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## Potential Benefits from University Mergers – An Attempt to Evaluate Future Efficiency Levels with a Selected DEA Model

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**Abstract:**

**Purpose:** The specificity of defining and describing the efficiency of higher education institutions and the related difficulties arise from the fact that the purpose of such an educational institution is perceived in various ways. Over the last years, there have been several significant reforms of higher education, including vocational education, which have led to a revision of the way in which universities are perceived. What remains unchanged is that the primary task of public vocational universities is to educate specialists for various fields of economy. The effective implementation of this very important function and many others makes it necessary to constantly reflect on the functioning of universities. In terms of the efficiency of these units, analytical, research, comparative, and other activities may lead to valuable conclusions, which in the long run have a chance to improve the position of public vocational universities in the competitive market of educational services.

**Design/Methodology/Approach:** The aim of this article is to present a simulation of a merger of a state higher vocational school on the example of ABNS in Biala Podlaska with three selected schools from the public vocational school sector and three selected academic universities from Poland. The simulation was based on the research material and conclusions from the research project entitled. "Forecasting changes in the efficiency of selected PWSZs as a result of university consolidation in the context of the ranking of PWSZs in Poland", which was conducted in 2020 – 2021.

**Findings:** The results of the simulation made it possible to evaluate the efficiency of the university in Biala Podlaska after merging with selected higher education institutions. This provided basis for inferring benefits in the area of efficiency for ABNS in Biala Podlaska, in the context of the analysed potential strategic alliances with selected educational units.

**Practical implications:** This made it possible to verify the following hypothesis: A greater benefit in terms of increased operational efficiency will be achieved by ABNS in Biala Podlaska if it merges with an entity from the public vocational university sector than from the academic university sector.

**Originality/Value:** The analyses conducted illustrate the potential of a new approach to the higher education system.

**Keywords:** operational efficiency, DEA, higher education, Poland.

**Paper type:** Research article.

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## **1. Introduction**

The last 30 years have seen many changes in the field of higher education in Poland. These were the consequence of various processes, especially those of transformation, through which restructuring measures were initiated.

Universities have tried and are still trying to increase their operational efficiency, which is a huge challenge to tackle. The most optimal methods and tools for achieving this are constantly being explored. One of these is the merger of universities. This is an extremely complicated process, which is intended to allow the potential of the merging universities to be combined in a synergetic effect.

The consolidation of universities in some education systems has been going on for several decades, including in China, the USA and France. Most often, such initiatives are implemented from the bottom up (Pinheiro *et al.*, 2016), although central-level programmes of this kind also occur, e.g., in Russia, South Africa or Norway (Karodia *et al.*, 2015). They have various goals, including entering the world's top universities. From the perspective of public vocational schools, this will be a restructuring to increase the efficiency of the entity.

There are plenty of examples of successful mergers with expected results, such as in Finland, Sweden and France (Ahmadvand *et al.*, 2012), but unsuccessful mergers have been observed too (Geschwind *et al.*, 2016). The situation is similar regarding researchers on the subject, namely some believe that it is the right instrument to improve organisational performance, while others believe the opposite (Cremonini, 2014).

Consolidation between Polish universities took place bottom-up and was not systemic. In case of non-public universities, there were more than 80 mergers by 2020, the main aim of which was to obtain a more favourable market position. The largest of these involved the creation of the Vistula group of universities and their development through the acquisition of banking colleges. An interesting example is a hybrid marriage, i.e., in 2009 the PWSZ in Gorzów Wielkopolski absorbed the non-public Higher Vocational School of Information Technology (Zygarłowski, 2015).

In case of public universities, there are far fewer mergers – only 13 by 2020. These are single cases for the present, but one can risk the thesis that the intensity of mergers of public universities will increase. Such a model example include the incorporation of the Medical University of Kraków into the structures of the Jagiellonian University or the consolidation of the Szczecin University of Technology with the Agricultural University of Szczecin, on the basis of which the West Pomeranian University of Technology was established.

There are already first attempts of mergers in the higher vocational education sector, such as the merger of the Jan Kochanowski University in Kielce with the PWSZ in Sandomierz, the PWSZ in Sulechów with the University of Zielona Góra or the PMWSZ in Opole with the University of Opole, which took place in 2020. In Poland, the following purposes of consolidation processes can be distinguished: strategic, positional, rescue and restructuring mergers (Sułkowski, 2018). The latter type, which aims to improve the efficiency of higher education institutions functioning, is the subject of inquiry for the authors of this article. The question of the usefulness of the university union on the efficiency of the operation of a public higher education institution remains open.

Therefore, it seems legitimate to carry out analyses, studies, simulations of university consolidation and forecast their effects. For this purpose, the Pope John Paul II State School of Higher Education in Biala Podlaska, which was ranked first in the "Perspektywy" ranking in 2021 in the group of public vocational universities, was selected.

The authors need to clarify and systematise at this point. The research project entitled "Forecasting changes in the efficiency of selected PWSZs as a result of consolidation of higher schools in the context of the ranking of PWSZs in Poland", which was conducted in 2020–2021 within the framework of the Science Development Fund, included a much broader scope of research. The subject of the research undertaken was the efficiency of public vocational universities across the country and the potential change in the evaluation of this efficiency following consolidation.

So, firstly, evaluation of the state of the sector of higher vocational schools in Poland from the perspective of their efficiency was made. DEA methods were used to create a ranking based on efficiency, which was the basis for further research work, i.e. forecasting the effects of a merger of selected PWSZs in the context of changes in the evaluation of their efficiency of operation, examined using the DEA method. Then, simulating the merger of ABNS in Biala Podlaska with selected universities in order to try to evaluate the future level of efficiency was conducted. The results of this final stage of the research project are presented later in the text.

## **2. The Polish Higher Education System**

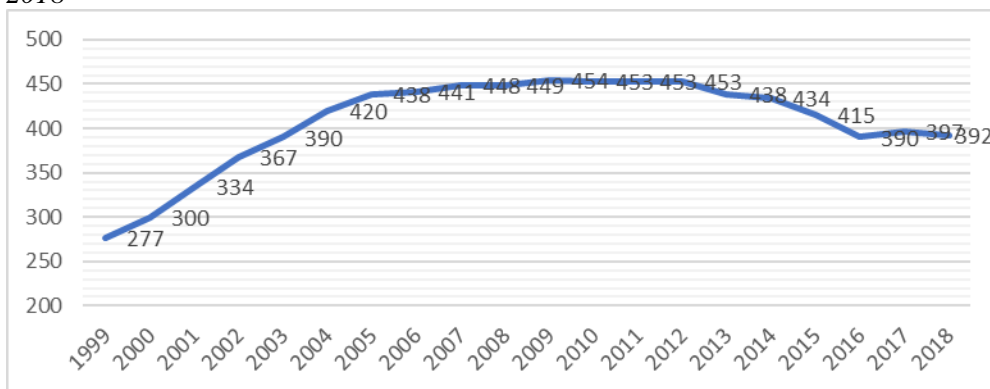
The Polish higher education system is based on the operation of 392 higher education institutions, both public and non-public<sup>3</sup>. The vast majority of them report to the Ministry of Education and Science. In case of medical higher education institutions, supervision is performed by the minister responsible for health, while military higher education institutions are subordinate to the minister of national defence.

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<sup>3</sup>As for the 3st December 2018.

Over the years 1999-2018, the number changed every year. In 1999, there were 277 institutions, while in the last year of the study there were 392. The significant increase in the number of higher schools in 2005-2012 was related, among others, to the possibilities of creating non-public higher schools – Figure 1. The number of higher schools is largely related to the demand reported by the market, social, and economic changes occurring over time both in the country and abroad.

**Figure 1.** Number of higher education institutions in Poland in 1999-2018



*Source:* Own work based on Central Statistical Office data.

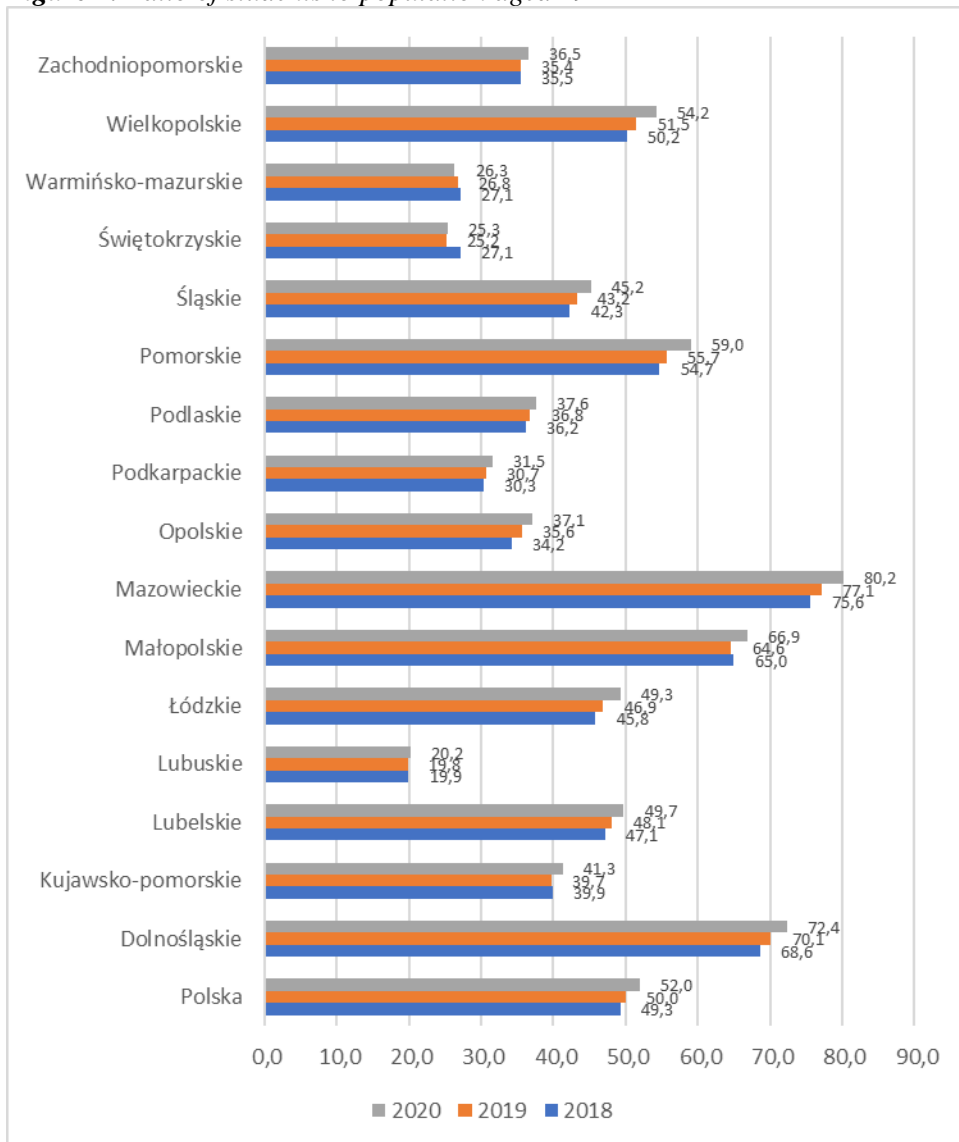
Analysing the spatial distribution of higher education entities, it may be observed that the largest number of facilities was in the Mazowieckie Province. It is mainly connected with the fact that in this area there is the capital city of Warsaw, which is the leading territorial area encouraging young people to change their place of residence, undertaking education there. It is also connected with the fact that these areas are located in the region where the highest growth of companies and institutions creating a competitive labour market can be observed. The opposite situation is observed in Lubuskie and Warmińsko-Mazurskie Provinces.

Changes related to the system transformation, the increase in the availability of higher education have significantly influenced the increase in the level of education of the whole society. According to data from the National Census 2021, the most dynamic growth (more than 30%) was recorded for people with higher education. Their share increased from 17.1% in 2011 to 23.1% in 2021. (an increase of 6 percentage points) among the total population aged 13 and over (GUS, 2021). Increasing education, acquiring it at higher level, is of interest mainly to young people just entering the labour market.

When analysing the ratio of students to the population aged 19-24 in the period under study, it can be observed that it remains at a similar level for Poland. However, looking at this indicator in regional terms, one may notice a diversification – Figure 2. Similar observations were noticed on the basis of data from the Census

2021. Preliminary results of the Census 2021 indicate the highest percentage of people with higher education in the Mazowieckie Province – 31.3%, which was higher than the average for Poland by as much as 8.2 p.p. On the other hand, the lowest percentage of people with higher education was recorded in the Lubuskie Province (GUS, 2021).

**Figure 2.** Ratio of students to population aged 19-24



**Source:** Own study based on Central Statistical Office data.

The following types of higher education institutions can be distinguished in the Polish higher education system<sup>4</sup> :

- universities – 19 in the country;
- technical universities – 24 in the country;
- agricultural universities – 7 in the country;
- economic universities – 56 in Poland;
- pedagogical universities – 13 in the country;
- maritime universities – 3 in the country;
- medical universities – 9 in the country;
- physical education academies – 6 in the country;
- Arts colleges – 22 in the country;
- theological universities – 15 in the country;
- other universities (including state higher vocational schools) – 212 in the country;
- universities of the ministry of national defence and internal affairs and administration – 7 in the country.

John Paul II University of Applied Sciences in Biala Podlaska is a higher education institution belonging to the group of state vocational schools of higher education. These universities were established on the educational market, among others, as a result of changes related to the territorial division of Poland, which was introduced on 1 January 1999.

As a result of the reduction in the number of provinces from 49 to 16 – as a "gratification" of the loss of the status of a provincial city – such higher education institutions appeared in a number of them. In retrospect, they have become an important element shaping the possibilities for improving the qualifications of those already on the labour market as well as high school graduates. The role of such educational institutions is related to the response to the changing market conditions of employers, as both the choice of courses of study and the programmes are analysed and developed in cooperation with the socio-economic environment.

John Paul II University of Applied Sciences in Biala Podlaska is one of 33 universities of its kind. It educates nearly 2,000 students, employs more than 200 academic teachers under employment contract, in addition to more than 150 with professional experience outside higher education, and nearly 150 non-academic employees (technical and administrative staff). For many years the university has been at the forefront of public vocational universities in Poland. This is the result of its rapid development, both in terms of the educational offer of studies at all levels, as well as the development of infrastructure and its essential role in the social and economic life of the region.

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<sup>4</sup>As for 31st December 2018.

### 3. Materials and Methods

The term efficiency is derived from the Latin phrase 'effectus', a concept that means, among others, making, doing, result, effect. The term efficiency is used to describe phenomena from different areas of knowledge, as well as the sphere of activity. However, it is important to remember that it is a key concept of economics, both in practical and theoretical terms (Mykhailenko, 2018). This importance of efficiency is highlighted, among others, in the definition of McConnell *et al.* (2009) who point out that economics deals with the study of problems of efficient use of scarce productive resources (Campbell *et al.*, 2009). According to P. Samuelson and W. Nordhaus, efficiency as a category of full resource exploitation, is the state of absence of wastage and loss. It implies such a use of resources that contributes to the maximum level of satisfaction possible with the given inputs and technology (Samuelson *et al.*, 2004).

The issue of performance measurement in its essence is related to the choice of its measurement method. When analysing the issue, it should be pointed out, following Szymańska, that we can distinguish the following methods, indicative, parametric, and non-parametric (Szymańska, 2009). The DEA method used in the study is one of the two non-parametric approaches.

This methodology is useful for analysing the efficiency of entities where the use of parametric methods is difficult. In the initial stage of its application, DEA was mainly used to evaluate the efficiency of entities in the service sector. The second group of subjects for which it was suitable to evaluate the efficiency of entities were non-profit and not-for-profit institutions. It means that these were subjects that focused on goals other than simply making profit (Dwórzniak, 2018). Higher education institutions are this type of entity. Their main purpose is to educate and thus enable skilled workers to enter the labour market.

One of the problems of addressing efficiency research in the context of higher education is to measure educational outcomes. It is worth pointing out that the DEA method is a flexible measurement method due to, among others, the fact that both the concepts of inputs and effects are much broader than they are in accounting; it is the researcher who defines them (Brzezicki, 2020).

The following software was used to perform the calculations in this study: MS Excel, R package with the relevant libraries. Table 1 summarises the public vocational universities included in the study with their assigned DMU designations. In addition, three randomly selected academic universities, i.e., the Koszalin University of Technology (DMU W30), the Pomeranian Medical University in Szczecin (DMU W31) and the Wrocław University of Technology (DMU W32), were included in option three.

**Table 1.** A summary of the universities surveyed with their assigned DMU numbers.

|        |  |        |   |        |   |
|--------|--|--------|---|--------|---|
| DMU 1  | The Angelus Silesius State School of Higher Vocational Education in Wałbrzych      | DMU 11 | State University of Szymon Szymonowic in Zamość             | DMU 21 | The Mazovian State University in Płock                        |
| DMU 2  | Hipolit Cegielski State College of Higher Education in Gniezno                     | DMU 12 | Witelon State Higher Vocational School in Legnica           | DMU 22 | State Higher Vocational School in Raciborz                    |
| DMU 3  | Jan Amos Komeński State School of Higher Vocational Education in Leszno            | DMU 13 | State Higher Vocational School in Chełm                     | DMU 23 | Stefan Batory State Higher Vocational School in Skierniewice  |
| DMU 4  | The Jan Grodek Higher Vocational State School in Sanok                             | DMU 14 | Vocational State School of IgnacyMościcki in Ciechanów      | DMU 24 | State Higher Vocational School in Tarnow                      |
| DMU 5  | The President Stanisław Wojciechowski Higher Vocational State School in Kalisz     | DMU 15 | The State School of Higher Professional Education in Elbląg | DMU 25 | State Higher Vocational School in Wałcz                       |
| DMU 6  | State Higher Vocational School. prof. E. Szczepanik in Suwalki                     | DMU 16 | State Higher Vocational School in Głogów                    | DMU 26 | State Higher Vocational School in Wloclawek                   |
| DMU 7  | State Higher Vocational School Memorial of Prof. Stanisław Tarnowski in Tarnobrzeg | DMU 17 | State School of Higher Professional Education in Konin      | DMU 27 | The Podhale State Higher Vocational School in NowyTarg        |
| DMU 8  | State Higher Vocational School Captain Witold Pilecki in Oświęcim                  | DMU 18 | The State Higher Vocational School in Koszalin              | DMU 28 | The Karkonosze State Higher School in Jelenia Góra            |
| DMU 9  | Carpathian State College in Krosno   | DMU 19 | State Higher Vocational School in NowySacz                  | DMU 29 | John Paul II University of Applied Sciences in Biala Podlaska |
| DMU 10 | StanisławStaszic State School of Higher Vocational Education in Piła               | DMU 20 | The State Higher Vocational School in Nysa                  |        |   |

Source: Own study.



For resources, the following variables were selected from the conceptual set of variables, the number of teaching/research staff, real estate (teaching facilities expressed in m<sup>2</sup>) and the number of subsidiaries of a given higher education institution. Due to the updating of databases (POL-on system, RAD-on) and their adaptation to the requirements of the Act of 20 July 2018. – Law on Higher Education and Science, data on the number of teaching/research staff was not available. An assumption was made about the correlation of the number of teaching/research staff with the number of students. This allows the number of staff to be adjusted based on the analysis of the data for the 2017/2018 academic year and the data for the 2018/2019 academic year (number of students). It was assumed that each university retains the teaching staff/student ratio at the level of the previous academic year (i.e., 2017/2018).

However, in case of real estate, which was assumed to reflect teaching facilities, its usable floor area was used as the measure, based on data from the POL-on/RAD-on system. For outcomes, three variables were selected from the conceptual set: number of students, number of graduates, educational offer. Data was obtained from the POL-on/RAD-on system and the CSO. The number of students and graduates was adopted according to the status of 2018, in line with the CSO methodology. The educational offer was adopted according to the status of 2019, citing POL-on.

Some of the data was verified by reviewing and analysing the educational offer of selected universities. All faculties and majors realised at a given higher school were taken into account in total. Variables describing both inputs and effects were processed and verified using statistical methods to eliminate variables with excessive correlation.

The analysis of the projections of changes in the performance evaluation of the ABNS in Biala Podlaska, appearing as DMU 29 in the core set of the surveyed universities, as well as the simulation of the merger of DMU 29 with several selected universities, was conducted in the following options (Table 2):

- 1) Option 1 – three universities out of the 29 researched with the lowest efficiency scores (DEA SE CCR-I CRS model) will merge with DMU 29 (each separately).
- 2) Option 2 – three universities out of the 29 researched with the lowest efficiency scores (DEA SE CCR-I CRS model) will merge with DMU 29 simultaneously.
- 3) Option 3 – DMU 29 will merge with three randomly selected academic universities (DMU W30, DMU W31, DMU W32).

Assumptions for the implementation of the options:

- In all options, the university undergoing the merger is excluded from the study group. This means that in Option 1, the university that is merging with

DMU 29 will not drop out of the study group, but both will be taken into account with the predicted effects of the merger (replacing their previous performance in the study group of universities).

- The efficiency of the newly merged unit was evaluated with the SE DEA CCR-I CRS model and compared with the previous efficiency evaluation of this unit.

**Table 2.** Assumptions on how changes in inputs and outputs are determined at merger.

| Input / Effect        | Factor formula                | Increase depending on the ratio of the coefficient   |  |
|-----------------------|-------------------------------|--|--|
|                       |                               | Condition  | Effect   |
| Staff (P)             | $P_R = \frac{P_A}{P_B} * 0,4$ | $P_R < 0,5$  | $P_E = (P_B - P_A) * P_R$                        |
|                       |                               | $0,5 < P_R < 1$                                      | $P_E = 0,2 * (P_R * P_A)$                        |
|                       |                               | $1 < P_R > 1,25$                                     | $P_E = 0,05 * (P_R * P_A)$                       |
|                       |                               | $P_R > 1,25$   | No effect  |
| Real estate (N)       | $N_R = \frac{N_B - N_A}{N_A}$ | $N_R > 0$  | $N_E = 0,1 * (N_B - N_A)$                        |
|                       |                               | $N_R = 0$  | $N_E = 0,05 * N_B$                               |
|                       |                               | $N_P < 0$  | No effect  |
| Subsidiaries (F)      | $F_R = F_B - F_A$             | $N_R > 1 \wedge F_R > 0$                             | $F_E = 1$  |
|                       |                               | Other cases  | No effect  |
| Educational offer (O) | $O_R = \frac{O_B - O_A}{O_A}$ | $O_R < 0$  | No effect  |
|                       |                               | $O_R = 0 \wedge 0 < P_R > 1,25$                      | $(O_E = O_B - O_A) * \left(\frac{P_E}{5}\right)$ |
|                       |                               | $0 < O_R > 0,4$                                      | $O_E = 0,1 * (O_B - O_A)$                        |
|                       |                               | $0,4 < O_R$  | $O_E = 0,25 * (O_B - O_A)$                       |
| Students (S)          |                               | $F_E = 1 \wedge O_E > 1 \wedge \frac{S_A}{P_A} < 13$ | $S_E = (F_E * 40) + (O_E * 60)$                  |
|                       |                               | $F_E = 0 \wedge O_E > 1 \wedge \frac{S_A}{P_A} < 13$ | $S_E = (O_E * 60) + (P_E * 5)$                   |
|                       |                               | $F_E = 0 \wedge O_E < 1 \wedge \frac{S_A}{P_A} < 13$ | $S_E = (P_E * 13) + (P_E * 5)$                   |
|                       |                               | $F_E = 0 \wedge O_E < 1 \wedge \frac{S_A}{P_A} > 13$ | No effect  |
| Graduates (A)         |                               | $S_E > 0$  | $A_E = \frac{A_A}{S_A} * S_E$                    |
|                       |                               | Othercases   | No effect  |

Explanation of indices:

A – university with a lower efficiency rating/university for which the combination effect is calculated

B – university with a higher efficiency rating or a university from outside the study group

R – ratio of inputs and outputs of both HEIs

E – projected effect

*Source: Own study.*

Assumptions as to how the changes in inputs and effects will be determined as a result of the merger are shown in the table above. These have been made on the basis of the predicted values of the ranges and the proportional increases in a given input or effect likely to occur, based on a hypothetical factor.

#### 4. Results of Empirical Studies

##### *Option 1:*

In this option, DMU 29 (ABNS in Biala Podlaska – DEA SE CCR-I CRS is 68.12%) combines with DMU 28 (The Karkonosze State Higher School in Jelenia Góra – DEA SE CCR-I CRS is 49, 87%), DMU 25 (State Higher Vocational School in Wałcz – DEA SE CCR-I CRS is 55.66%) and DMU 18 (The State Higher Vocational School in Koszalin – DEA SE CCR-I CRS is 56.60%). We consider the situation where the effects from the merger arise simultaneously for DMUs 28, 25 and 18, as well as for DMU 29. As a result, the efficiency evaluation will be conducted for the basic set of DMUs with modification of inputs and effects for the two DMUs simultaneously. The effects expected for each of the merger options considered are summarised in Table 3.

**Table 3.** Summary of the predicted effects of the DMU 29 merger in Option 1.

| <b>Merges</b>     |          |        | <b>Emerges</b>   |                | <b>Emerges</b>   |               |
|-------------------|----------|--------|------------------|----------------|------------------|---------------|
|                   |          |        | DMU 29 W1-1      |                | DMU 28 W1-1      |               |
| Input / Effect    | DMU 29   | DMU 28 | Predicted effect | After increase | Predicted effect | After merging |
| Staff             | 195      | 136    | 7,59             | 144            | 15,60            | 211           |
| Real estate       | 31909,15 | 6250   | 2565,92          | 8816           | 0,00             | 31909,2       |
| Subsidiaries      | 1        | 0      | 0,00             | 0              | 0,00             | 1             |
| Educational offer | 24       | 9      | 3,75             | 13             | 0,00             | 24            |
| Students          | 2322     | 799    | 262,94           | 1062           | 280,80           | 2603          |
| Graduates         | 720      | 201    | 66,15            | 267            | 87,07            | 807           |
|                   |          |        | DMU 29 W1-2      |                | DMU 25 W1-2      |               |
| Input / Effect    | DMU 29   | DMU 25 | Predicted effect | After increase | Predicted effect | After merging |
| Staff             | 195      | 39     | 12,48            | 51             | 0,00             | 195           |
| Real estate       | 31909,15 | 24243  | 766,61           | 25010          | 0,00             | 31909         |

|                   |          |            |                  |                |                  |               |
|-------------------|----------|------------|------------------|----------------|------------------|---------------|
| Subsidiaries      | 1        | 0          | 0,00             | 0              | 0,00             | 1             |
| Educational offer | 24       | 9          | 3,75             | 13             | 0,00             | 24            |
| Students          | 2322     | 407        | 287,40           | 694            | 0,00             | 2322          |
| Graduates         | 720      | 85         | 60,02            | 145            | 0,00             | 720           |
|                   |          | DMU 29W1-3 |                  | DMU 18 W1-3    |                  |               |
| Input Effect /    | DMU 29   | DM U 18    | Predicted effect | After increase | Predicted effect | After merging |
| Staff             | 195      | 86         | 19,23            | 105            | 15,60            | 211           |
| Real estate       | 31909,15 | 6200       | 2570,92          | 8771           | 0,00             | 31909,2       |
| Subsidiaries      | 1        | 0          | 0,00             | 0              | 0,00             | 1             |
| Educational offer | 24       | 9          | 3,75             | 13             | 0,00             | 24            |
| Students          | 2322     | 678        | 321,14           | 999            | 280,80           | 2603          |
| Graduates         | 720      | 179        | 84,79            | 264            | 87,07            | 807           |

Source: Own study.

Based on the above simulation estimates of mergers, three analyses were conducted consecutively for modified options of the baseline set of DMUs under study. This resulted in an updated efficiency evaluation for the DMUs involved in the merger, as can be seen in the table below.

**Table 4.** Summary of efficiency ratings for the analysed options after applying the DEA SE CCR-I CRS model.

| Merging |                       |        |                       | Post-merging |                       |             |                       |
|---------|-----------------------|--------|-----------------------|--------------|-----------------------|-------------|-----------------------|
| DM U    | Efficiency evaluation | DMU    | Efficiency evaluation | DMU          | Efficiency evaluation | Model       | Efficiency evaluation |
| DM U 29 | 68,12%                | DMU 28 | 49,87%                | DMU 29 W1-1  | 72,57%                | DMU 28 W1-1 | 54,94%                |
| DM U 29 | 68,12%                | DMU 25 | 55,66%                | DMU 29 W1-2  | 68,12%                | DMU 25 W1-2 | 66,46%                |
| DM U 29 | 68,12%                | DMU 18 | 56,60%                | DMU 29 W1-3  | 72,57%                | DMU 18 W1-3 | 65,81%                |

Source: Own study.

Studies of the efficiency of DMUs subject to merger, taking into account the predicted effects for both merging universities, showed that:

- In the merger of DMU 29 and DMU 28, from the perspective of the change in efficiency rating, the greater benefit is in case of DMU 28. ABNS in Biala Podlaska still achieves the benefit of an increase in efficiency rating (4.45 p.p.), but it is less than that of KPSW in Jelenia Gora (5.07 p.p.).
- In the merger of 29 and DMU 25, from the perspective of the change in efficiency rating, the greater benefit is in case of DMU 25. ABNS in Biala Podlaska does not achieve the benefit an increase in efficiency rating, while

- PWSZ in Walcz achieved a significant increase in efficiency rating (10,8 p.p.).
- In the merger of DMU 29 and DMU 18, from the perspective of the change in efficiency rating, the greater benefit is in case of DMU 18. in Biala Podlaska still achieves the benefit of an increase in efficiency rating (4.45 p.p.), but it is less than that of PWSZ in Koszalin (9,21 p.p.).
  - From the perspective of the ABNS in Biala Podlaska and changes in its efficiency evaluation, the merger with the KPSW in Jelenia Góra and the PWSZ in Koszalin is the same. This means that for the ABNS in such a situation there is no difference with which unit the merger will take place.
  - Option one considered merging the more efficient universities with the least efficient units in the group. None of them achieved a baseline efficiency rating above the median (i.e., 77.56%) for the baseline group of DMUs studied.
  - Option one shows that merging universities with greater resources with universities with lower resources, under the conditions that predict the effects in Table 3, is not always beneficial, from the perspective of changes in efficiency ratings. The "smaller" the university, the greater the benefits are to be expected. Thus, it seems that from the perspective of the more developed (in regard to the resources) universities, merging with a smaller entity should ultimately aim at absorbing it as a subsidiary, which could bring about more favourable results in the long run.

### **Option 2:**

In the second option, it was predicted that the merger takes place with the university formed as a result of the merger of DMUs 28, 25 and 18 (formed DMU W2-1). Consequently, the considered merger had effects for DMU 29, as shown in Table 5.

**Table 5. Summary of predicted effects of DMU 29 merger in option 2**

| <b>Merging</b>    |          |          | <b>Post-merging</b> |               |
|-------------------|----------|----------|---------------------|---------------|
| Input / Effect    | DMU 29   | DMU W2-1 | DMUW2-2             |               |
|                   |          |          | Predicted effect    | After merging |
| Staff             | 195      | 261      | 20,88               | 216           |
| Real estate       | 31909,15 | 36693,06 | 478,39              | 32387,15      |
| Subsidiaries      | 1        | 0        | 0,00                | 0             |
| Educational offer | 24       | 27       | 0,00                | 24            |
| Students          | 2322     | 1884     | 375,84              | 2698          |
| Graduates         | 720      | 465      | 94,55               | 815           |

*Source: Own study.*

In terms of resources, both units should be considered quite "expanded," although the consolidated, newly built facility (DMU W2-1) will surpass the university in Biala Podlaska in some expenditures/effects. This is the opposite of the situation analysed in Option 1.

**Table 6.** Summary of efficiency evaluation for the analysed option after applying the DEA SE CCR-I CRS model.

|        | <b>Baseline</b> | <b>Post-merging</b> |
|--------|-----------------|---------------------|
| DMU 29 | 68,12%          | 73,04%              |

*Source:* Own study.

In the second option, from the perspective of efficiency evaluation, a positive effect is noticeable for ABNS in Biala Podlaska. Post-merger efficiency was evaluated at 73.04%, which is 4.92 p.p. more than the baseline value. Evaluating this change in the context of the option, it can be noted that:

- The beneficial effect in terms of efficiency rating growth of DMU 29 after merging with DMU W2-1 is only slightly higher (0.47 p.p.) than the highest positive effect in option one.
- Given the difference in the scale of inputs and resources of DMU W2-1 and DMU 29, it is expected that DMU 29 will not play a leading role in the merger.
- DMU 29 can achieve similar effects by merging with smaller entities. Thus, from the perspective of efficiency evaluation, there is no significant (the difference of 0.47 p.p. in the increase in efficiency evaluation does not appear to be significant) benefit in favour of merging with the entity created by the merger of the weakest in the core group of public vocational universities.

### **Option 3:**

In the third option, it is predicted that DMU 29 merges with universities outside the core group of the studied public vocational universities. These are the academic universities randomly selected for the merger simulations analyzed, from outside the Lubelskie Province, and thus with an interesting perspective for further cooperation from the perspective of ABNS in Biala Podlaska. Table 7 summarises the expected effects of the mergers under consideration.

**Table 7.** Summary of predicted effects of DMU 29 merger in option 3.

| <b>Merging</b>    |         |          | <b>Post-merging</b> |               |
|-------------------|---------|----------|---------------------|---------------|
|                   |         |          | DMU W3-1            |               |
| Input / Effect    | DMU W30 | DMU 29   | Predicted effect    | After merging |
| Staff             | 500     | 195      | 47,58               | 243           |
| Real estate       | 77673,9 | 31909,15 | 4576,48             | 36485         |
| Subsidiaries      | 1       | 1        |                     | 1             |
| Educational offer | 51      | 24       | 6,75                | 31            |
| Students          | 4247    | 2322     | 642,90              | 2965          |
| Graduates         | 1244    | 720      | 199,35              | 919           |
|                   |         |          | DMUW3-2             |               |
| Input / Effect    | DMU     | DMU 29   | Predicted           | After         |

|                   | W31     |          | effect           | merging       |
|-------------------|---------|----------|------------------|---------------|
| Staff             | 687     | 195      | 55,86            | 251           |
| Real estate       | 150422  | 31909,15 | 11851,28         | 43760,15      |
| Subsidiaries      | 0       | 1        | 0,00             | 1             |
| Educational offer | 32      | 24       | 0,80             | 25            |
| Students          | 4368    | 2322     | 327,30           | 2649          |
| Graduates         | 1008    | 720      | 101,49           | 821           |
|                   |         |          | DMUW3-3          |               |
| Input / Effect    | DMU W32 | DMU 29   | Predicted effect | After merging |
| Staff             | 2199    | 195      | 71,08            | 266           |
| Real estate       | 326910  | 31909,15 | 29500,04         | 61409,15      |
| Subsidiaries      | 3       | 1        | 1,00             | 2             |
| Educational offer | 86      | 24       | 15,50            | 40            |
| Students          | 25442   | 2322     | 1285,42          | 3607          |
| Graduates         | 7528    | 720      | 398,58           | 1119          |

*Source: Own study.*

Based on the above simulation estimates of mergers, three analyses were conducted consecutively, resulting in an updated efficiency rating for the DMUs involved in the merger, as seen in the table below.

**Table 8.** Summary of efficiency ratings for the analyzed alternatives after applying the DEA SE CCR-I CRS model.

| <b>Merging</b> |                       |         |                       | <b>Post-merging</b> |                       |
|----------------|-----------------------|---------|-----------------------|---------------------|-----------------------|
| DMU            | Efficiency evaluation | DMU     | Efficiency evaluation | Model               | Efficiency evaluation |
| DMU 29         | 68,12%                | DMU W30 | 48,56%                | DMU W3-1            | 71,94%                |
| DMU 29         | 68,12%                | DMU W31 | 30,67%                | DMU W3-2            | 58,96%                |
| DMU 29         | 68,12%                | DMU W32 | 67,39%                | DMU W3-3            | 67,50%                |

*Source: Own study.*

The study of the efficiency of universities subject to merger, in regard to the predicted effects for both merging units, showed that:

- Among the simulations analysed under option three, the largest increase in the efficiency rating of ABNS in Biala Podlaska was recorded when it merged with Pomeranian University in Szczecin. This was the university which efficiency rating ranked second among the group of randomly selected universities outside the core set of DMUs studied.
- In case of DMU 29, the postulated effect occurred, related to the merger of two units with relatively high efficiency ratings (ABNS in Biala Podlaska

with Wroclaw University of Technology). As a result of such a process, DMU 29 slightly lowered its rating – there was some averaging. However, this cannot be perceived as a fixed relation, since the analysed case is a single observation, thus not allowing such an inference. This is a valuable indication to look for this type of relation in subsequent studies, verifying the hypothesis of the existence of such a regularity in a limited range of differences between the efficiency ratings of merging universities.

- As expected, the merger of ABNS in Biala Podlaska with Koszalin University of Technology (the worst-rated in terms of efficiency, among the group of randomly selected universities outside the core set of surveyed DMUs) resulted in the least favourable outcome for DMU 29. The consolidation process of the two units mainly resulted in an increase in resources, which "diluted" the effect of more optimal technology, translating into a reduction in the efficiency rating of DMU 29.

Summarising options 1, 2 and 3 for simulating the merger of ABNS in Biala Podlaska with selected entities from the core set of DMUs under study and three randomly selected universities from outside this set, it is necessary to summarise evaluations of the effectiveness of the newly created facilities under these mergers.

**Table 9.** Summary of efficiency evaluation of newly emerged facilities under all options of simulated mergers, after applying the DEA SE CCR-I CRS model.

|          | Nominal values (%) |        |        |        | Nominal growth (p.p.) |        |        |        |
|----------|--------------------|--------|--------|--------|-----------------------|--------|--------|--------|
|          | DMU 28             | DMU 25 | DMU 18 | DMU 29 | DMU 28                | DMU 25 | DMU 18 | DMU 29 |
| BASELINE | 49,87              | 55,66  | 56,60  | 68,12  |                       |        |        |        |
| W1-1     | 54,94              |        |        | 72,57  | 5,07                  |        |        | 4,45   |
| W1-2     |                    | 66,46  |        | 68,12  |                       | 10,80  |        | 0,00   |
| W1-3     |                    |        | 65,81  | 72,57  |                       |        | 9,21   | 4,45   |
| W2       |                    |        |        | 73,04  |                       |        |        | 4,92   |
| W3-1     |                    |        |        | 71,94  |                       |        |        | 3,82   |
| W3-2     |                    |        |        | 58,96  |                       |        |        | -9,16  |
| W3-3     |                    |        |        | 67,50  |                       |        |        | -0,62  |

Source: Own study.

## 5. Discussion and Conclusions

When undertaking an evaluation of the efficiency of state higher schools of vocational education operating in the Polish higher education system, it is worth using a variation of the DEA model referred to as super effective (Eng. *Super Efficiency*, SE). The models of this group allow for accurate differentiation of efficient units, and consequently the characterization of the studied entities is more accurate from the perspective of individual evaluations of the efficiency of the



studied entities (DMU). Given the purpose and scope of this study, the DEA SE CCR-I model proved to be the most useful

Analysing the collective data on the evaluation of the efficiency of ABNS in Biała Podlaska (DMU 29) in the merger options considered, it can be noted that:

- From the perspective of increasing the efficiency rating of ABNS in Biała Podlaska, it is most beneficial to merge with the conglomerate formed by the merger of KPSW in Jelenia Góra, PWSZ in Walcz and PWSZ in Koszalin (DMU W2). This guarantees an increase in the efficiency rating by 4.92 pp. However, this comes with some foreseeable problems. As noted earlier, merging the weakest entities is not the way to increase their efficiency. This raises concerns whether merging a university with a slightly better efficiency rating with the formed conglomerate in the long run will not result in a decrease in its efficiency in the long run?
- The consolidation of ABNS in Biała Podlaska with KPSW in Jelenia Góra, according to the predicted results, translates into an increase in DMU 29 efficiency rating by 4.45 p.p.. Thus, this is slightly less than in case of a merger with a conglomerate of the three analysed public vocational universities. A similar situation takes place in case of a merger between the university in Biała Podlaska and the PWSZ in Koszalin.
- In a situation where merging with a selected DMU brings about identical or similar predicted effects in terms of changes in efficiency evaluation, DMU 29 should take into account the effects that such a merger produces for the pair's universities. In case of DMU 28 and DMU 18, the merger with DMU 29 was more favourable to PWSZ Koszalin. This shows the presence of asymmetry in positive effects. Its magnitude may be due to the assumptions made, but it is nevertheless certainly present. It indicates that when analysing mergers or university cooperation in practice, the effects on both sides should always be considered. This may allow to discover the potential for synergies and long-term harmonious development of both entities.
- A situation was observed where the positive effect of the merger for ABNS in Biała Podlaska did not occur, while from the perspective of the other unit it occurs on a significant scale. This was the case for PWSZ in Walcz, where after the merger with DMU 29, based on the predicted benefits, the increase in efficiency was estimated at 10.8pc. In such a situation, from the perspective of the university in Biała Podlaska, the merger should go in the direction of transforming DMU 25 into a subsidiary and developing its specialties (or absorbing specialties absent from DMU 29).
- Analysis of options involving merging ABNS in Biała Podlaska with universities outside the region and the core group of DMUs studied, large-scale units showed that such cooperation is not always beneficial. All of the options analysed predicted merging of DMU 29 with universities with greater resources (especially in regard to staff), but with lower efficiency ratings. The effects of these mergers for the university in Biała Podlaska

tended to be lower in terms of efficiency rating gains than in previous options. In two out of three cases considered, the effect was negative (a drop in efficiency ratings). This suggests that merging with relatively large universities, is not always as beneficial as with smaller ones. Thus, it seems that for ABNS in Biała Podlaska, the recommended strategy is to look for a smaller partner, preferably with a subject specialization (educational offer) different from its own.

The literature study, empirical research and analysis conducted for the purpose of this article and the entire research project allowed to confirm the research hypothesis that a greater benefit in the form of increased operational efficiency will be obtained by a public vocational university through a merger with an entity from the same higher education sector than from the academic university sector.

In conclusion, the authors are convinced that the research on the consolidation of higher education institutions and its importance for the efficiency of individual educational units operating is an important element in the development of Polish higher education and should be continued in the future.

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