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Quality of Teaching and Research in Public Higher Education in Poland: Relationship with Financial Indicators and Efficiency

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Abstract

Purpose: The article addressed the problem of relationships between university funding and efficiency on the one hand and the quality of teaching and research on the other.

Methodology: The measurement of teaching and research quality in Polish universities was derived from two sources: 1) evaluation scores of teaching quality given to universities by the Polish Accreditation Committee, and 2) the research category grades given to university departments or units by the Polish Committee for Evaluation of Scientific Units. Subsequently, the quality measurements were correlated with financial indicators and efficiency scores obtained from data envelopment analysis.

Findings: The correlation and regression results indicated that public universities that have received higher scores of teaching quality simultaneously have higher average scientific categories. There was also a substantial relationship between the revenue per student and the revenue per teacher and variables describing quality but the regression analysis exhibited opposite directions regarding the type of quality indicator.

Research limitations/implications: The quality of teaching and research at universities was assessed despite the limited availability of internal information gathered from higher education institutions (HEIs).

Practical implications: The authorities of a university can simultaneously track the improvement of quality or financial efficiency without losing their interdependence when reforms of HEI operations are conducted.

Originality: The study proposed new measurements of quality derived from external evaluation bodies and investigated the relations of these measures with selected financial and efficiency indicators.

Keywords: higher education, quality evaluation, efficiency, performance measurement (quality)

JEL: H21, I22, I23

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Introduction

The relation between funding and quality of teaching and research conducted by universities is an important and controversial issue, especially when it comes to public financing in times of austerity and diminishing government budgets. Many schemes of budgetary financing are based on performance measurements provided by universities and involve quality criteria. This encourages this study's investigation into the relationship between financing and efficiency measures and universities teaching and research quality on a sample of Polish higher education institutions (HEIs). In general, it is expected that a higher availability of funds should enhance the quality of teaching and research. To prove this, the indicators of teaching and quality were compared with the financial data of universities (such as revenue per student or revenue per teacher), as well as with efficiency scores derived from data envelopment analysis. However, it should be emphasized that one cannot rule out the positive contribution of quality of teaching and research on the funds available for universities. Therefore, the study was more interested in the confirmation of existing interdependence than in proving the causal relationship. It concentrated on the correlation analysis supplemented by ordinary least squares regression with panel-corrected standard errors covering two consecutive years (2010 and 2011). The choice of methods was mainly determined by the availability of data on the quality of teaching and research in Poland, which were provided by external public institutions[4]. Unfortunately, one cannot use internal indicators of universities' performance that could be more specific and precise[5].

Incidentally, it was recognized that the question of how funding relates to quality is not an easy one to answer because measuring university quality itself is ambiguous and difficult to operationalize (Mizikaci, 2006; Bergseth, Petocz and Dahlgren, 2014). However, in general, it was observed that a higher position of universities coincides with their financial strength (Jabnoun, 2015). To assess the quality of teaching and research, the study proposed a variable built on data provided by external evaluation bodies: Polish Accreditation Committee (PAC) and Polish Committee for Evaluation of Scientific Units (PCESU). This approach was particularly useful in measuring teaching and research quality when data was insufficient or incomparable. Examples are when one cannot compare the skills and knowledge of graduates between universities or when faculty members have a preference for publishing in journals not cited in popular citation indices. Last but not least, this approach allowed dealing with the

[4] Unfortunately after 2011, the teaching quality assessment methods have been changed, making any further updates impossible.

[5] For example, Sułkowski (2015) distinguished several types of indicators of HEIs, including: 1) economic indicators (related to budgeting), 2) performance indicators (present productivity, expenditures per unit and 3) effectiveness indicators (degree of achievement of the assumed goals).

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lack of publicly available data about universities' performance and hampered efforts concentrated on hiding the true quality of teaching and research.

There were several studies on the interdependency between quality and higher education financing. For instance, a study of American universities by Michael (2005) investigated the correlation between quality rankings and HEI financing. Generally, the relationship turned out to be positive for top national doctoral U.S. universities and this was especially evident if the endowment per student was considered. According to this finding, money plays a significant role in how an institution is ranked and how a higher ranking position is cost-inducing. In another study, Leifner (2003) showed that financing and resource allocation had a significant impact on the level and type of activity that academics concentrate on, but not on the long-term success of universities.

The literature more frequently dealt with the problem of funding allocation on the basis of universities' performance. For example, Sav (2013) examined the efficiency of performance-based funding schemes for U.S. public higher education institutions with the use of graduation rates in a four-stage data envelopment analysis. In this setting, the performance measurements were applied to the completion rate of students (the relation of students graduating to students admitted for studies). However, this approach could be misleading because academic institutions operate in different environments and the completion rates are easy to manipulate. Two applications of the Sav (2013) study were particularly important. First, the evaluation of higher education institutions should be objectified. This idea was applied by adopting uniform criteria from independent third-party institutions. Second, the quality of universities should be judged according to their efficiency rather than simple revenues or costs. Such an approach better captures the specifics of higher education, where multiple objectives are pursued at the same time and the identification of a singular outcome is insufficient to explain both the quality of teaching and research.

This article splits into four sections. The first section describes the context of Polish higher education as well as the methods used to evaluate teaching and research quality. The second section describes the method of examining the interdependences of financial data with teaching and research quality indicators. The third section outlines the correlation and regression results. The last section provides conclusions and possible extensions for future research.

Higher education and quality assessment in Poland

Since 1990, there have been two sectors of higher education in Poland: public and private (non-public). Currently there are more private universities in Poland than public ones, yet more students study in the public system. The two sectors differ to a great extent both in their research and teaching activity, which also implies a diversification of quality offered. Generally, public universities are older and larger, offering many types of programs as well as having the power to grant scientific degrees (Ph.D. and Ph.D. with habilitation, the second scientific degree). In contrast, private universities are newer and smaller, offering a limited number of educational programs and rarely having the power to grant a Ph.D. degree (and only a few have the right to grant a Ph.D. with habilitation). Therefore, the quality of teaching and research of public universities is perceived to be higher. Most private universities pursue a dumping policy to the high quality academic schools by offering low tuition studies with a low quality of teaching. Only a few of them compete on quality of teaching and research, especially in humanities where equipment requirements are moderate.

In terms of students attending higher education, Poland is lately experiencing a significant decrease in student population. This reduction in student population was brought on by persistently low birth rates and wider demographic declines. For example in 2010, there were 1,261,175 students in public higher education institutions and 580,076 in non-public universities. In 2011, the number of students dropped to 1,245,864 in public HEIs and to 518,196 in private ones. These trends are expected to continue for at least the next decade, which puts great pressure on universities to find ways to attract and keep a sustainable number of students to maintain current levels of revenues.

For public universities, the prevailing sources of funding come from state budget grants for specified teaching or research tasks. The main part of government subsidies for public universities is relatively stable and calculated on the basis of the number of students and the scientific category of departments (granted by the PCESU), or the number of employed staff if the scientific category is not applicable for the given unit (i.e. for departments without a scientific category). The direct budgetary financing is complemented with revenue from other public or non-public sources, such as tuition fees. Private HEIs collect most of their funds from private sources of financing and their access to public sources is very limited. Generally, in comparison with other countries, the system of higher education receives relatively little financing. In 2010, it comprised only 0.71% of the country's gross domestic product (Central Statistical Office, 2011), and 0.67% in 2011 (Central Statistical Office, 2012). At the same time in 2010, the expenses on research and development in Poland reached only 0.74% of GDP. As a consequence,

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the revenue per employee in HEIs was equal to about 40,000 EUR and about 4,000 EUR per student. These levels were lower than in most other OECD countries. Recently, the poor financial situation of Polish universities triggered the financial reform of the science and higher education system, striving to promote the HEIs with the highest quality in both areas. The reform has two purposes: increase of university autonomy and extension of financing based on performance.

Official assessments of quality of Polish universities are made by the Polish Accreditation Committee (PAC). The PAC is an independent institution established to enhance the quality of Polish higher education. It evaluates universities on the basis of self-evaluations provided by universities themselves in combination with site visits. After a site visit, which may last two or more days, a PAC evaluation team prepares a report. The report contains a quality assessment grade for teaching, taking into account the learning outcomes and compliance with the legal requirements. There are four possible quality grades: outstanding, positive, conditional and negative. In program evaluations, all grades refer to the specified field of study. A positive grade is valid for 6 years, an outstanding one for 8 years, and a conditional one for 1 year. For the latter, a reassessment is required and a new grade can be either positive or negative. In the case of a negative evaluation the academic institution is forced to close down the existing program of study. However, it can take some time as current students are still allowed to graduate the existing program. In practice, this may take up to three years after receiving a negative assessment. Sometimes the higher education institution appeals to PAC to reevaluate the negative or conditional decision and this request is approved by the Committee. In such a situation after receiving a negative grade, the institution may receive a conditional or positive grade. Outstanding grades for specific programs are awarded after receiving a positive grade and not earlier than after assessment of all programs of the same type in Poland. Starting from 2011, the program evaluations have been gradually replaced by institutional evaluations or the evaluations of departments. In contrast to program evaluations, the institutional evaluation applies to all fields of study provided by a given university's faculty or department.

In addition to the PAC evaluation process, research activity at Polish universities is assessed by the Committee for Evaluation of Scientific Units (PCESU). Based on its assessment, the PCESU places departments of universities in different categories depending on their research performance (taking into account the number of scientific publications, grants, etc.). The categorization process is voluntary and open to all universities (public and private ones), but it has an impact on the funds received from the government. There are 5 categories in which universities can be placed. Once the PCESU places a university in a given category, the category is valid for 3 years.

Methodology

The study measured the correlation between two quality indicators (teaching and research activity) and the financial or efficiency variables to confirm or refute the existence of positive relationships between these indicators. The correlation analysis was carried out twice, once for 2010 and once for 2011. The use of two years limited the detection of incidental dependencies that can occur in a single year. The data on evaluation and research performance covered a period of 8 years (2004–2011) for the evaluation of teaching quality of the program studies and two results of scientific categorization in Poland taking place in 2006 and 2010. The analysis left the evaluation grades of teaching granted after 2011 in the study because they were obtained under a different methodology; since 2012, the final evaluation grade is assessed on 8 separate criteria. The analysis of relation between higher institution funding, efficiency and teaching and scientific quality was performed in the form of five regressions. Data was used from 2010 (with scientific grades of 2006 as the most accurate categorization results for most of 2010 and actual financial and teaching evaluation data for 2010) and from 2011 (with scientific grades of 2010 and actual financial and teaching evaluation data for 2011). The previous data was used only for calculating the average quality of teaching and research for a given year because grades are valid for 5 consecutive years. Generally, this time frame ensures that each program of the study was evaluated by the PAC at least once and the bodies inside the institutions had the possibility to obtain the scientific category from PCESU.

The analysis concerned only public universities in Poland and omitted the large number of private universities. This was due to the complications caused by the different funding schemes of the two types of entities. The study also concentrated on the most important categories of public institutions including: universities (18), technical (18), economic (5), pedagogical (5) and agricultural (7), all higher education institutions. To avoid distortions generated by specific features of some types of academic institutions, it was decided to drop the data for military, maritime, medical and theological public universities.

The indicators of HEI quality included two new measures: "evaluation" describing the quality of teaching and "category" describing the quality of research. The construction of variables stemmed from the evaluation and categorization data provided by PAC and PCESU[6]. As a proxy of teaching quality, the analysis used the average grades

[6] The raw data about PAC evaluation grades are available at the PAC website http://www.pka.edu.pl/index.php? page=s _ ocenione and raw data about categorization can be taken from the Polish Ministry Science and Higher Education website http://www.nauka.gov.pl/finansowanie/finansowanie-nauki/dzialalnosc-statutowa/ocena-parametryczna-jednostek-naukowych/

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given by the PAC for all educational programs that were evaluated in a university before the given year. The grades granted in a given year were not used because the choice of program assessment was not random in the past. Beforehand, the PAC started its evaluations process by looking first at university programs that were perceived as better to set the initial standards of quality. This meant that evaluation results were time-biased and the higher grades were more often granted at the beginning of the quality assessment process. This bias was subsequently replicated according to the expiration date of early-issued decisions granting the evaluation levels. The number of negative evaluations decreased over time because poor academic institutions started to mimic the programs of good universities or they ceased to exist.

The calculation of evaluation measures covered only program evaluation and omitted the results of institutional assessments. The nominal grades obtained by a program study inside of a particular university faculty or department were represented by four categories: 4 – outstanding, 3 – positive, 2 – conditional or 1 – negative. The teaching assessment grade of an HEI was the average of grades in its departments. Generally, it was assumed that the distance between grades was equal, which was met when many grades and the number of outstanding grades was not very high. Nevertheless, some weaknesses of this measurement method should be stressed. In particular, the PAC assessment did not distinguish between university programs if they received a "positive" grade. This grade may include both very good programs (but not outstanding) and only satisfactory ones. It constrained the usefulness of the proposed measurement for education quality comparison over time. Moreover, the averaging procedure was sensitive to the changes of the program number offered by the academic institution. This is because most of programs obtained positive grades so the universities with a lower number of programs exhibited a higher variation of the quality measurements average. Finally, it did not take into account the number of students attending each type of studies (outstanding studies can be exclusive).

Similarly, the quality of university research was measured by the average scientific category obtained by institutes or departments inside a given university. A higher research category provides more public funding for universities in the future but it can also be regarded as a university output. The value of scientific categories increases with the quality of research. For units without a categorization grade, the number one was assigned. Therefore, the research quality indicator had a maximum value of six and a minimum value of one. This was similar to the quality of teaching measurements as described. The measurement was vulnerable to the number of categorized units (while the teaching measurement was sensitive to the number of programs of study offered). The mergers of institutes or faculties inside higher education institutions were assumed neutral to the average category obtained by a university. The new non-categorized institutes or faculties established between assessment years had to be dropped.

Financial variables included revenue per teacher and revenue per student. Both variables were calculated as ratios to avoid the impact of the institution size. Large institutions can collect more revenues but they are not necessarily more effective. The data was taken from financial statements of HEIs and public governmental statistics, provided by Polish Ministry of Science and Higher Education. Unfortunately, there were no indicators for the multiplicity of goals pursued by HEIs. To partially deal with this problem, the analysis used the efficiency results obtained with data envelopment analysis (DEA).

DEA is a popular non-parametric method of computing the total productivity of decision-making units. Total productivity reflects the relationship of weighted outputs to weighted inputs. The method enables the use of multiple inputs and outputs in the same time, representing more than one operational purpose. DEA does not require the application of specific production functions, so it is frequently used in efficiency assessments of service and non-profit industries. In other words, one does not need to know how exactly the inputs transform into outputs. Instead, one should specify the inputs and outputs to compute whether the decision unit (in this case, the university) is relatively effective inside the group of analyzed entities. The method was developed in the late 1970s (Charnes, Cooper and Rhodes, 1978) and was quickly acknowledged as an effective analytical tool. The success of this approach had two sources: 1) it has a close connection with the intuitive understanding of efficiency as a relation of weighted effects to the weighted costs, and 2) it can be applied easily in comparison with parametric methods.

The DEA optimization procedure applies a linear combination of inputs and outputs taken from efficient units and weights of inputs and outputs to produce the same outputs with fewer inputs (in the input-oriented model). Instead of inputs reduction, it is also possible to achieve no less outputs for the same inputs (in the output-oriented model). If the minimization of inputs (maximization of outputs) without worsening the outputs is not possible, the unit is recognized as effective and becomes a pattern (in terms of inputs consumed and outputs achieved) for inefficient units. The efficient units designate the efficient frontier as a benchmark for inefficient HEIs. The distance to the frontier helps to set targets for inefficient units and regularly control the progress of their achievement. A reduction of inputs (increase of outputs) can be applied in a proportional (radial models without slacks) or non-proportional (models with slacks, radial or additive) manner. The input-oriented models are preferred when resources for

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decision making unit are limited or when the increase of outputs is hard to achieve. The efficiency scores are equal to or greater than one (if one allows for the so-called superefficiency) for a decision unit laying on the efficient frontier in the input oriented model, and smaller than one for inefficient units. The output-oriented models have an advantage when the effects are the most important, for example in determining the sales targets. Radial models allow for simple efficiency comparison between decision units, which is not so intuitive in additive models. The latter models better reflect the required adjustment of inputs (or outputs) that is not proportional[7].

The simplest radial input-oriented DEA model without slacks has the following form:

$$\min \Theta_0$$

with two constraints:

$$\sum_{j=1}^{n} y_{rj}\lambda_j \geq y_{r0},$$

$$x_{i0}\Theta_0 - \sum_{j=1}^{n} x_{ij}\lambda_j \geq 0,$$

where weights λ_j of inputs and outputs are nonnegative $\lambda_j \geq 0$.

The weights are set in the optimization procedure. The analysis had $i = 1,\dots,m$ inputs, $r = 1,\dots,s$ outputs and $j = 1,\dots,n$ decision-making units (HEIs); y_{rj} represents r result in j unit, x_{ij} *is* i input in j unit and subscript 0 means a unit for which was calculated the efficiency score Θ_0. Very important in this model was the interpretation of Θ_0 because it described the share of current inputs that can remain in a unit to obtain the current outputs, using available technology (the weighted relation of outputs to inputs from efficient units). For efficient units, the parameter Θ equals one (the reduction of inputs preserving the size of outputs is impossible); for inefficient ones, it is lower than one. This allowed for making a benchmark for an inefficient unit that is efficient by adjustment of inputs and outputs. Precise lambdas described how many shares of inputs and outputs from chosen efficient units should be taken to obtain the new (virtual) unit, providing the same size of outputs as before but with fewer inputs.

7 To achieve the same goal, the radial model can be augmented with slacks (non-proportional reductions of inputs or increments of outputs) aside from proportional change of inputs (or outputs).

Up until now, DEA of higher education was used in more than 20 papers (Sav, 2012) and spanned over 9 countries. In several cases, DEA was applied to measure the efficiency of individual departments or programs within a university. Only a minority of studies concentrated on the efficiency of whole educational institutions (Ahn, Charnes and Cooper, 1988; Breu and Raab, 1994; Dunbar and Lewis, 1995; Athanassopoulos and Shale, 1997; Avkiran, 2001; Abbott and Doucouliagos, 2003; Johnes, 2006; Worthington and Lee, 2008). This study belongs to the second group but contrary to the listed papers, the efficiency scores were not the main focus of attention. Instead, the studied tried to capture the relationship between quality of teaching and research with financial efficiency computed with DEA[8]. In Poland, the efficiency analyses of HEIs were conducted by Ćwiąkała-Małys (2010).

The efficiency measurements were calculated at the university level because data about funding was neither available for study programs nor for the internal bodies of HEIs, such as departments. This was sufficient for the purpose of the study but it should be stressed that the efficiency assessed on the sub-units level was different from the efficiency of the whole university (Agasisti and Bonomi, 2014). The study chose a radial and input-oriented DEA model with constant return of scale[9]. The radial calculation allowed for obtaining efficiency scores and the input orientation assumed the limitation of sources of financing available. The rationale for this orientation was similar to the arguments of Sav (2013). There were no other restrictions imposed on the composition of inputs and outputs.

The study version of DEA was relatively simple and concentrated on pure efficiency measurement without inputs or outputs representing quality of teaching or research. This was because most of the quality indicators (for example, number of articles published by the faculties, citations or patents of HEIs) were not accessible in Poland. Additionally, the number of graduates (relatively the easiest data to be collected) did not represent the current activity of a HEI because most of the students were admitted several years ago and on programs with different length. Therefore, the inputs to DEA included financial costs incurred by universities, number of students attending the university and number of teachers. The outputs consisted of financial revenues collected by the HEI. Financial costs directly measured expenses. Academic institutions

8 Several DEA studies coped with the problem of the quality of universities' outcomes. However, most of them concentrated only on the research activity and in the context of technical efficiency, e.g. Athanassopoulos and Shale (1997) and Johnes and Johnes (1995) used the weighted indices of research publications as a proxy of research quality. Tomkins and Green (1988) chose the value of research grants attracted by university. To cover the quality of teaching, the weighted assessment of students' degree was used (Johnes, 2006).

9 In a model with a constant return of scale, the sum of inputs and outputs shares taken from efficient unit should sum up to 1. This differs from the model of Charnes, Cooper and Rhodes (1978) and from the model of Banker, Charnes and Coopers (1984). See Sav (2013) for a detailed explanation.

used human capital to produce their outcome so it was captured by the number of teachers (academic staff) and students. The latter two helped to gather financing from external sources (public or private ones) increasing the revenues of universities. The values of external quality measures and efficiency scores for 2010 and 2011 for 53 public Polish HEIs are included in Table 1.

Table 1. External quality measurements and DEA efficiency scores of Polish HEIs (2010–2011)

HEIs	Evaluation 2010	Category 2010	Score 2010	Evaluation 2011	Category 2011	Score 2011
University of Bialystok	2.00	4.88	0.74	2.06	4.30	0.55
Kazimierz Wielki University in Bydgoszcz	2.00	3.94	0.99	2.00	3.67	0.59
University of Gdansk	2.00	5.25	0.78	2.03	5.42	0.61
University of Silesia in Katowice	2.00	5.14	0.82	2.05	5.36	0.65
Jan Kochanowski University in Kielce	1.90	4.21	0.72	2.00	4.33	0.53
Jagiellonian University in Krakow	2.02	5.94	0.95	2.02	5.87	0.85
Maria Curie-Sklodowska University	2.00	4.92	0.74	2.00	5.00	0.68
University of Lodz	2.00	5.33	0.77	2.03	5.17	1.35
University of Warmia and Mazury in Olsztyn	2.00	5.13	0.80	2.06	4.69	0.67
Opole University	2.00	5.14	0.77	2.05	4.88	0.56
Adam Mickiewicz University in Poznan	2.11	5.79	0.78	2.11	5.50	0.65
University of Rzeszow	2.00	3.56	0.71	2.00	3.58	0.54
Szczecin University	1.88	4.50	0.78	1.81	4.70	0.60
Nicolaus Copernicus University	2.08	5.36	0.78	2.09	5.31	0.65
Cardinal Stefan Wyszynski University in Warsaw	2.00	4.38	0.74	2.00	5.00	0.52
University of Warsaw	2.10	5.50	0.99	2.10	5.70	0.91
University of Wroclaw	2.10	4.90	0.85	2.20	5.10	0.69

University of Zielona Gora	2.00	4.50	0.76	2.04	4.50	0.59
John Paul II Catholic University of Lublin	1.89	4.35	0.73	1.95	4.17	0.59
Bialystok University of Technology	2.00	4.83	0.85	2.00	4.17	0.64
University of Bielsko-Biala	2.00	2.80	0.98	2.00	3.60	0.58
Czestochowa University of Technology	2.00	4.83	0.86	2.00	4.33	0.69
Gdansk University of Technology	2.06	5.00	0.99	2.05	5.44	0.80
Silesian University of Technology	2.10	5.08	0.89	2.12	4.62	0.81
Kielce University of Technology	2.00	4.25	0.94	2.00	4.25	0.68
Koszalin University of Technology	1.80	3.40	0.77	1.82	4.20	0.50
Tadeusz Kosciuszko Cracow University of Technology	2.06	5.14	0.85	2.06	4.57	0.74
University of Science and Technology in Cracow	2.22	5.47	0.97	2.26	5.40	0.86
Lublin University of Technology	2.00	4.67	0.83	2.00	4.33	0.64
Lodz University of Technology	2.00	5.20	1.00	1.96	5.40	0.89
Opole University of Technology	1.86	4.50	0.98	1.86	4.50	0.59
Poznan University of Technology	2.06	5.00	0.90	2.12	5.20	0.75
Kazimierz Pulaski University of Technology and Humanities in Radom	2.00	4.00	0.88	2.00	4.33	0.58
Rzeszow University of Technology	2.00	4.29	0.82	2.00	4.14	0.61
West Pomeranian University of Technology in Szczecin	2.00	5.10	0.89	2.00	4.70	0.80
Warsaw University of Technology	2.09	5.32	1.02	2.09	5.26	0.92

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Wroclaw University of Technology	2.14	5.83	0.97	2.17	5.17	0.80
University of Technology and Life Sciences in Bydgoszcz	2.00	4.33	0.78	2.00	4.25	0.68
University of Agriculture in Krakow	1.83	4.88	0.87	1.85	4.71	0.72
University of Life Sciences in Lublin	2.00	5.00	0.78	2.00	4.29	0.66
Poznan University of Life Sciences	2.00	4.75	1.03	2.08	4.13	0.75
University of Science and Humanities in Siedlce	1.93	4.08	0.96	2.00	3.75	0.58
Warsaw University of Life Sciences	2.00	5.00	0.90	2.06	4.85	0.71
Wroclaw University of Environmental and Life Sciences	2.08	5.80	0.89	2.08	5.20	0.79
University of Economics in Katowice	2.25	5.67	0.88	2.20	5.50	0.70
Cracow University of Economics	2.00	5.25	0.81	1.86	5.50	0.63
Poznan University of Economics	2.67	3.60	0.89	2.67	5.60	0.70
Warsaw School of Economics	2.67	5.83	0.84	2.50	5.17	0.75
Wroclaw University of Economics	2.00	5.50	0.83	2.00	6.00	0.64
Jan Dlugosz University in Czestochowa	1.88	3.31	0.94	1.89	4.40	0.59
Pedagogical University of Cracow	2.00	3.87	0.75	2.00	3.50	0.54
Pomeranian University in Slupsk	2.00	2.67	0.96	2.00	4.33	0.59
Maria Grzegorzewska Academy of Special Education in Warsaw	2.00	5.00	0.98	2.00	4.00	0.61

Source: calculations on data from PAC, PCESU and Polish Ministry of Science and Higher Education.

Correlations and regressions results

The variables "Evaluation" and "Category" are not normally distributed, which was confirmed by the Wilk-Shapiro test at a significance level of 5%. Therefore, the Spearman rank correlation was more suitable for the relation assessment than the pairwise Pearson correlation. The basic results of the former are presented in two tables, respectively for 2010 (Table 2) and 2011 (Table 3). From these tables, one can make several observations. First, the 2010 correlations of financial variables with teaching and research quality were both significant (at 1% significance level). HEIs with higher average teaching quality (according to the PAC evaluation) had simultaneously better average scientific categories (correlation is positive 0.5993 so quality of teaching increased with quality of research). At the same time, correlations with financial variables were positive and significant. This may indicate that HEIs with higher financing obtain higher quality of teaching and research or higher quality increases the inflow of revenues. The only correlation that turned out to be insignificant was the relation between "Category" and efficiency score (0.1294). Interestingly, it was despite positive and significant dependences of both types of external quality measures ("Evaluation" and "Category"). This may suggest that universities with higher quality are more financially efficient but better scientific positions coincide with a deterioration of efficiency. One can argue that conducting extensive research activity is unprofitable for universities in Poland and this remains in line with results obtained for American universities (Michael, 2005). However, this reasoning is hampered by the significance of similar correlations for 2011.

Table 2. Spearman rank correlation between quality and financial measurements (2010)

	Evaluation	Category	Revenue per teacher	Revenue per student	Score
Evaluation	1				
Category	0.5993 (0.0000)	1			
Revenue per teacher	0.5730 (0.0000)	0.5517 (0.0000)	1		
Revenue per student	0.5149 (0.0001)	0.5421 (0.0000)	0.7492 (0.0000)	1	
Score	0.2708 (0.0499)	0.1294 (0.3558)	0.5278 (0.0000)	0.4111 (0.0022)	1

Source: calculations in STATA (P-values in parentheses).

Second, there was a substantial relationship between efficiency measured in the DEA model and the two variables describing quality. The direction of the impact was positive. As one might expect, revenue positively affected efficiency but obviously was partially forced by the construction of the DEA model where revenue was an output. The importance of this result was weakened by the insignificance of the correlation between "Category" and "Score."

The results for 2011 were similar. The relationship between the quality of teaching and research with revenues confirmed that higher quality was linked with higher financial inflow. Interestingly, the correlation turned out to be stronger with efficiency scores produced by DEA. This was evidenced by all significant correlations in the last row of Table 3. It was concluded that the two quality measures predicted the overall HEIs quality quite well, despite that they were only partially interdependent, reflecting different kinds of university purposes: a focus on research or on teaching.

Table 3. Spearman rank correlation between quality and financial measurements (2011)

	Evaluation	Category	Revenue per teacher	Revenue per student	Score
Evaluation	1				
Category	0.4674 (0.0004)	1			
Revenue per teacher	0.5502 (0.0000)	0.6011 (0.0000)	1		
Revenue per student	0.4865 (0.0002)	0.4315 (0.0013)	0.7366 (0.0000)	1	
Score	0.5230 (0.001)	0.5723 (0.0000)	0.8912 (0.0000)	0.887 (0.0000)	1

Source: own calculations in STATA (P-values in parentheses).

In order to extend the analysis, the study applied five regression models with panel-corrected standard errors to better utilize the gathered information from two years of observations. The panel was extremely short (it covered only two periods), so the typical GLS panel estimation with random or fixed effects was not appropriate in the case. Instead, the study used linear regressions with panel-corrected standard errors (Kmenta, 1997; Beck and Katz, 1995). The latter procedure modified estimates of standard errors and was especially suitable for short panels. It assumed correlated (balanced) panels with no autocorrelation. The analysis could not determine whether there was an autocorrelation since panel consisted of only two years of data.

Besides the variables described in the correlation procedure (evaluation, category, revenue per teacher, revenue per student, score), several other control variables were included to better reflect factors affecting quality, funding and efficiency of public HEIs:

- Additional variables covered the number of units in the university with scientific category (categorization is voluntary so the high number of units with category in given institution can hint at better quality);
- Number of studies assessed by PAC at the university (assessment procedure was not randomly applied to the HEIs in the past, so better quality can be associated with a larger number of evaluations);
- Number of citizens in the headquarters of the university (quality can be higher in big cities);
- Profits generated by HEIs from their activity (shows financial strength of an institution);
- Tangible fixed assets (represent equipment that can be used for research or teaching purposes);
- Tangible assets per teacher (treated as a proxy of working conditions for scientists and teachers); and
- Ratio of student to teachers (high ratio reflects overburdening with teaching and stimulates a decrease of teaching quality and research performance).

Some other variables were rejected because of high correlation; this refers to the number of students and the number of teachers, revenues and costs of HEIs. It should be emphasized that rejected variables were partially incorporated in the construction of variables used in the regression (e.g., revenue per student was the value of HEI revenues divided by the number of students).

After estimation of each of the basic models (five models including all eleven variables), insignificant variables at the 10% level were excluded and models were again recalculated with a reduced number of variables. Actually, the final models included only significant variables with at least a 10% significance level. The omitted variables are shown in Table 4 with the dash sign (–). Separately, the impact of HEIs types on dependent variables was checked by the augmentation of each final model with a dummy variable representing the type of university (with one dummy for the model).

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Table 4. Linear regression estimates with panel corrected standard errors

	Evaluation	Category	Revenue per teacher	Revenue per student	Score
Evaluation	–	0.7981 (0.003)	19324.59 (0.000)	-674.32 (0.001)	-0.1517 (0.005)
Category	0.0429 (0.039)	–	-1617.15 (0.018)	251.35 (0.000)	-0.0335 (0.054)
Revenue per teacher	0,00000352 (0.000)	-0,00000073 (0.000)	–	0.0581 (0.000)	0.0000024 (0.000)
Revenue per student	-0,0000344 (0.004)	0,0002101 (0.000)	15.28 (0.000)	–	–
Score	-0.1458 (0.015)	–	15420.18 (0.056)	–	–
Number of units categorized by PCESU	-0.006462 (0.095)	-0.02392 (0.014)	1497.29 (0.000)	-67.79 (0.000)	-0.0105 (0.012)
Number of studies assessed by PAC	-0.00463 (0.001)	0.02853 (0.000)	–	–	–
Number of citizens in the HEIs' headquarters	0.0000598 (0.000)	0.000215 (0.001)	-7.49 (0.000)	0.481 (0.000)	0.000264 (0.008)
Profits of HEIs operational and financial activity	-0.0000000012 (0.008)	0.000000007 (0.002)	–	–	–
Tangible fixed assets	0.000000000195 (0.000)	–	-0.0000222 (0.000)	0.0000011 (0.000)	0.00000000016 (0.000)
Tangible fixed assets per teacher	-0.00000045 (0.000)	–	0.0436 (0.000)	-0.00205 (0.000)	-0.0000003 (0.000)
Students to teachers ratio	-0.025 (0.000)	0.1357 (0.000)	8503.54 (0.000)	-542.35 (0.000)	-0.0047 (0.029)
Constant	3.2927 (0.000)	-1.5217 (0.004)	-208239.7 (0.000)	11098.96 (0.000)	1.1373 (0.000)
R^2	0.35	0.51	0.97	0.97	0.38

Source: calculations in STATA (P-values in parentheses).

The regression analysis confirmed most of the observations provided by correlation analysis but it provided some additional refinement on the relation between quality measures and revenues indicators. The quality of teaching and quality of research were positively and mutually affected. The quality of teaching was affected by more variables than quality of research. Especially, it covered tangible assets that turned out to be insignificant in explaining research activity performance. Curiously, the revenue on teachers and revenue on students worked in opposite directions, which was replicated in the regression of two types of revenues. It might probably indicate the specialization in research or teaching activity. Higher production efficiency (variable "Score") required lower teaching and research quality. It might explain the problem with quality improvement of Polish public HEIs that can be perceived as unprofitable in the pure financial efficiency context.

The process of categorization and teaching quality assessment provided by public institutions (PAC and PCESU) starts with better units and studies and then spills over on other units and studies with lower quality. Therefore, the number of assessed or categorized units of an institution is important for the average quality measures. This sequence was acknowledged by the regression results confirming deterioration of quality with increasing number of assessed units. The quality of teaching and quality of research were higher in larger cities that remained in line with expectations. On the one hand, tangible assets are important for financial revenues, efficiency and quality of teaching but on the other hand, they should not be accompanied by too small a teaching staff. A high number of students per teacher fosters improvement of research activity but discourage teaching quality. It may be that this relation was a consequence of increases in available funds in HEIs focused on reward teaching (for example, in the form of part-time studies). The profits were irrelevant for funding and efficiency but they spurred the quality of research activity. Surprisingly, higher profits seemed to hamper the quality of teaching. It is possible that in many educational institutions, financial surpluses are generated at the expense of too low wages for teaching staff.

Besides the results presented in Table 4, the type of universities effect was investigated and some conclusions were reached. The quality of teaching (variable "Evaluation") as well as the quality of research (variable "Category") were positively affected by general and economic universities but negatively affected in other types of HEIs. Only for agriculture universities did the parameter turn out to be insignificant, when the impact on "Category" was estimated. At the same time, the type of HEIs had a very limited impact on the revenue per teacher. This was because a positive reaction was expected only for pedagogical and economic universities. In the model of the revenue per student, the revenue was greater for technical and economic universities, while for general and pedagogical universities it was lower. Once again, this could support the specialization of universities with respect to their area of interest. The efficiency scores were higher only for general universities and insignificant for all other types of HEIs.

Conclusions and possible extensions

The completed study was one of the first investigating the relationship between technical efficiency (calculated by data envelopment analysis) and quality of teaching and research. It covered a large group of universities in Poland as well as variables reflecting data on teaching and research quality taken from external sources (PAC and PCESU), which helped avoid obstacles with regard to data availability. It should be stressed that new measurements of quality derived from external evaluation bodies can be utilized to control quality and efficiency during a reform process in tertiary education.

At the end, one can formulate several conclusions. First, the derived external quality measurements affected revenue per student and revenue per teacher. More precisely, the measures of teaching and research quality were positively correlated with financial data. Nevertheless, the results of OLS regressions with panel-corrected standard errors hinted at opposite impacts of revenue per student and revenue per teacher on two types of quality measures. Revenue per teacher was increasing with the PAC assessment and decreasing with PCESU grades. Simultaneously the revenue per student revealed an inverse pattern. It could be due to the HEI specialization in research or teaching activity but it could also be a consequence of unequal and excessive financing from part-time studies. For example, higher revenues from part-time studies could help in research quality improvement but at the same time, an excessive number of students could deteriorate teaching quality. Unfortunately, the ultimate verification of this question would require a longer time series that was unavailable.

According to the DEA model and the results of regressions, higher categorization (better quality of scientific research) and higher assessment of quality research could translate into lower efficiency scores. Therefore, the preferred way to obtain high financial efficiency for a university would be to concentrate on low quality teaching and to neglect research activity. It seems reasonable that this improper strategy for HEIs should be corrected by an appropriate policy of supervision and public financing of universities. Despite this ominous result, it should be stressed that the study only had data from two years and any of these conclusions should not be made too hastily. Especially taking into account the relatively flat distribution of teaching and (to a lesser extent) research grades (e.g. most grades were positive that could hide acceptable grades as well as those close to outstanding), they could be insufficient to properly discriminate between different quality levels and consequently between units and universities. The other problem involved the formula for quality measures calculations and the variables used in DEA calculations. The proposed specification was not unique so the distinct construction of inputs and outputs could affect correlation and regression estimation results, denying the obtained outcomes.

In terms of future research, this study could be extended in several directions. First, the methodology could be used to analyze private higher education institutions, which receive only minimal funding from the state budget. Second, it would be interesting to compare the internal quality measurements used by universities with external quality measurements. This would require the collection of data at the HEI level, covering the information about graduate completions or the average citation index of published scientific publications. Finally, one could check whether efficiency changes are accompanied by quality improvement.

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