Guzik, 2009) that the DEA method is particularly appropriate when we deal with multiple outputs as in case of HEIs. The method does not require that the inputs and outputs should be expressed in the same units. The basic disadvantage of the DEA method is its sensitivity to outliers; a change of the point of reference changes the situation of the other DMUs, for the set analysed, one may be efficient, while not, when compared to a different set of units.

So far, the DEA method has been used for estimation of the efficiency of educational institutions in several countries. The United Kingdom is the leader in this type of analysis (e.g. Flegg, Allen, Field and Thurlow, 2004; Glass, McCallion, McKillop, Rasaratnam and Stringer, 2006; Johnes and Johnes, 1995), which is undoubtedly owing to availability of institutional data. Studies in Austria (Leitner, Prikoszovits, Schaffhauser-Linzatti, Stowasser and Wagner, 2007) were motivated by higher education reform, in Germany (Kempkes and Pohl, 2010) by the reduction of funds, while in Italy (Abramo, D'Angelo and Pugini, 2008; Bonaccorsi, Daraio and Simar, 2006) by the need to introduce a method of assessment of the HEI performance. Conclusions from the work mentioned above however, do not allow generalisations exceeding the specificity of the country in which it was carried out. In Poland, there is much less experience with the DEA method for assessment of HEI efficiency. So far, it has been mainly used for evaluation of teaching efficiency (e.g. Ćwiąkała-Małys, 2010; Mongiało, Pasewicz and Świtłyk, 2010; Pasewicz and Świtłyk, 2010).

Since the main aim of this article is to confirm any correlation between teaching and research efficiency of HEIs, it is worth discussing studies, in which the problem has previously been examined. The issue of trade-off between research and teaching activities of the HEIs was tackled by Bonaccorsi et al. (2006). They conducted an analysis of 45 Italian universities using the non-parametric conditional measure of research and teaching efficiency. The authors indicated that universities efficient in terms of teaching were also efficient in terms of conducted scientific research. In addition, they concluded that the higher the quality of the research (measured by the ratio of the number of citations to the number of publications), the higher the efficiency of teaching. Aubyn, Pina, Garcia and Pais (2009), in an analysis carried out in 27 countries at the level of the whole higher education sector, found that the relationship between research and teaching efficiency depends on country. For example, the United Kingdom is a country that is efficient in both areas, while Nordic countries, Austria and Belgium have higher indicators for research than teaching efficiency, unlike the states of Central and Eastern Europe. According to this study, Poland has a very low research efficiency and relatively low level of teaching efficiency. Wolszczak-Derlacz and Parteka (2010) in their report, proxied the teaching load by the ratio of the number of student to the number of academic staff and the outcome of scientific research by the number of publications per academician. They showed a negative correlation between the analysed variables, both for the group of Polish higher education institutions analysed and those from the other six European countries (Germany, Switzerland, the United Kingdom, Austria, Finland and Italy). On this basis they concluded that there was a negative relationship between teaching and research activities.

Empirical analysis of efficiency in Polish higher education institutions

Data

The analysis covered 31 public higher education institutions (universities and technical universities) supervised by the Ministry of Science and Higher Education (*Ministerstwo Nauki i Szkolnictwa Wyższego*, MNiSW) in the years 2001–2008 (listed in Table 1). The selection of institutions for this study was determined by the methodological requirement for relative homogeneity of the institutions under scrutiny (a requirement imposed by the DEA methodology) and, to a great extent, by the availability of data. The study did not cover specific institutions: agricultural schools, universities of natural sciences, economics, physical education, pedagogical universities and entities supervised by other ministries, e.g. art, medical or military. Universities for which collection of full data for the period under examination was for various reasons impossible (e.g. the Technical University of Koszalin, the University of Zielona Góra, the Kazimierz Wielki University in Bydgoszcz) were also excluded from the analysis.

In Poland, access to disaggregated data at the level of individual HEIs is very difficult. There is no universal and generally accessible database which provide information on specific institutions' inputs and outputs. Data selected for this analysis has several sources. They cover financial resources (total revenues) and human resources (academic staff, administrative employees, full-time and part-time students) of the individual institutions. The financial data come from financial statements published by the institutions in the Journal of Laws, *Monitor Polski B*, and data on personnel are taken from publications of the MNiSW (*Szkoły wyższe – dane podstawowe*, issues 2002 through 2009)[1]. The research activity is measured by three outputs: number of publications of individual HEIs' indexed in the Web of Science (WoS) database, being a part of the ISI Web of Knowledge, by the number of citations from the same database and by the value of ministerial research grants. The first two variables are characteristic for the bibliometric approach to measuring research outputs and, as such, are often used in studies of this type (e.g. Abramo, D'Angelo and Pugini, 2008; Bonaccorsi, Daraio and Simar, 2006; Johnes and Johnes, 1995). The value of research grants (Source: MNiSW, Department of Financing Higher Education Institutions) is proof of the institution's ability to obtain external sources for carrying out scientific research.

Table 1 presents the basic characteristics of the HEIs covered by the study in 2008. The first column presents the number of students per academic. The measure may to some extent represent the teaching load of staff, i.e. the more students per teacher, the higher the teaching load, expressed e.g. in the number of papers (assignments, term papers, theses) for supervision and checking[2]. Subsequent columns present partial measures of research productivity: the number of publications per staff member, the number of citations per staff member and the value of research grants per academic.

Figures 1–3 present the relationship between the average number of students per academic staff member and three partial measures of research productivity in the years 2001–2008: the number of publications (Figure 1), the number of citations (Figure 2) and the value of research grants, all expressed per academic (Figure 3). Each point on the graph represents an observation for a give institution in a given year for a total of 248 observations. The shape of points in specific graphs

[1] Some of the data come from work on the project "The competitiveness of research and scientific efficiency of Polish technical universities", conducted under the Better Government programme sponsored by Ernst&Young.

[2] It needs to be stressed that the number of students per academic staff member may be treated as only an approximation of the value of the teaching load. The number of teaching hours is influenced by the size of the lecture groups.

Table 1
Selected indicators for the analysed higher education institutions in 2008 (*expressed per academic staff member)*

No.	Institution	No. of students	No. of publications	No. of citations	Value of grants ['000 PLN]
1.	University of Science and Technology (AGH)	14.75	0.47	3.15	9.38
2.	Technical University of Bielsko-Biała	20.77	*0.01*	*0.05*	2.69
3.	Białystok University of Technology	18.49	0.24	0.51	2.22
4.	Częstochowa University of Technology	17.34	0.22	0.96	3.02
5.	Gdańsk University of Technology	19.18	0.53	4.04	8.72
6.	Cracow University of Technology	13.33	0.14	0.96	4.25
7.	Łódź University of Technology	13.75	0.38	3.04	9.24
8.	Lublin University of Technology	17.65	0.24	1.24	5.35
9.	Opole University of Technology	*24.30*	0.23	0.48	1.78
10.	Poznań University of Technology	15.32	0.38	3.12	8.35
11.	Radom University of Technology	18.53	0.06	0.19	2.78
12.	Rzeszów University of Technology	19.77	0.28	1.09	3.74
13.	Silesian University of Technology	15.33	0.25	1.26	7.03
14.	Kielce University of Technology	21.73	0.14	0.22	6.08
15.	Szczecin University of Technology	13.14	0.47	2.60	5.61
16.	Warsaw University of Technology[(a)]	14.41	0.44	*4.37*	8.63
17.	Wrocław University of Technology	17.34	*0.54*	4.29	6.98
18.	University of Gdańsk	16.67	0.21	5.66	3.71
19.	Jagiellonian University of Cracow[(b)]	*11.30*	0.37	6.18	4.34
20.	Maria Curie-Skłodowska University	15.86	0.20	3.38	2.18
21.	Nicolaus Copernicus University[(b)]	12.84	0.22	4.18	3.09
22.	University of Opole	19.21	0.14	1.21	1.02
23.	Univeristy of Rzeszów	17.94	0.09	1.07	0.98
24.	University of Szczecin	*25.49*	0.04	2.05	1.82
25.	University of Warmia and Mazury in Olsztyn	16.92	0.11	0.57	2.66
26.	University of Warsaw	17.22	0.29	*14.28*	5.83
27.	University of Wrocław	19.73	0.33	4.43	5.16
28.	Adam Mickiewicz University in Poznań	16.73	0.26	3.56	4.86
29.	University of Białystok	16.40	0.11	2.99	2.22
30.	University of Silesia	18.42	0.23	4.05	2.59
31.	University of Łódź	17.15	0.14	5.23	2.01
Mean		*17.32*	*0.25*	*2.92*	4 463.53

[(a)] for Warsaw University of Technology excl. grants awarded to the Academic Centre in Płock.
[(b)] for Jagiellonian University and for Nicolaus Copernicus University excl. Collegium Medicum.
Source: own compilation, based on: MNiSW, 2009, number of publications and citations – the Web of Science database, value of grants – Department of Budget and Finances, MNiSW.

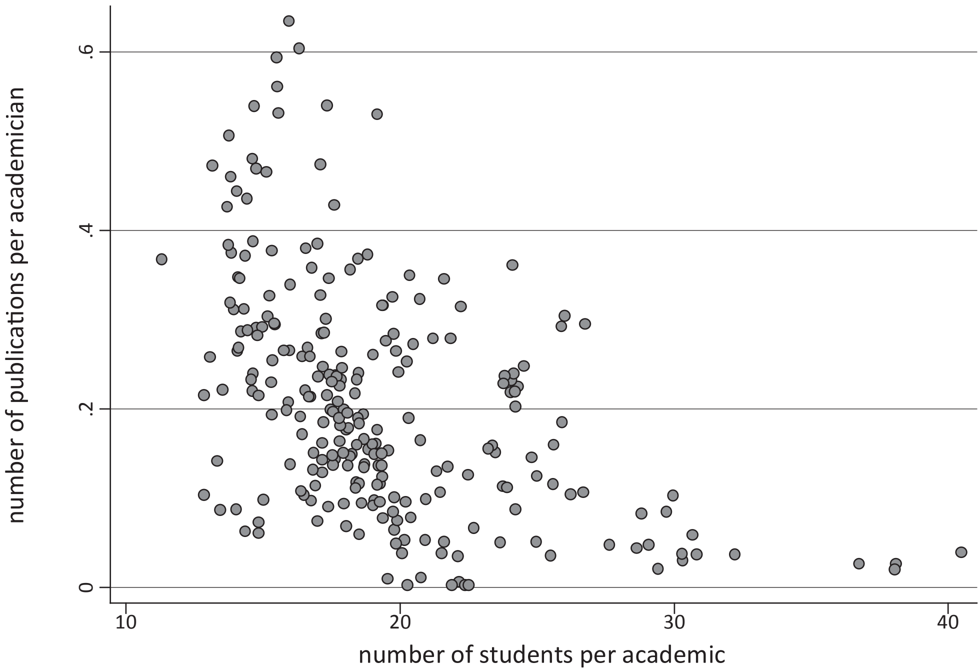

Figure 1. Ratio of the number of students and number of publications per academic staff member in selected Polish higher education institutions in the years 2001–2008.

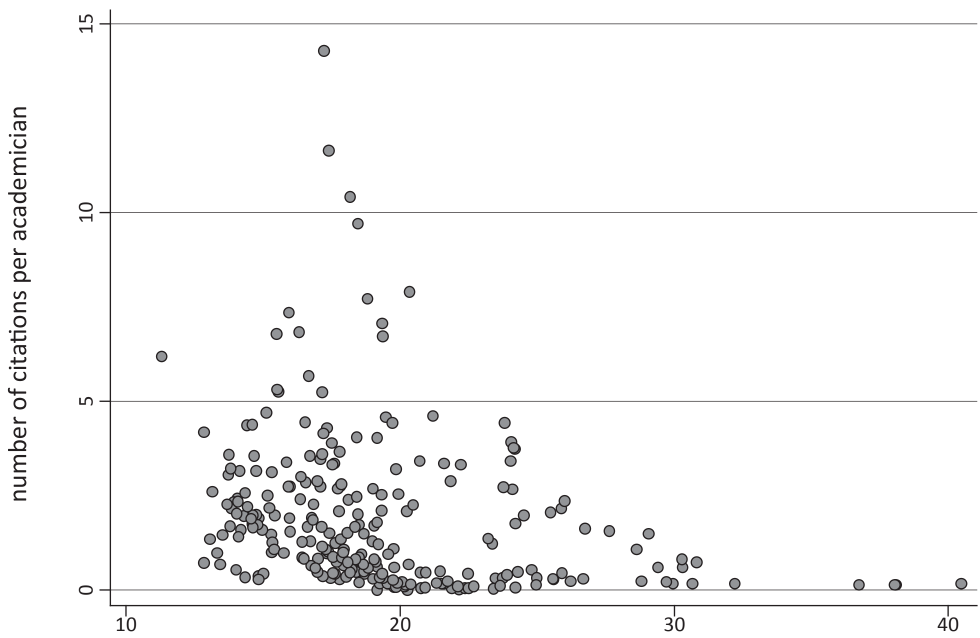

Figure 2. Ratio of the number of students and number of citations per academic staff member in selected Polish higher education institutions in the years 2001–2008.

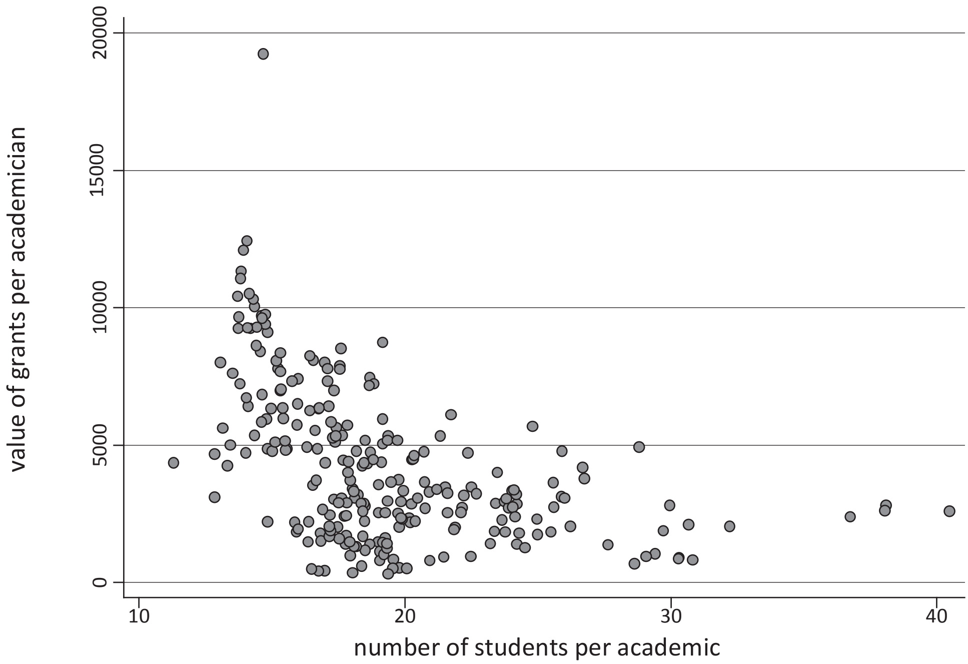

Figure 3. Ratio of the number of students and value of research grants per academic staff member in selected Polish higher education institutions in the years 2001–2008.

may suggest a negative relationship between analysed variables. However, the following part of the article discusses validation of the relationships described above, requiring calculation of research and teaching efficiency scores and comparison.

Efficiency measure

In order to maintain homogeneity of the analysed DMUs, the calculations were made separately for two subgroups of HEIs, technical universities and universities[3]. For each subgroup, two models of efficiency were calculated: a model of research and teaching efficiency. Table 2 presents a set of inputs and outputs for the two models.

In both models, the same set of inputs was adopted, i.e. the number of academic staff and the institutional revenue. However, the outputs vary according to the adopted model. The outcome of research activity was measured as the number of publications indexed in the Web of Science, number of citations and value of ministerial research grants allocated to the institution. For the teaching efficiency model, the number of full-time and part-time graduates was adopted as output. The selection of these particular inputs and outputs was determined by availability of data and by the results of previous studies using similar methodology (c.f. Bonaccorsi, Daraio and Simar, 2006).

Table 3 presents the efficiency scores for technical universities, and Table 4 for universities. To ensure clarity of presentation, results are shown only for the first and last year of analysis and mean values are calculated for all years of the study (2001–2008). In the base study, an output oriented model with constant returns to scale was adopted.

[3] I would like to thank an anonymous rewiever for this suggestion.

Table 2
Inputs and outputs in the research and teaching efficiency models

Model	Inputs	Outputs
Research efficiency	Total revenue, number of academic staff	Number of publications, number of citations, value of grants
Teaching efficiency	Total revenue, number of academic staff	Number of graduates of full time studies, number of graduates of part-time studies

An efficiency score with unity value signifies that a given HEI is a benchmark unit with 100% efficiency. However, an indicator higher than unity infers that a given institution is inefficient and, to become efficient, it should increase output production, using given inputs by: (efficiency score – 1) · 100%. For technical universities, the average research efficiency score was 1.64, suggesting that, with the given inputs, 64% more outputs could have been generated, and the teaching efficiency score was 1.47, which could be interpreted as that with given inputs, it should be possible to generate 47% more outputs. Respective values for the university group were: 1.44 and 1.24.

Table 3
Efficiency scores for the model of teaching and research efficiency, 2001–2008: technical universities

No.	Institution	Research efficiency			Teaching efficiency		
		2001	2008	Mean	2001	2008	Mean
1.	University of Science and Technology (AGH)	1.00	1.00	1.00	2.27	2.38	2.33
2.	Technical University of Bielsko-Biała	1.08	2.58	1.84	1.16	1.00	1.04
3.	Białystok University of Technology	3.33	1.59	1.96	1.00	1.49	1.20
4.	Częstochowa University of Technology	1.79	1.79	1.81	1.92	1.08	1.32
5.	Gdańsk University of Technology	1.06	1.00	1.04	1.27	1.61	1.59
6.	Cracow University of Technology	1.47	1.40	1.89	1.59	2.04	1.72
7.	Lublin University of Technology	1.00	1.01	1.01	1.39	2.08	1.66
8.	Łódź University of Technology	1.45	1.30	1.50	1.56	2.08	1.84
9.	Opole University of Technology	2.44	1.82	2.64	1.22	1.30	1.15
10.	Poznań University of Technology	1.15	1.00	1.10	1.49	1.52	1.64
11.	Radom University of Technology	3.70	2.44	3.70	1.00	1.00	1.00
12.	Rzeszów University of Technology	1.59	1.45	1.68	1.20	1.30	1.14
13.	Silesian University of Technology	1.22	1.20	1.32	1.23	1.56	1.29
14.	Kielce University of Technology	2.22	1.33	2.40	1.56	1.52	1.49
15.	Szczecin University of Technology	1.10	1.00	1.03	1.22	1.54	1.29
16.	Warsaw University of Technology	1.00	1.00	1.02	1.72	2.08	1.80
17.	Wrocław University of Technology	1.00	2.13	1.84	1.54	1.39	1.53
Mean		1.62	1.41	1.64	1.43	1.59	1.47
No. of effective institutions		4	6		2	2	

The institutions could be divided into 4 groups according to their efficiency scores:

- I: institutions with high research efficiency (efficiency score below the mean) and low teaching efficiency (efficiency score above the mean) – e.g. in 2008, there were 10 such institutions (6 technical universities and 4 universities);
- II: institutions with relatively low research efficiency (efficiency score above the mean) and high teaching efficiency (efficiency score below the mean) – in 2008, there were 11 such institutions (6 technical universities and 5 universities);
- III: institutions with high teaching and research efficiency (both efficiency score below the mean) – in 2008, there were 7 such institutions (5 technical universities and 2 universities);
- IV: institutions with low research and teaching efficiency (both scores above the mean) – in 2008, there were 3 such institutions (only universities).

The most numerous are the first two groups of HEIs, characterised by either high research or teaching efficiency. This trend is constant for the whole study period (e.g. in 2001, there were 10 institutions in group I and 8 in group II). The tendency may indicate trade off between the activities of the institutions on the two areas. This is confirmed by the negative correlation between teaching and research efficiency scores calculated for the whole period of study. In the group of technical universities, the Pearson correlation coefficient was -0.66 at $p < 0.01$, and -0.52, also at $p < 0.01$ in the group of universities. It seems comforting that only a few institutions were characterised by poor performance in both

Table 4
Efficiency scores for the model of teaching and research efficiency, 2001–2008: universities

No.	Institution	Research efficiency			Teaching efficiency		
		2001	2008	Mean	2001	2008	Mean
1.	University of Gdańsk	1.23	1.11	1.15	1.22	1.06	1.36
2.	Adam Mickiewicz University in Poznań	1.06	1.00	1.03	1.22	1.39	1.37
3.	Jagiellonian University of Cracow	1.00	1.00	1.00	1.69	2.13	1.71
4.	University of Łódź	1.85	1.43	1.65	1.45	1.79	1.69
5.	Maria Curie-Skłodowska University	1.61	1.39	1.62	1.18	1.23	1.23
6.	Nicolaus Copernicus University	1.18	1.33	1.33	1.00	1.41	1.09
7.	University of Opole	2.08	2.04	2.61	1.02	1.49	1.22
8.	Univeristy of Rzeszów	1.56	2.27	2.57	1.00	1.00	1.00
9.	Univeristy of Szczecin	2.78	2.44	3.17	1.00	1.00	1.00
10.	University of Silesia	2.00	1.41	1.72	1.06	1.16	1.04
11.	University of Białystok	1.49	1.64	1.56	1.47	1.47	1.44
12.	University of Warmia and Mazury in Olsztyn	1.27	1.82	1.39	1.09	1.00	1.05
13.	University of Warsaw	1.00	1.00	1.00	1.41	2.08	1.67
14.	University of Wrocław	1.20	1.00	1.15	1.05	1.23	1.13
Mean		1.41	1.37	1.44	1.18	1.32	1.24
No. of effective institutions		2	4		3	3	

areas (group IV). In 2008, these were the Universities of Łódź, Opole and Białystok.

To verify the correctness of the inference, three alternative versions of the models were calculated: an output-oriented model with variable returns to scale, an input-oriented model with constant returns to scale and an output-oriented model with constant returns to scale with the number of students as an additional input. The correlation between the research and teaching efficiency scores for all alternative models was negative and statistically significant (the Pearson correlation coefficient was within the range from -0.40 to -0.59 at $p < 0.01$).

Conclusions

This article presented a measurement of efficiency of scientific research and teaching for 31 Polish public higher education institutions between the years 2001–2008. Due to the differing profiles of the institutions studied, calculations were performed separately for technical universities and universities. The HEIs were characterised by relatively low efficiency in their use of financial and human resources, both in terms of teaching and research efficiency. The average values for efficiency scores indicated that in the case of technical universities, the research output should be 64% more and 44% more for universities to become fully efficient. As far as teaching efficiency is considered, technical universities should increase output by 47% and universities by 24%. The results lead to the conclusion that there is a negative correlation between teaching and research activities in the HEIs studied. The largest groups had relatively low research with high teaching efficiency, or the converse.

It must be emphasised that a certain degree of caution should be applied in extrapolating the conclusions about the institutions in the study to the whole population of Polish HEIs. In the above analysis, it was assumed that both the teaching and research outcomes can validly be measured quantitatively. This approach has the disadvantage that there is no reference to quality of the described processes, especially with reference to the teaching. The adopted outputs for research activity, publications and citations identified in the Web of Science (WoS) database, do to some extent reflect their quality since WoS lists publications from quality journals. However, as regards teaching efficiency, only the number of graduates was considered. This criterion has only a quantitative dimension and does not allow any inference about teaching quality. It seems that it could have a bearing on the negative correlation between research and teaching efficiency. Yet it should be stressed that adoption of those measures of activity in higher education was determined not only by the data available, but also by practices applied to similar analyses. In the studies of Italian institutions referred to above (Bonaccorsi et al., 2006), the number of publications was adopted as the measure of institutions' research activity, while number of graduates was the measure for teaching activity. They showed that universities efficient in terms of teaching are also efficient in terms of conducting scientific research. However, the authors admitted that there was no unanimous opinion in the literature on the subject about the direction of the relation between research and teaching efficiency. Since the potential trade off between teaching and research remains an open question, we hope that this study will stimulate further research in this field. Future studies should cover not just a measure of the efficiency of HEIs, but also identification of other factors influencing efficiency.

Literature

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