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Cooperation and Merger: Forecasting the Results of the Amalgamation of Selected Higher Education Institutions in the Context of a Change in their Effectiveness Rating

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Abstract:

Purpose: *This article is aimed at presenting forecast results of the consolidation of selected higher education institutions in terms of evaluating their effectiveness.*
Design/Methodology/Approach: *An analysis of forecast and simulation results in terms of a change in the effectiveness rating for selected higher vocational state schools was carried out in the three following variants. Variant 1: three higher education institutions with the highest effectiveness rating of all 29 analysed ones (model SE DEA CCR-I CRS) will merge with those with the lowest effectiveness rating, creating a total of 9 new entities. Variant 2: three higher education institutions with the lowest effectiveness rating of all 29 analysed ones (model SE DEA CCR-I CRS) will merge with one another, creating one new entity, and the three merging institutions will leave the analysed group. Variant 3: three higher education institutions with the lowest effectiveness rating of all 29 analysed ones (model SE DEA CCR-I CRS) will merge with three randomly selected academic higher education institutions (DMU W30, DMU W31, DMU W32), creating three new pairs, and the three merging institutions will leave the analysed group.*
Findings: *In terms of mutual benefits, i.e. changes in both higher education institutions undergoing a merger, there may be situations when similar effects are obtained by one of the merging institutions when paired with another entity. Nevertheless, this does not mean that the reverse applies. We may formulate a thesis that the benefits arising from a merger are not symmetrical.*
Practical Implications: *The conclusions drawn from the simulations prove that not every merger between higher education institutions is a priori beneficial. In order to achieve the expected result, i.e. improved effectiveness, the consolidation process must proceed in a well-thought-out manner; importantly, it should involve appropriately selected educational institutions.*
Originality/Value: *The analyses conducted illustrate the potential of a new approach to the higher education system.*

Keywords: *Operational efficiency, DEA, higher education, forecasting.*

JEL Classification: *I23, C14.*
Paper type: *Research article.*

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1. Introduction

Because of its objective and subjective scope, public sector economy affects multiple aspects of human existence, which makes it a compelling field of research (Stiglitz, 2004). In the 2020s, the age of knowledge-based economy, in which society becomes increasingly aware of the role of public services, effective organisation of the state system is a crucial factor in the development of a country (Kachniarz, 2012).

In this context, a vital role is played by educational services provided by various higher education institutions, including higher vocational state schools. The educational and research process is inextricably linked to organisational matters, management decisions concerning the functioning of an educational unit, which should be optimal as far as possible (Miszczyńska, 2019).

The effectiveness category is already well-recognised and quite commonly used (Blaik, 2015), primarily in theory but also in practice, in higher education. The concept itself is interpreted in numerous ways, although not always correctly understood. Cohen offers an interesting take on the subject, defining effectiveness as producing the expected result with minimum effort or "the ability to produce maximum results with minimum effort" (Cohen, 2013).

Such understanding of this economic category is important from the perspective of the present article. The problem of the effectiveness of higher education institutions has been explored by researchers worldwide, in many dimensions and multiple disciplines. Some of those studies pertain to the role of leadership and quality in the context of institutional effectiveness (Middlehurst, 1995), while others discuss pro-quality, accreditation, and financial mechanisms (Volkwein and Sweitzer, 2006).

In Poland, the DEA method has been used for evaluating the effectiveness of higher education institutions for over a dozen years. However, most of the research has been focused on academic schools, ignoring the vocational education sector. There were effectiveness assessments for higher education institutions in Poland in comparison with systems in other countries (Wolszczak-Derlacz, 2018), in addition, measurement of teaching effectiveness in academic schools using a non-parametric approach was also carried out (Pietrzak and Baran, 2018).

More recently, increased interest in the effectiveness of the functioning of public higher vocational schools has been observed. Researchers analysed relative technical effectiveness of higher vocational education institutions using the DEA model (Pasewicz, Wilczyński and Świtłyk, 2012). A noteworthy and substantial contribution to effectiveness studies in higher education was made by authors analysing research trends in systems of education by means of quantitative methods (Brzezicki, 2019).

Consolidations and mergers in the educational sector have been taking place for many years in different countries in Europe as well as globally. Among them we find success stories but also there were cases which missed the mark (Karodia, Shaikh and Soni, 2015). Amalgamation processes are primarily determined by bottom-up factors, arising from the needs of local and regional stakeholders.

They happen much less frequently as part of a planned systematic policy for higher education or centralised decision-making. The literature of the subject allows us to draw a conclusion that mergers which are voluntary and triggered by bottom-up initiatives are less complex and bring better results (Harman and Harman, 2003). Therefore, consolidation processes can increasingly often be described as "bottom-up", yet they are stimulated and supported by central government (Harman and Harman, 2008). Each time they constitute some form of restructuring aimed at the rationalisation and optimisation of the operations of a higher education institution.

Ł. Sułkowski offers interesting discussion and analyses with regard to the Polish higher education system, emphasising human capital management and cultural determinants at work during mergers. In Poland, amalgamations of higher education institutions have been performed spontaneously rather than systematically (Sułkowski, 2018). Both public and non-public schools have experienced consolidation processes.

There have been quite a small number of consolidations in the sector of public vocational higher schools, which were previously reluctant to use such solutions. The attitude towards merger initiatives has changed recently in the face of the demographic decline, as well as numerous other issues related to the reform of higher education. First higher vocational school mergers are taking place, intended to increase effectiveness of the newly formed units. Since the phenomenon may intensify in years to come, it is worth analysing the process of cooperation and mergers between higher education institutions in the context of forecast effects of their future activities.

2. Material and Methods

An analysis of the literature reveals a vast array of possible ways of defining and interpreting effectiveness depending on the area of knowledge. It is likely that there are as many proposed interpretations of the terms as studies in which it was applied in various research contexts (Winkler, 2010). It should be emphasised that "effectiveness" is a capacious, multidimensional term representing different perspectives.

In a narrow sense, economists define effectiveness similarly to the concept of "economy" [in the sense of being economical] (Pszczołowski, 1982) in praxeology, as the ratio of results produced to the effort made (Dąbrowski, 2012). In a broader sense, effectiveness is understood as the difference between results and outlays

(similarly to the concept of "gainfulness" (Pszczołowski, 1982)) and as the relationship between the results produced to the outlays incurred (Ćwiąkała-Małys and Nowak, 2010).

Citing Pszczołowski (1978) and Winkler (2010), we may define effectiveness as a positive feature of planned actions, the effects of which could be considered realistic and rated positively against other outcomes, a feature which is highly significant due to a specific evaluation criterion and a specific method for the valuation of the actions in the light of the criterion. Actions which are regarded as positive are those which contribute to survival and growth.

The literature of the subject offers numerous examples of measuring various effectiveness categories referring to businesses, administrative units, organisations, and domains of governmental activity. Commonly employed effectiveness measurement methods are based on ratio, parametric, and nonparametric approach (Rutkowska, 2003).

Nonparametric methods are highly useful in measuring diverse aspects of effectiveness, as they do not require supplying any functional relationship between effort and result. These methods make use of linear programming and help studying the effectiveness of objects transforming multiple inputs (efforts) into multiple outputs (results).

Data Envelopment Analysis (DEA) is a standard nonparametric effectiveness evaluation method, with other methods belonging to this group being modifications of the original DEA model (Sekuła and Julkowski, 2017). Please note that there are two basic types of DEA models, namely constant returns-of-scale model ("CRS" or "CCR") and variable return-of-scale model ("VRS" or "BCC") (Łękawa, 2012). Calculations in the present study were made in Microsoft Excel software: "R" package with relevant libraries.

The table below contains a list of public higher vocational education institutions analysed in this study together with their assigned DMU reference numbers. In addition, Variant 3 includes three randomly selected academic higher education institutions, i.e. Koszalin University of Technology (DMU W30), Pomeranian Medical University in Szczecin (DMU W31), and Wrocław University of Technology (DMU W32).

Table 1. *List of higher education institutions analysed in this study together with their assigned DMU numbers*

DMU 1	Angelus Silesius Higher Vocational State School in Wałbrzych	DMU 11	Szymon Szymonowic Public Higher School in Zamość	DMU 21	Mazovian State University in Płock

DMU 2	Hipolit Cegielski State University of Applied Sciences in Gniezno	DMU 12	Witelon Collegium State University in Legnica	DMU 22	University of Applied Sciences in Racibórz
DMU 3	Jan Amos Komeński Higher Vocational State School in Leszno	DMU 13	The University College of Applied Sciences in Chełm	DMU 23	Higher Vocational State School in Skierniewice
DMU 4	Jan Grodek State University in Sanok	DMU 14	Higher Vocational State School in Ciechanów	DMU 24	Higher Vocational State School in Tarnów
DMU 5	State University of Applied Sciences in Kalisz	DMU 15	University of Applied Sciences in Elbląg	DMU 25	The University of Applied Sciences in Wałcz
DMU 6	Prof. Edward F. Szczepanik Higher Vocational State School in Suwałki	DMU 16	Głogów Higher Vocational State School	DMU 26	State Academy of Applied Sciences in Włocławek
DMU 7	Prof. Stanisław Tarnowski Higher Vocational State School in Tarnobrzeg	DMU 17	State University of Applied Sciences in Konin	DMU 27	Podhale Vocational State University in Nowy Targ
DMU 8	Cavalry Captain Witold Pilecki State University of Małopolska in Oświęcim	DMU 18	Higher Vocational State School in Koszalin	DMU 28	The Karkonosze University of Applied Sciences in Jelenia Góra
DMU 9	Carpathian State College in Krosno	DMU 19	State University of Applied Sciences in Nowy Sącz	DMU 29	John Paul II University of Applied Sciences in Biała Podlaska
DMU 10	Stanisław Staszic State University of Applied Sciences in Piła	DMU 20	University of Applied Sciences in Nysa		

Source: *Authors' own work.*

As regards resources, the following were selected from a conceptual set of variables: number of teaching/research staff, real property (teaching facilities in square metres), and number of branches of the higher education institution. Information on the number of teachers/researchers was not available owing to the POL-on/RAD-on

system database update and adaptation for compliance with the requirements of the Higher Education and Science Act of July 20, 2018.

Hence, we assumed that the number of teaching/research staff is correlated to the number of students. This allowed us to adjust the number of employees based on an analysis of data for the academic years 2017/2018 and 2018/2019 (number of students). Specifically, we assumed that each higher education institution maintains a proportion of teaching staff to the number of students on a level from the previous academic year (i.e. 2017/2018).

As a measure of the real property category, intended to reflect the size of teaching facilities, we used floor surface on the basis of data from the POL-on/RAD-on system. Three variables were selected as a measure of results: number of students, number of graduates, and educational offer. Relevant information was sourced from the POL-on/RAD-on system as well as the Polish Central Statistical Office (GUS).

The number of students and graduates was as of the year 2018, in accordance with methods applied by GUS. The educational offer reflected the status as of 2019, based on data from the POL-on system. A portion of data was verified by way of review and analysis of the educational offer of selected higher education institutions. Total number of majors and specialisations offered by a given institution was taken into account. Variables describing effort and results were processed and verified by statistical methods in order to exclude variables with excessive correlation.

An analysis of forecast and simulation results in terms of a change in the effectiveness rating for selected higher vocational state schools was carried out in the three following variants:

1) Variant 1: three higher education institutions with the highest effectiveness rating of all 29 analysed ones (model SE DEA CCR-I CRS) will merge with those with the lowest effectiveness rating, creating a total of 9 new entities.
2) Variant 2: three higher education institutions with the lowest effectiveness rating of all 29 analysed ones (model SE DEA CCR-I CRS) will merge with one another, creating one new entity, and the three merging institutions will leave the analysed group.
3) Variant 3: three higher education institutions with the lowest effectiveness rating of all 29 analysed ones (model SE DEA CCR-I CRS) will merge with three randomly selected academic higher education institutions (DMU W30, DMU W31, DMU W32), creating three new pairs, and the three merging institutions will leave the analysed group.

Assumptions for the performance of the three variants:

- In all variants, the higher education institution subject to merger is excluded from the group of examined entities. This means that in

Variant 1 the higher education institution with the higher effectiveness rating, which is theoretically merging with one with a lower rating, will remain in the group.

- The effectiveness of the newly formed entity was evaluated in accordance with the SE DEA CCR-I CRS model and compared with the previous effectiveness rating for the entity.

Table 2. *Assumptions concerning the method of determining changes in effort and result at merger*

Effort / Result	***Ratio formula***	***Increase depending on the relationship ratio***	
		Condition	***Result***
Employees (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 result
Real property (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 result
Branches (F)	$F_R = F_B - F_A$	$N_R > 1 \wedge F_R > 0$	F_E =1
		Other cases	No result
Educational offer (O)	$O_R = \frac{O_B - O_A}{O_A}$	$O_R < 0$	No result
		$O_R = 0 \wedge 0 < P_R > 1.25$	$(O_E = O_B - O_A) * \left({}^{P_E}/_{5}\right)$
		$0 < O_R > 0.4$	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 result
Graduates (A)		$S_E > 0$	$A_E = \frac{A_A}{S_A} * S_E$
		Other cases	No result
Key to indexes: A – higher education institution with a lower effectiveness rating/higher education institution for which the merger result is being calculated B – higher education institution with a higher effectiveness rating or a higher education			

institution outside of the analysed group
R – effort-to-result relationship ratio for both higher education institutions
E – predicted result

Source: *Authors' own work.*

The assumptions with regard to the method of determining the effort and result of the merger are presented in the table below. They were made on the basis of predicted possible ranges and proportional growth of the specific effort or result, with the use of a hypothetical ratio.

3. Empirical Research Findings

3.1 Variant 1

In this variant, we shall analyse three higher education institutions rated highest for effectiveness: DMU 6 (Prof. Edward F. Szczepanik Higher Vocational State School in Suwałki with a DEA SE CCR-I CRS of 158.41%), DMU 7 (Prof. Stanisław Tarnowski Higher Vocational State School in Tarnobrzeg with a DEA SE CCR-I CRS of 153.73%), and DMU 26 (State Academy of Applied Sciences in Włocławek with a DEA SE CCR-I CRS of 116.45%), as well as three least effective higher education institutions, namely: DMU 28 (The Karkonosze University of Applied Sciences in Jelenia Góra – DEA SE CCR-I CRS equal to 49.87%), DMU 25 (The University of Applied Sciences in Wałcz – DEA SE CCR-I CRS equal to 55.66%), and DMU 18 (Higher Vocational State School in Koszalin with a DEA SE CCR-I CRS of 56.60%).

For each of the 9 combinations, conditions from Table 2 were applied and the amount of effort and results for the newly formed entity was determined. Results for each analysed merger combination were listed in Table 3.

Table 3. *List of forecast results of the amalgamation of selected DMUs in Variant 1*

Merging entities			***Newly formed entity***	
			DMU W1-1	
Effort / Result	DMU 6	DMU 28	Expected result	After expansion
Employees	41	136	2.72	139
Real property	23684	6250	1743.40	7993
Branches	0	0	0.00	0
Educational offer	17	9	2.00	11
Students	1339	799	133.60	933
Graduates	449	201	33.61	235

			DMU W1-2	
Effort / Result	DMU 6	DMU 25	Expected result	After expansion
Employees	41	39	0.76	40
Real property	23684	24243	0.00	24243
Branches	0	0	0.00	0

Educational offer	17	9	2.00	11
Students	1339	407	123.80	531
Graduates	449	85	34.65	120

			DMU W1-3	
Effort / Result	DMU 6	DMU 18	Expected result	After expansion
Employees	41	86	6.88	93
Real property	23684	6200	1748.40	7948
Branches	0	0	0.00	0
Educational offer	17	9	2.00	11
Students	1339	678	154.40	832
Graduates	449	179	40.76	220
			DMU W1-4	
Effort / Result	DMU 7	DMU 28	Expected result	After expansion
Employees	53	136	2.72	139
Real property	2672	6250	0.00	6250
Branches	0	0	0.00	0
Educational offer	10	9	0.54	10
Students	685	799	46.24	845
Graduates	220	201	11.63	213
			DMU W1-5	
Effort / Result	DMU 7	DMU 25	Expected result	After expansion
Employees	53	39	4.12	43
Real property	2672	24243.06	0.00	24243
Branches	0	0	0.00	0
Educational offer	10	9	0.82	10
Students	685	407	70.05	477
Graduates	220	85	19.61	105
			DMU W1-6	
Effort / Result	DMU 7	DMU 18	Expected result	After expansion
Employees	53	86	6.88	93
Real property	2672	6200	0.00	6200
Branches	0	0	0.00	0
Educational offer	10	9	1.38	10
Students	685	678	116.96	795
Graduates	220	179	30.88	210
			DMU W1-7	
Effort / Result	DMU 26	DMU 28	Expected result	After expansion
Employees	107	136	10.88	147
Real property	10279.99	6250	403.00	6653
Branches	0	0	0.00	0
Educational offer	26	9	4.25	13
Students	1138	799	309.40	1108

Graduates	209	201	77.83	279
			DMU W1-8	
Effort / Result	DMU 26	DMU 25	Expected result	After expansion
Employees	107	39	9.91	49
Real property	10279.99	24243.06	0.00	24243
Branches	0	0	0.00	0
Educational offer	26	9	4.25	13
Students	1138	407	304.57	712
Graduates	209	85	85.24	170
			DMU W1-9	
Effort / Result	DMU 26	DMU 18	Expected result	After expansion
Employees	107	86	6.75	93
Real property	10279.99	6200	0.00	6200
Branches	0	0	0.00	0
Educational offer	26	9	4.25	13
Students	1138	678	288.76	967
Graduates	209	179	76.24	255

Source: *Authors' own work.*

Based on the above estimations for simulated mergers, suitable modifications in the input data set for the SE DEA CCR-I CRS model were made, with results listed in Table 4. The list only contains results for the newly formed entities which replaced DMUs with lower effectiveness ratings (in line with the assumptions for the model). Ratings for the remaining DMUs did not change.

Table 4. *List of results for class W1 models: effectiveness of the newly assessed units*

	DMU 28	DMU 25	DMU 18	DMU 28	DMU 25	DMU 18
	Nominal values			Nominal growth		
BASE	49.87%	55.66%	56.60%			
W1-1	50.65%			0.78%		
W1-2		66.32%			10.66%	
W1-3			61.50%			4.90%
W1-4	52.74%			2.87%		
W1-5		56.76%			1.10%	
W1-6			62.50%			5.90%
W1-7	64.96%			15.09%		
W1-8		68.89%			13.23%	
W1-9			76.02%			19.42%

Source: *Authors' own work.*

A review of the outcome of the changes in the effectiveness rating for three DMUs with hitherto lowest effectiveness rating, with the assumptions presented earlier in this article, reveals that:

- As a result of the amalgamations of the higher education institutions within the group, the merger between DMU 18 and DMU 26 proved the most effective. The effectiveness rating for the newly formed DMU18 (W1-9) increased by 19.42 pp to 76.02%, which corresponded to a value approximating the median (77.56%) for the entire group of 29 DMUs.
- For DMU 18, we may notice a clear increase in the value of effectiveness, and it occurs after the merger with DMU 26. For the other two DMUs, effectiveness rating increases respectively by 4.9 pp and 5.9 pp. This implies the presence of an additional effect related to the difference in ratings (considered for this class of models) for the merging higher education institutions.
- A similar effect may be observed in the case of DMU 28, whose nominal effectiveness rating increments in Variant W1-7 (merger with DMU 26) were the highest, amounting to 15.09 pp. In the two other variants their values were, respectively, 2.87 pp. and 0.78 pp. Therefore, the most effective partner can also be found in the analysed variants.
- DMU 25 attained the lowest nominal growth in effectiveness rating compared to DMU 25 and DMU 18. It equalled 13.23%, taking into account the maximum reported value. For DMU 25, relatively high increases in effectiveness rating were present in two variants, i.e. W1-8 and W1-2.
- Maximum values of nominal increments in effectiveness rating were reported for the merger with DMU 26, whose effectiveness rating was 116.45%. As such, it was not the highest rating in the group (cf. DMU 6 with a rating of 158.41%). Hence, on these grounds we may argue that higher education institutions rated lowest in terms of effectiveness should seek amalgamation with the institution with the highest rating. This could be related to the use of the "optimum technology" by institutions rated highest for effectiveness. Because of the access to optimum technology, their high effectiveness rating is not caused merely by a quantitative representation of effort. Accordingly, a merger with another higher education institution and sharing part of resources (on which assumptions in class W models were based) will not translate into such a dramatic rise in effectiveness rating.

Our analysis proved that:

- The greatest nominal growth in the effectiveness rating of higher education institutions created by merger was accompanied by a nominal increase in effort (outlay) in the form of research staff.
- The increase translated into generating an effect defined here as educational offer. This was related to the number of students and graduates.

- Nominal growth in the number of students and the accompanying (proportional) increments in the number of graduates led to increased research staff count.
- The most advantageous path to an improvement in effectiveness for a higher education institution with a low effectiveness rating is to increase its number of teaching staff and enhance its educational offer.
- We may suppose that the benefits of these actions will attenuate with the growth in the effectiveness rating above the average level for a given group of higher education institutions. After exceeding a certain level, maintaining the growing number of majors and students will necessitate stepping up effort (outlays) in the form of real property. As demonstrated in the tobit model employed in previous stages of this research project (Pyra and Adamowicz 2021), this will lead to a significant deterioration in the effectiveness rating. Therefore, we should not expect a linear growth in the effectiveness rating as an inevitable consequence of a linear increase in effort and results. This implies the likely existence of the limits to deriving benefits from relatively straightforward actions such as hiring more teaching/research staff. It is possible that there is more than one such limit, and they may be correlated with the effectiveness rating level for a given higher education institution and the arrangement of its components (this hypothesis may be verified in subsequent studies based on extended data and research tools).
- Focusing on expanding the effort does not seem a good strategy for higher education institutions which are rated relatively high for effectiveness. Instead, optimisation of technology appears to be of greater significance in this group.
- The institution's scale of operations does not translate directly into its effectiveness rating, assuming that the institution uses its resources in an optimum way. It is optimum technology that is of key significance for attaining high effectiveness rating.

Higher education institutions which consider merging with their counterparts should pursue synergies that would allow them to boost their performance without excessively increasing outlays. Thus, it appears more beneficial to merge higher education institutions in order to obtain know-how rather than physical resources.

As demonstrated by class W models, higher education institutions with low effectiveness ratings cannot always rely on maximum results by a merger with the leaders in the ranking.

From the perspective of changing effectiveness rating, cooperation and mergers between higher education institutions are a multifaceted phenomenon, one that requires a broader and in-depth analysis.

3.2 Variant 2

The second variant simulated the merger between DMUs 18, 25, and 28 – three units with the lowest effectiveness rating. The amalgamation brought into existence a single DMU, with efforts and effects being the sum of the efforts and effects of the three DMUs. This is shown in Table 5.

Table 5. *List of forecast results of the amalgamation of selected DMUs in Variant 2*

Effort / Result	DMU 28	DMU 25	DMU 18	DMU W2
Employees	136	39	86	261
Real property	6250	24243.06	6200	36693.06
Branches	0	0	0	2
Educational offer	9	9	9	27
Students	799	407	678	1884
Graduates	201	85	179	465

Source: *Authors' own work.*

DMUs 18, 25, and 28 leave the group as a consequence of the creation of DMU W2. In terms of the number of branches, the newly formed DMU W2 is at the top of the group, since it was assumed that the merger of the three higher education institutions means the creation of DMU W2 plus two branches. In terms of real property area, the new entity is in the second position among all institutions analysed in the study.

Considering the number of researchers/teachers, it ranks third on our list of higher education institutions. As for its educational offer, the institution leads the ranking. At this point we should reinstate that in line with the assumptions for this variant, effects and efforts for DMU W2 are expressed as a plain total. With regard to educational offer, this may not be the most appropriate assumption, since it largely depends on the profile of a given higher education institution and the majors offered.

Taking into account the fact that all units are higher vocational schools, we may realistically expect that there will be duplicate majors after amalgamation. This possibility should be taken into account when interpreting the results. However, for the purpose of the remainder of this study, the assumption is maintained, since the model is examined in the context of other variants and aimed at presenting the effect of the merger between the weakest higher education institutions, even if some results are overstated.

It is noteworthy that the new unit DMU W2 ranks ninth in terms of the number of students and eleventh with regard to the number of graduates. Its student-to-researcher/teacher ratio is 7.21891, which is much lower than the mean (approx. 13). We may thus expect that the effectiveness rating of the emergent higher education

institution is going to be rather low. This is indeed the case, as it equals 44.19% (Table 6), a value below the mean for the previous minimum and for the three merging institutions.

Table 6. *Effectiveness ratios for merged higher education institutions and newly formed one in Variant 2*

Description	DMU 18	DMU 25	DMU 28	DMU W2
Effectiveness ratio	56.60%	55.66%	49.87%	44.19%

Source: *Authors' own work.*

Our analysis proved that:

- The merger between the "weakest" higher education institutions does not raise the effectiveness of the newly formed entity compared to component ratings of the merging institutions. Consequently, it is not a viable method of increasing effectiveness. Higher education institutions should start by increasing their individual effectiveness by optimising technology and resource utilisation.
- Expanding resources led to the creation of a relatively large education institution in terms of available assets. However, it did not translate into raising the new entity's effectiveness rating. Interestingly, the rating is lower than the lowest rating among the merging institutions. This corroborates earlier conclusions that a mere merger to expand available resources is not a viable way to boost effectiveness (it may prove viable eventually, if accompanied by other actions aimed at optimising operations).

By merging with a less effective entity, effective higher education institutions risk a decline in their effectiveness if a new unit emerges in the process, and the less effective institution becomes a branch.

This means that more effective schools should use stricter criteria for the selection of candidates for mergers or cooperation. In this context, it appears reasonable to claim that the variant of cooperation (rather than merger) is more beneficial for both institutions.

During the cooperation period, both units stand a better chance of learning more about each other and identifying potential paths for the future development of their cooperation. Moreover, in the course of cooperation the aforementioned optimum technology should be transferred. In the long run, the cooperation may culminate in a merger, which seems to be a more advantageous option.

3.3 Variant 3

Variant 3 required the identification (purposive randomised sampling) of a potential partner to merge with each of the three DMUs with the lowest effectiveness rating.

Table 7 shows effectiveness rating values for external higher education institutions randomly selected for merger with the least effective units from the base group.

Table 7. *External (academic) higher education institution effectiveness ratios with the use of the SE DEA CCR-I CRS model*

Description	DMU W30	DMU W31	DMU W32
Effectiveness ratio	48.56%	30.67%	67.39%

Source: *Authors' own work.*

For this purpose, model SE DEA CCR-I CRS was applied. Table 8 lists the expected outcomes of the mergers. As presented in the table above, external entities randomly selected for mergers, each having a strong position in their province (voivodeship), attained relatively low effectiveness ratings.

Applying the assumptions and conditions contained in Table 2, we generated forecast values of changes due to mergers for DMUs 28, 25 and 18, together with new values of efforts and results for the newly formed DMUs W3-1, DMU W3-2, DMU W3-3.

Having removed data for DMUs 18, 25 and 28 from the base group, and then including DMUs W30, W31 and W32 in the group, an effectiveness evaluation was performed for new entities using model SE DEA CCR-I CRS.

Table 8. *List of forecast results of the amalgamation of selected DMUs in Variant 3*

Merger in progress				Post-merger	
DMU	*Effectiveness rating*	*DMU*	*Effectiveness rating*	*DMU*	*Effectiveness rating*
DMU W30	48.56%	DMU 28	49.87%	DMU W3-1	56.46%
DMU W31	30.67%	DMU 25	55.66%	DMU W3-2	66.99%
DMU W32	67.39%	DMU 18	56.60%	DMU W3-3	78.10%

Source: *Authors' own work.*

In Variant 3, in two of the three analysed mergers between higher education institutions with the lowest effectiveness scores in the group and entities from outside the group, the units from the base group received higher effectiveness ratings than the entity with which they were supposed to merge. In the third case, an entity from outside the group had a higher effectiveness rating.

The variants discussed in this study presented various situation,: mergers between entities rated identically (similarly) for effectiveness, and mergers between a lower-rated entity and a higher-rated entity. Still, it was always an amalgamation of a smaller institution with a larger one. An assessment of entities formed in this

manner, with merger outcome assumptions as in Variant 1, proved that in all three cases the amalgamation had positive results in terms of effectiveness rating for a DMU from the base group. The greatest effect was reported for DMU 18 merging with DMU W32. The merger between DMU W31 and DMU 25 resulted in a slightly lower increase in effectiveness rating for the newly formed entity DMU W3-2 compared to the rating for DMU 25.

The effect was nearly twice as low as in the above-described case. A similar observation was made for the merger between DMU W30 and DMU 28. Considering differences in effectiveness rating for merging units (a unit from outside the group + a unit from the group), as shown in Table 9, one cannot argue that the effect of nominal increase was proportional to the differences.

This confirms the claim that an estimation of the outcome of amalgamation of higher education institutions and changes in effectiveness caused by the amalgamation is a more complex and multi-faceted subject with no simple correlation observable for the analysed data.

Table 9. *Cumulative effectiveness rating list for all new higher education institutions established as a result of merger variants*

Description	DMU 28	DMU 25	DMU 18	Newly formed
DMU 6	50.65%			W1-1
DMU 6		66.32%		W1-2
DMU 6			61.50%	W1-3
DMU 7	52.74%			W1-4
DMU 7		56.76%		W1-5
DMU 7			62.50%	W1-6
DMU 26	64.96%			W1-7
DMU 26		68.89%		W1-8
DMU 26			76.02%	W1-9
DMU W30	56.46%			DMU W3-1
DMU W31		66.99%		DMU W3-2
DMU W32			78.10%	DMU W3-3
DMU 28	44.19%			DMU W2
DMU 25				
DMU 18				

Source: *Authors' own work.*

A cumulative juxtaposition of results for variants W1, W2, and W3 shows that:

- For DMU 28, in terms of an increase in effectiveness rating, the most advantageous merger within the base group of entities rated using the SE DEA CCR-I CRS model with the aforementioned assumptions is the merger with DMU 26.
- For DMU 28, the merger with DMU 25 and DMU 18 is the least beneficial.
- For DMU 25, in terms of an increase in effectiveness rating, the most advantageous merger within the base group of entities rated using the SE DEA CCR-I CRS model with the aforementioned assumptions is the merger with DMU 26.
- For DMU 25, the merger with DMU 28 and DMU 18 is the least beneficial.
- For DMU 18, in terms of an increase in effectiveness rating, the most advantageous merger within the base group of entities rated using the SE DEA CCR-I CRS model with the aforementioned assumptions is the merger with DMU W32.
- For DMU 18, the merger with DMU 25 and DMU 28 is the least beneficial.

A situation wherein the effectiveness rating of a newly formed entity exceeded mean effectiveness rating for entities in the base group (83.22%) was reported for none of the analysed mergers between higher education institutions with the lowest effectiveness rating. In one situation, the effectiveness rating only approached the median (77.56%).

4. Discussion and Conclusions

Performing a simulated amalgamation of higher education institutions subject to effectiveness assessment required making certain assumptions as to the extent and timing of specific outcomes in each area. Lack of data or previous analyses for a process that has been completed and well-described rendered it necessary to make a certain set of assumptions.

These assumptions were formulated subject to some obvious relationships, e.g., limitations arising from real property surface area in the context of opening new majors or increasing student intake, etc. In this part of the study, the assumptions were applied consistently throughout all elements of the simulation. Simulated mergers between higher education institutions within the base group, with particular reference to entities with the lowest effectiveness ratings, provided a number of findings on the viability of such operations.

As a result of research activities and an analysis of the effects of the simulation, we were able to identify the following relationships:

- The merger of the DMU with the highest rating among the 29 DMUs in the group with the DMU with the lowest rating in the group was not the most

effective amalgamation variant in terms of a change in the effectiveness rating for the lower-rated DMU measured prior to and after merger.

- The greatest nominal growth in the effectiveness rating of higher education institutions created by merger was accompanied by a nominal increase in effort (outlays) in the form of research staff. The increase translated into generating an effect defined here as educational offer. This was related to the number of students and graduates.
- Nominal growth in the number of students and the accompanying (proportional) increments in the number of graduates led to increased research staff count.
- The most advantageous path to an improvement in effectiveness for a higher education institution with a low effectiveness rating is to expand its teaching staff and enhance its educational offer. This finding corroborates the conclusion made in the analysis of the results of the tobit model (Pyra, Adamowicz, 2021).
- One may suspect that the benefits of these actions will gradually attenuate along with the growth in the effectiveness rating above the average level for a given group of higher education institutions. After exceeding a certain level, maintaining the growing number of majors and students will necessitate stepping up effort (outlays) in the form of real property. This, as demonstrated by the tobit model (Pyra, Adamowicz 2021), leads to a significant decline in the effectiveness rating. Therefore, we should not expect a linear growth in the effectiveness rating as an inevitable consequence of a linear increase in effort and results. This implies the likely existence of the limits to deriving benefits from relatively straightforward actions such as hiring more teaching/research staff. It is possible that there is more than one such limit and that they may be correlated with the effectiveness rating level for a given higher education institution and the arrangement of its components (this hypothesis may be verified in subsequent studies based on extended data and research tools).
- Focusing on expanding the outlays does not seem a good strategy for those higher education institutions which are rated relatively high for effectiveness. Instead, optimisation of technology appears to be of greater significance in this group.
- The institution's scale of operations does not translate directly into its effectiveness rating, assuming that the institution uses its resources in an optimum way. Thus, optimum technology is of key significance for attaining high effectiveness rating.
- Amalgamation between the "weakest" higher education institutions does not raise the effectiveness of the newly formed entity compared to component ratings of the merging institutions.
- A merger between poorly performing higher education institutions does not constitute a successful method of boosting effectiveness. Higher education

institutions should start by improving their individual effectiveness through the optimisation of technology and of utilisation of resources.

- Scaling up resources, as in the case of the amalgamation of the three weakest higher education institutions, gave rise to a relatively large entity in terms of available resources. However, it did not immediately boost the new entity's effectiveness rating. Interestingly, its rating was lower than the lowest rating among the merging institutions. This is in line with earlier findings which imply that a mere merger to expand available resources is not a viable way to improve effectiveness (it may prove viable in the long run, if accompanied by other actions aimed at optimising operations). In the light of the above results, mergers between weakest-performing higher education institutions do not seem a productive way of improving their effectiveness. This also implies a significant role of the "optimum technology", whose transfer does not take place through mergers between non-effective entities.
- Amalgamation of higher education institutions of highly diverse effectiveness will not always yield positive results for both entities. A merger between an institution with more resources with one with less resources (considering the assumptions as to the effects of the merger) is not always advantageous in terms of changes in effectiveness rating. The "smaller" the institution, the more benefits it may expect. Accordingly, from the perspective of the size (of the resources) of an institution, a merger with a smaller entity should ultimately lead to the assimilation of the latter, as a result of which the entity becomes a branch of the larger one. In the long run, this should prove more beneficial than cooperation on the principles assumed in the simulation.
- Mergers described in this study may lead to unilateral benefits, i.e. when a DMU with lower effectiveness rating attains a positive change (increase) in its effectiveness rating. At the same time, the DMU merging with the weaker institution does not experience any change.
- In terms of mutual benefits, i.e. changes in both higher education institutions undergoing a merger, there may be situations when similar effects are obtained by one of the merging institutions when paired with another entity. Nevertheless, this does not mean that the reverse applies. We may formulate a thesis that the benefits arising from a merger are not symmetrical.

The discussion contained in this article, based on simulations and forecast outcomes of the amalgamation of selected higher education institution in terms of their operational effectiveness measured by the DEA method, constitutes a fragment of a larger whole.

Specifically, as part of the research grant "Forecasting changes in the effectiveness of selected higher vocational state schools as a result of the consolidation of higher education institutions in the context of the ranking of Polish higher vocational state schools", in addition to the above analyses, research activities were performed to assess the public vocational schools in Poland for their operational effectiveness.

The use of the DEA approach, both in variant CCR-0, CCR-I, BCC-0, BCC-I, SE CCR-I (CRS, VRS) and in the tobit model, allowed us to compile an effectiveness ranking for higher education institutions and to make interesting conclusions on the application of each model in reference to the higher education sector (Pyra and Adamowicz, 2021). In addition, attempts at a simulated merger were made between a representative of the public higher vocational school sector, namely the Applied Science University in Biała Podlaska, with selected higher education institutions.

The experience of mergers between Polish higher education institutions reveals considerable room for improvement with regard to increasing efficiency. Suitable proportions of efforts and outlays, reasonable resource management, and pending cooperation undertakings may enable an optimisation of the operations of individual entities in the higher vocational state school sector.

What seems necessary in this respect is the knowledge of amalgamation processes, which is available from foreign colleges and universities. Leveraging that experience should enable higher education institutions to cooperate effectively and, what is more, avoid mistakes in the process of implementation. Further research initiatives and investigating the subject further also appear as a viable step forward.

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