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Efficiency of the Education System (Primary, Secondary and Tertiary) in Particular Voivodeships of Poland[1]

The reform of the Polish education system (both lower and higher education) that was carried out in recent years has shown the need to improve the efficiency of schools. Therefore, it is reasonable to analyse and evaluate the efficiency of educational centres before implementing reforms. Educational units influence the development of human capital, which should translate into an increase in the wealth of a given region. To our knowledge, there is a lack of research on the technical efficiency of the primary, secondary and tertiary education systems in particular Polish voivodeships. Therefore, the aim of this paper was to present the results of studies on the efficiency of the three levels of the Polish education sector in 2016. The non-radial Slack-Based Directional Distance Function (SBDDF) model, which belongs to the nonparametric Data Envelopment Analysis (DEA) method, was used to test the efficiency. The number of teachers employed in particular voivodeships, as well as the number of schools and universities were assumed as inputs. The number of pupils and students was assumed as outputs. We hypothesise that there is a positive correlation between the efficiency of the education system and the labour market economic indicators in the province. The hypothesis was verified positively as the findings showed that the higher the education system efficiency indicator in a given voivodeship, the greater the number of the SME sector companies per 10,000 inhabitants, the higher the gross Domestic Product (GDP) per capita and the lower the percentage of the unemployed in the region. The study results may be of use to various groups of stakeholders, in particular, employees of ministries responsible for the functioning of primary, secondary and tertiary education. The limitations of the study concern the selection of variables adopted on the input and output side. Moreover, the conducted analysis is static (in one year). Therefore, there is a need to continue research using a dynamic approach.

Keywords: efficiency, lower education, primary education, secondary education, tertiary education, higher education, DEA method, labour market, voivodeship, Poland

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Эффективность системы начального, среднего и высшего образования в воеводствах Польши

Недавно проведенная реформа системы школьного и университетского образования в Польше показала необходимость повышения эффективности учебных заведений. В связи с этим является целесообразным проанализировать и оценить эффективность образовательных центров до проведения реформ. Положительное влияние образовательных учреждений на развитие человеческого капитала может вести к увеличению благосостояния региона. На данный момент тема эффективности систем начального, среднего и высшего образования в польских воеводствах остается недостаточно изученной. Цель данной статьи — представить результаты исследований эффективности трех уровней польской системы образования за 2016 г. Для проверки эффективности была применена нерадиальная асимметричная функция направленного расстояния (Slack-Based Directional Distance Function), которая относится к методологии анализа среды функционирования (DEA). В качестве входных переменных модели были использованы показатели количества учителей, работающих в отдельных воеводствах, количества школ и университетов. Количество школьников и студентов рассматривалось как выходная переменная. Была выдвинута гипотеза о существовании положительной корреляция между эффективностью системы образования и экономическими показателями рынка труда в провинции. Полученные данные подтвердили эту гипотезу: чем выше показатель эффективности системы образования в воеводстве, тем больше количество малых и средних предприятий на 10000 жителей, и, в свою очередь, выше валовой внутренний продукт на душу населения и ниже процент безработных в регионе. Результаты исследования могут быть использованы различными группами заинтересованных сторон, в частности, сотрудниками министерств, отвечающих за функционирование системы начального, среднего и высшего образования. Ограничения исследования касаются выбора входных и выходных переменных, поскольку проведенный анализ статичен (изучались данные за один год), поэтому дальнейшие исследования необходимо продолжить с использованием динамического подхода.

Ключевые слова: эффективность, начальное образование, среднее образование, вузовское образование, высшее образование, анализ среды функционирования, рынок труда, воеводство, Польша

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Introduction

The reason to undertake this analysis was the reform of the Polish education system (both lower level education and higher education) implemented in recent years, which indicated the need to improve the efficiency of school functioning. It should be noted here that the very concept of efficiency is difficult to define precisely. Many authors have pointed out the interdisciplinary nature of efficiency, e. g. Denek (1997). It can be assumed that the efficiency of schools is a relation between the results (output) — connected to key areas of their functioning — and financial, material, as well as human resources involved in obtaining them (Baran, Pietrzak, Pietrzak, 2015). It is worth emphasising, however, that there is no universal set of diagnostic variables included in inputs and output. Their selection is often limited by the availability of data and results from the experience of the authors from previous studies (Pietrzak, 2016). Problems related to defining and measuring the efficiency of schools (in particular, universities) have been discussed, among others, by Wolszczak-Derlacz (2013).

The Data Envelopment Analysis (DEA) method has been widely used in assessing the efficiency of

public sector units (including educational units). In 1978, its authors Charnes, Cooper and Rhodes, based on the concept of productivity formulated by Debreu and Farrell, applied it to a multidimensional situation (Charnes, Cooper, Rhodes, 1978). According to their assumptions, the efficiency result of each unit can be presented as the quotient of the weighted sum of effects and the weighted sum of expenditures. This is the relative efficiency determined for a specific set of objects, called Decision Making Units (DMUs). In managerial applications, DMUs may include banks, department stores, and extend to hospitals, public libraries and schools (Cooper, Seiford, Tone, 2007). On the basis of the constructed linear programming task, the most efficient objects are selected. They also become benchmarks for other objects from the examined set. In addition, the DEA method, being one of the non-parametric methods of measuring efficiency, does not require determining the functional relationship between inputs and results (Karbownik, Kula, 2009).

Research on the efficiency of schools using the DEA method has been conducted around the world for many years. Recently, also in Poland (especially after 2010) one can observe an increased interest in the abovementioned issues. Previous analyses were carried out at three levels: individual universities and their faculties, groups of universities of a particular type (usually technical universities) and all public universities. Thus, there is a lack of research on, among others, secondary and primary schools. Hence, the purpose of this article is to present the preliminary results of studies on the efficiency of the Polish education sector (including the lower levels education system and higher education) using the Slack-Based Directional Distance Function (SBDDF) model, belonging to the non-parametric DEA method, by cross-section of individual provinces. One hypothesis was made based on the literature review and the objectives of the study:

H1: the higher the indicator of the efficiency of the education system in a given province, the better the labour market economic indicators in the province.

The article consists of five parts. The first one is an introduction. The second part provides a critical literature review in the field of research into the efficiency of higher education and lower levels education. The third part is devoted to research methodology, including the selection of variables and the DEA model for the research. The fourth part presents the results of empirical research. The article ends with conclusions and a summary.

Literature Review

Government policies, including educational policy, are nowadays supposed to be based on knowledge, such as statistics, research, analyses. Salmi (2015) explicitly points out that regulatory bodies should base educational policy decisions on objective evidence. That is why, for over three decades, research has been conducted to measure the efficiency of schools.

The DEA method is most often used to test the efficiency of education sector entities around the world. A similar trend also occurs in research conducted by Polish authors. According to Brzezicki (Brzezicki, 2020a; Brzezicki, 2020b), the DEA method has been used for years to examine the efficiency of both the lower levels education system and higher education. However, there is a huge disproportion between the number of studies devoted to schools belonging to the lower levels education system (14 studies, according to Brzezicki (2020a)) and universities (80 studies, according to Brzezicki (2020a)). While in the case of academic education, research that relates to the efficiency of individual universities dominates (only 3 studies are in regional perspective, according to Brzezicki (2020a)), in the case of the lower levels education system most of the research focuses on educational efficiency in regional terms (powiats or voivodeships). The above dependence results from the fact that universities are autonomous and independent units whereas entities operating within the lower levels education system, depending on the form and level of education, are usually supervised by various levels of local government. This implies the problem of the availability of data on individual schools, which often operate within teams that prevent the distribution of resources used in a given educational cycle.

Osińska (2012) was the first researcher in Poland to assess the efficiency of higher education in particular voivodeships using the DEA method. The research procedure was carried out in two stages. At the first stage ("mass" of education), the input and output system included: the number of academic teachers per 1000 students, the number of universities per citizen aged 19+, the percentage of people with higher education in the population aged 25+. In turn, the composition of inputs and effects at the second stage ("appropriateness" of education) included: the percentage of people with higher education in the population aged 25+, the percentage of employees with higher education among all the professionally active, the percentage of graduates working for the first time among all university graduates. In 2006–2007, the fully efficient voivodeships in terms of "mass" ed-

ucation were Masovian and Świętokrzyskie. In terms of the "appropriateness" of education in the analysed period, the leading voivodeships were Opole and West Pomeranian.

Kucharski (2014), on the other hand, while assessing the efficiency of the use of human resources by Polish universities on a regional basis, adopted the following diagnostic variables: on the input side — the ratio of the number of 1st year students to the number of graduates who obtained the matriculation certificate in a given province and the number of assistant professors, associate professors and senior lecturers; on the output side — the number of graduates of universities operating in the voivodeship in relation to the number of the 2nd and higher years students and the number of doctoral and postdoctoral degrees awarded. The obtained research results indicated that in each of the six regions (i. e. Central, Southern, Eastern, North-Western, Southwest and Northern) there was one efficient voivodeship. These were: in the Central region — Masovian, in the Southern region — Lesser Poland, in the Eastern region — Lublin, in the North-West — Lubusz, in the South-West region — Opole, and in the Northern region — Warmian-Masurian.

The regional approach was also used by Ćwiąkała-Małys and Łagowski (2017), who estimated the efficiency of academic promotion in different Polish voivodeships. In their analysis, they included the number of post-graduate students, the number of doctoral degrees awarded, and the number of scholarships for post-graduate students, the share of post-graduate students per 10,000 residents. Kaczyńska (2016) assessed the efficiency of public expenditure on primary education in the Greater Poland Voivodeship in terms of three types of municipalities: urban (including cities with powiat rights), urban-rural and rural areas. The author adopted three expenditure categories for input: current expenses incurred for public primary schools, targeted subsidies for current expenses of private primary schools, and funds transferred, among others, in the form of benefits in kind, social benefits, rewards for teachers, scholarships for students and other forms of allowances for them. The result of the final test of knowledge conducted at the end of primary school was, however, considered as an output.

Also worldwide, numerous studies on the efficiency of education sector entities have been carried out in regional terms. For example, Sotiriadis, Menexes and Tsamadias (2018), measured the technical efficiency of secondary schools in the Central Macedonia region in the years 2007/2008 — 2010/2011. Thus, the research period covered the years before and during the economic crisis in Greece. The authors used three variables as inputs and two as output. The study used a model focused on minimising inputs at a certain level of output (input-oriented). Halkiotis, Konteles and Brinia (2018) estimated the efficiency of 23 secondary schools located in Ftiotyda prefecture. The following inputs were assumed in the analysis: the number of students per teacher, the average number of students in one class, and the average annual public expenditure per student. The output side included: the percentage of secondary school graduates admitted to universities, the percentage of secondary school graduates admitted to polytechnics, or the percentage of secondary school graduates who obtained the highest score during the university entrance exam.

Research Methodology

As mentioned earlier, the research on the efficiency of educational units was most often carried out using the non-parametric DEA method. Within this framework, researchers mostly used the radial models: CCR (Charnes, Cooper and Rhodes) — with constant return to scale, BCC (Banker, Charnes and Cooper) — with variable return to scale and their modifications, as well as the sporadic non-radial SBM model (Slack-Based Models).

However, the progress in measuring efficiency using a more general and flexible approach, which is the Directional Distance Function (DDF), has made it increasingly used to measure the efficiency of business entities under the DEA methodology. Chambers, Chung and Färe (1996; 1998), using the works of Luenberger (1992a; 1992b; 1995), redefined the benefit function and the shortage function that Luenberger had developed as a measure of efficiency. The authors thus introduced a new distance function, calling it the directional distance function. Färe and Grosskopf (2000) stated that the Shephard distance function used so far in DEA radial models (Shephard, 1953; Shephard, 1970) is a special case of the directional distance function. However, Färe and Primont (2006) pointed out directly that the function of directional distance is an alternative to respective concepts of measuring radial efficiency.

In the literature on the subject (Brzezicki, 2017), it is emphasised that the basic disadvantage of the radial approach in measuring efficiency is the lack of taking into account the level of backlash. In response to this imperfection, Färe and Grosskopf (2010a; 2010b) using the concept of the directional distance function (Chambers, Chung, Färe, 1996; Chambers, Chung, Färe, 1998)

and the assumptions of the non-radial SBM model (Tone, 2001) presented the non-radial slack-based directional distance function — SBDDF.

Since the SBDDF model was relatively rarely used in previous studies devoted to measuring the efficiency of educational systems, we decided to fill the knowledge gap. In the study undertaken, the main criterion for choosing diagnostic variables was the availability of data. Because the basic resources used in the education process are people who determine both the quantitative and qualitative aspect of educational activities, the total number of full-time teachers in particular voivodeships of Poland (in full-time positions) was assumed as expenditure. The second outlay was the total number of schools in a given voivodeship. The adoption of such a research convention resulted, in a sense, from the subsidy algorithm for educational schools, by means of which the amount of financial resources transferred by the Ministry of National Education to individual territorial self-government units (JSTs) is defined. JSTs are supervisory and management units for particular schools (primary, junior high, secondary schools). Consequently, local government units are responsible for the entire structure of the network of educational establishments in their area of exercising territorial power.

In the literature (Pietrzak, 2016), the number of pupils (students) and/or graduates was most often taken as effects of the learning process, and the number of academic teachers as inputs. Therefore, it was decided to use these variables in this study (Table 1).

In the case of the study of the entire education system in regional terms, the combined data was adopted from both systems, including lover levels education and higher education (Table 1). In connection with the above, the total number of full-time teachers (in full-time positions) was assumed as the first input, and the number of schools in a given voivodeship as the second one. The overall number of pupils in the lower levels education system and students in higher education system served as an output.

The survey covered all voivodeships in Poland. The following codes were assigned to them: W_1 — Lower Silesia, W_2 — Kuyavian-Pomeranian, W_3 — Lublin, W_4 — Lubusz, W_5 — Łódź, W_6 — Lesser Poland, W_7 — Masovian, W_8 — Opole, W_9 — Subcarpathian, W_{10} — Podlaskie, W_{11} — Pomeranian, W_{12} — Silesian, W_{13} — Świętokrzyskie, W_{14} — Warmian-Masurian, W_{15} — Greater Poland, W_{16} — West Pomeranian.

We also decided to confront the results concerning the efficiency of the education system with selected socio-environmental variables characterising particular voivodeships (data availability was taken into account in their selection). These variables illustrate selected aspects of human capital and the level of public administration's involvement in the education system. In addition, their impact may positively (stimulants — the higher the value, the better) or negatively (destimulants — the lower the value, the better) affect the situation in the voivodeship. Thirteen socio-environmental variables were selected for the study and subjected to statistical verification. Due to the low level of the coefficient of variation V(x) (below 10 %), three variables were excluded from the analysis. The other variables are given the designations X_1 to X_{10}.

Table 1

Expenditure and effects adopted for testing the efficiency of the lower levels education system, higher education, the entire education system (lower levels education + higher education) in particular provinces of Poland

Characteristics of the variable	Name of the variable
A. Lower levels education system	
Inputs	number of full-time primary and secondary education teachers in the voivodeship
	number of primary and secondary schools in the voivodeship
Output	number of pupils/students in primary and secondary schools in the voivodeship
B. Higher education system	
Inputs	number of full-time academic teachers in the voivodeship
	number of universities (tertiary education units) in the voivodeship
Output	number of university students in the voivodeship
C. Education system (in total: including primary, secondary and tertiary education systems)	
Inputs	number of full-time lower levels education teachers and academic teachers in the voivodeship
	number of primary, secondary, tertiary educational units in the voivodeship
Output	number of pupils in primary education schools and students in secondary and tertiary in the voivodeship

Source: own study.

Table 2

Socio-environmental variables included in the study

Impact characteristics	Code of the variable	Name of the variable
Positive (stimulants)	X_1	Expenditure of municipal budgets on education and upbringing (in PLN thousand)
	X_2	Expenditure of powiat budgets for education and upbringing (in PLN thousand)
	X_3	Expenditure of voivodeship budgets on education and upbringing (in PLN thousand)
	X_4	Number of the SME sector companies per 10,000 residents
	X_5	GDP per capita (in current prices)
	X_6	Expenditure of enterprises on research and development (R&D) in relation to GDP (in %)
Negative (destimulants)	X_7	Percentage of persons not in employment, education or training at the age of 15–29 (in %)
	X_8	Percentage of registered unemployed in the productive age (in %)
	X_9	Percentage of registered unemployed with higher education (in %)
	X_{10}	Percentage of registered unemployed with post-secondary education and vocational average (in %)

Source: own study.

The education system in Poland depends primarily on public funding, whose structure is formed on the basis of the educational subsidy algorithm of the Ministry of National Education (MEN) and the grant algorithm for teaching activities of the Ministry of Science and Higher Education (MSHE). In relation with the above, socio-environmental variables that have a positive impact on the situation in voivodeships are, among others: expenditure of municipal budgets on education and upbringing (in PLN thousand) (X_1), expenditure of powiat budgets on education and upbringing (in PLN thousand) (X_2), expenditure of voivodeships budgets on education and upbringing (in PLN thousand) (X_3).

The education system also affects the growth of entrepreneurial attitudes in the society, which is why the number of the small and medium (SME) sector companies per 10,000 residents was also included in the analysis (X_4). Moreover, entrepreneurial behaviour and the number of companies in the SME sector affect the society's wealth in voivodeships expressed in gross domestic product (GDP)per capita (X_5), as well as on enterprises' expenditure on research and development (R&D) in relation to GDP (in %) (X_6).

In turn, the following factors were assumed as variables having a negative impact on the socio-economic situation in voivodeships: the percentage of people not working, not in education or training, aged 15–29, i. e. the so-called NEET (not in employment, education or training) (in %) (X_7), percentage of registered unemployed in working age (in %) (X_8), percentage of registered unemployed with higher education (in %) (X_9), percentage of registered unemployed with post-secondary and secondary vocational education (in %) (X_{10}). The list of all environmental variables included in the study is presented in Table 2.

In order to maintain consistency with the results of the efficiency of the education system, all environmental variables apply to the year 2016. In addition, these variables (except for subsidies for universities, whose values were taken from the Ministry of Science and Higher Education declarations) were obtained from publicly available databases of the Ministry of Science and Higher Education (The Integrated System of Information on Science and Higher Education[1]) and Statistics Poland (Local Bank Data[2]; STRATEG[3]). The DJL package and the R program were used to estimate the level of efficiency of education with the use of a model of the slack-based directional distance function (Färe, Grosskopf, 2010a; Färe, Grosskopf, 2010b). Descriptive, graphical and tabular methods were used to present research results.

Results and Discussion

Table 3 presents the synthetic characteristics of Polish provinces in cross-section of variables included in the DEA model. Based on the results of the model, the efficiency of particular voivodeships was determined and a ranking was created (Table 4). The average values of DEA efficiency indicators for Polish voivodeships in 2016 were respectively: 0.879 (for the lover levels education system), 0.771 (for the higher education system) and 0.789 (for the lover levels education system). Six voivodeships (Lower Silesia, Lubusz, Masovian, Opole, Pomeranian and Greater Poland voivodeship) out of the sixteen analysed were considered

[1] The Integrated System of Information on Science and Higher Education. Retrieved from: https://polon.nauka.gov.pl/polon-network (Date of access: 31.07.2020).

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Table 3

Characteristics of Polish voivodeships according to variables used in the DEA model

Specification	Minimum	Average	Maximum
Number of full-time lower levels education teachers (full-time positions)	8662	22 298	51523
Number of full-time academic teachers (full-time positions)	1216	5965	17125
Number of lower levels schools	642	1568	3296
Number of higher education schools	6	24	94
Number of pupils of lower levels education schools	101 609	280 185	653 496
Number of students of higher education schools	29 968	168 435	539 332

Source: own study based on the conducted research.

Table 4

Ranking of Polish voivodeships in terms of the value of the indicators of the efficiency of the systems: lower levels education, higher education, education (Note: the voivodeships were ranked in terms of the value of the education system efficiency index)

Specification	Lower levels education system efficiency index	Higher education system efficiency index	Education system efficiency index
W_1	1.000	1.000	1.000
W_4	1.000	1.000	1.000
W_7	1.000	1.000	1.000
W_8	1.000	1.000	1.000
W_{11}	1.000	0.956	0.907
W_{10}	0.854	0.324	0.906
W_{16}	0.944	0.448	0.838
W_{14}	0.868	1.000	0.754
W_{15}	1.000	0.691	0.743
W_6	0.779	1.000	0.738
W_2	0.857	0.637	0.706
W_5	0.844	0.554	0.696
W_{12}	0.993	0.685	0.690
W_{13}	0.707	0.398	0.682
W_3	0.633	0.640	0.522
W_9	0.579	1.000	0.438
Minimum	0.579	0.324	0.438
Average	0.879	0.771	0.789
Maximum	1.000	1.000	1.000

Source: own study based on the conducted research.

to be fully efficient in terms of the lower levels education system, and their efficiency index was one (Table 4). It is worth noting that the Silesian voivodeship was very close to the efficiency limit (0.993).

In the case of the higher education system, seven voivodeships were fully efficient. These were the following voivodeships: Lower Silesian, Lubusz, Masovian, Opole, Warmian-Masurian, Lesser Poland, and Subcarpathian. This means that these voivodeships have strong academic centers, which are popular with secondary school graduates. These are: Wrocław (e. g. Wrocław University of Technology, University of Wrocław, Wrocław University of Environmental and Life Sciences), Zielona Góra (e. g. University of Zielona Góra), Warsaw (e. g. University of Warsaw, Warsaw University of Technology, Warsaw School of Economics, Warsaw University of Life Sciences, Kozminski University, Polish-Japanese Academy of Information Technology), Opole (e. g. University of Opole, Opole University of Technology), Olsztyn (e. g. University of Warmia and Mazury in Olsztyn, University of Life Sciences in Olsztyn), Krakow (e. g. Jagiellonian University, AGH University of Science and Technology in Krakow, Cracow University of Technology), and Rzeszów (e. g. Rzeszów University, Rzeszów University of Technology). Efficiency indicators for other voivodeships ranged from 0.324 (Podlaskie voivodeship) to 0.956 (Pomeranian voivodeship).

It is worth noting that four voivodeships were fully efficient in both the lower level education system and higher education. For this reason, they became leaders in the ranking in terms of the education system efficiency index. These were

Fig. 1. *Fully efficient voivodeships — lower level education system (Note: the voivodeships were marked in black) (source: own study based on the conducted research)*

Fig. 2. *Fully efficient voivodeships — higher education system (Note: the voivodeships were marked in black) (source: own study based on the conducted research)*

the following provinces: Lower Silesian, Lubusz, Masovian, and Opole voivodeship. The last position in the ranking of the efficiency of the education system was taken by the Subcarpathian voivodeship (Table 4).

Since 2018, Statistics Poland (GUS) has distinguished seven macro-regions (the names of voivodeships are given in brackets) in Poland (Wojnarowski, 2019): 1. Central (Łódź, Świętokrzyskie voivodeships); 2. Southern (Lesser Poland, Silesia voivodeships); 3. Eastern (Lublin, Subcarpathian, Podlaskie voivodeships); 4. North-Western (Lubusz, Greater Poland, West Pomeranian voivodeships); 5. South-Western (Lower Silesia, Opole voivodeships); 6. North (Kuyavian-Pomeranian, Pomeranian, Warmian-Masurian voivodeships), 7. Masovian voivodeship. Comparing this division with the performance indicators from Table 4, it can be stated that almost all regions have at least one voivodeship whose lower level education and/or higher education system is fully efficient (Figure 1 and Figure 2).

In the next step of the analysis, the results obtained in terms of the efficiency of the education system were confronted with selected socio-environmental variables (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}) that characterise particular voivodeships. To begin with, it is worth mentioning that the voivodeship with the highest value of budget expenditure of communes, powiats and voivodeship on education and upbringing (8,522,798.5 thousand PLN, 843,029.0 thousand PLN and 102,158.3 thousand PLN, accordingly), with the largest number of the SME sector companies per 10 thousand residents (1,467 companies), the highest GDP per capita (159.7), as well as the lowest percentage of persons not in employment, education or training (aged 15–29) (NEET) (12.0 %), in 2016 was the Masovian voivodeship (Table 5.). In turn, the Lesser Poland voivodeship had the highest expenditure of enterprises on research and development (R&D) in relation to GDP (in %) (1.7 %.) The voivodeship with the lowest percentage of registered unemployed in the productive age (in %) was the Greater Poland voivodeship (3.6 %). The lowest percentage of registered unemployed with higher education (in %) was in the Kuyavian-Pomeranian voivodeship (8.7 %). Finally, the West Pomeranian voivodeship was the one with the lowest percentage of registered unemployed with post-secondary and vocational secondary education (18.2 %).

In Figures 3–12, scatter charts between indicators of the efficiency of the education system in a given voivodeship and socio-environmental variables are presented.

In general, on the basis of the results obtained, it can be concluded that the higher the education system efficiency indicator in a given voivodeship, the greater the number of the SME sector companies per 10,000 inhabitants and the higher the GDP per capita (in current prices). On the other hand, the higher the education sys-

Table 5

Characteristics of Polish voivodeships according to social-environmental variables

Specification	Social-environmental variables									
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
W_1	3 734 606.7	547 636.4	52 413.8	1 243.0	110.8	0.5	14.0	4.8	12.0	20.5
W_2	2 827 659.0	372 471.8	52 217.6	930.0	81.6	0.2	17.5	7.6	8.7	19.1
W_3	2 900 961.2	390 728.1	41 591.6	816.0	68.9	0.2	18.0	7.3	15.4	24.5
W_4	1 317 488.9	192 541.3	16 381.7	1 098.0	83.9	0.1	17.8	5.1	10.2	20.6
W_5	3 158 505.4	475 845.3	37 031.2	978.0	93.3	0.3	12.8	6.0	11.8	19.7
W_6	4 783 805.3	620 788.3	62 475.6	1 096.0	90.6	1.7	13.5	4.6	16.3	23.8
W_7	8 542 798.5	843 029.0	102 158.3	1 467.0	159.7	1.1	12.0	5.8	15.4	21.7
W_8	1 278 751.6	249 455.3	22 424.5	1 009.0	79.6	0.2	16.2	5.2	11.9	19.4
$W9$	2 867 432.5	481 455.2	45 790.7	788.0	70.4	0.8	19.3	8.0	15.0	25.4
W_{10}	1 683 838.9	159 413.9	16 709.1	842.0	70.8	0.1	15.2	6.5	14.5	22.9
W_{11}	3 312 087.7	447 678.4	29 099.5	1 238.0	96.9	0.8	14.7	4.5	12.9	20.3
W_{12}	6 482 188.7	468 539.3	76 444.0	1 023.0	103.6	0.4	13.7	4.3	13.7	22.0
W_{13}	1 505 067.4	318 318.4	19 775.0	886.0	71.5	0.2	19.2	7.4	16.3	24.6
W_{14}	1 821 453.1	375 604.8	22 535.9	864.0	71.3	0.1	22.3	8.1	9.4	19.1
W_{15}	4 909 973.4	748 360.5	49 560.3	1 190.0	109.1	0.3	13.1	3.6	13.0	21.5
W_{16}	2 137 251.6	325 871.8	16 642.2	1 294.0	83.8	0.1	19.7	6.2	10.8	18.2
Minimum	1 278 751.6	159 413.9	16 381.7	788.0	68.9	0.1	12.0	3.6	8.7	18.2
Average	3 328 991.9	438 608.6	41 453.2	1 047.6	90.4	0.5	14.7	6.0	13.0	21.5
Maximum	8 542 798.5	843 029.0	102 158.3	1 467.0	159.7	1.7	22.3	8.1	16.3	25.4

Source: own study based on POL-on, Statistics Poland.

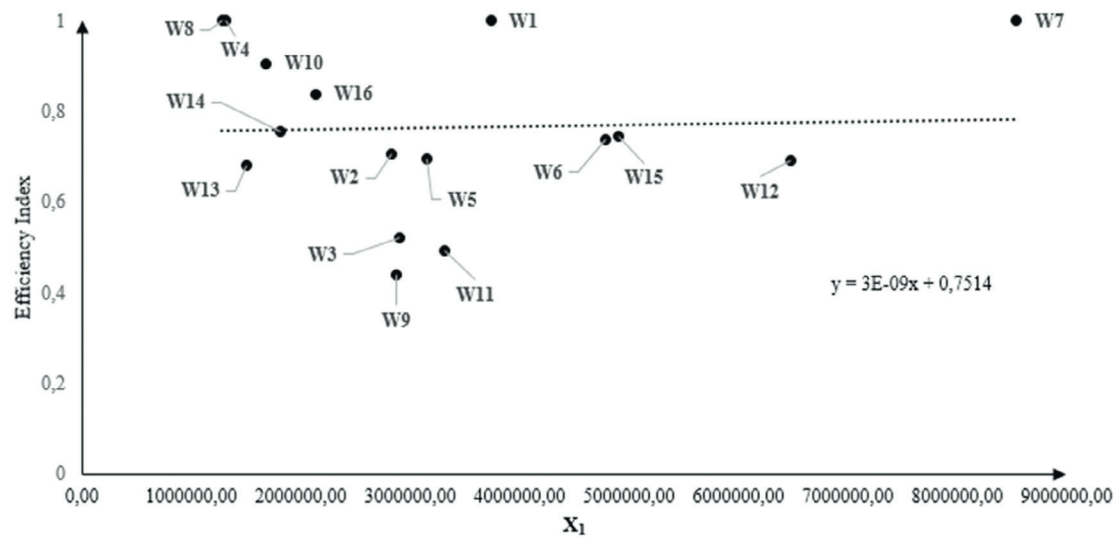

Fig. 3. *Scatter plot — education system efficiency index vs. expenditure of municipal budgets on education and upbringing (in PLN thousand) (source: own study based on the conducted research)*

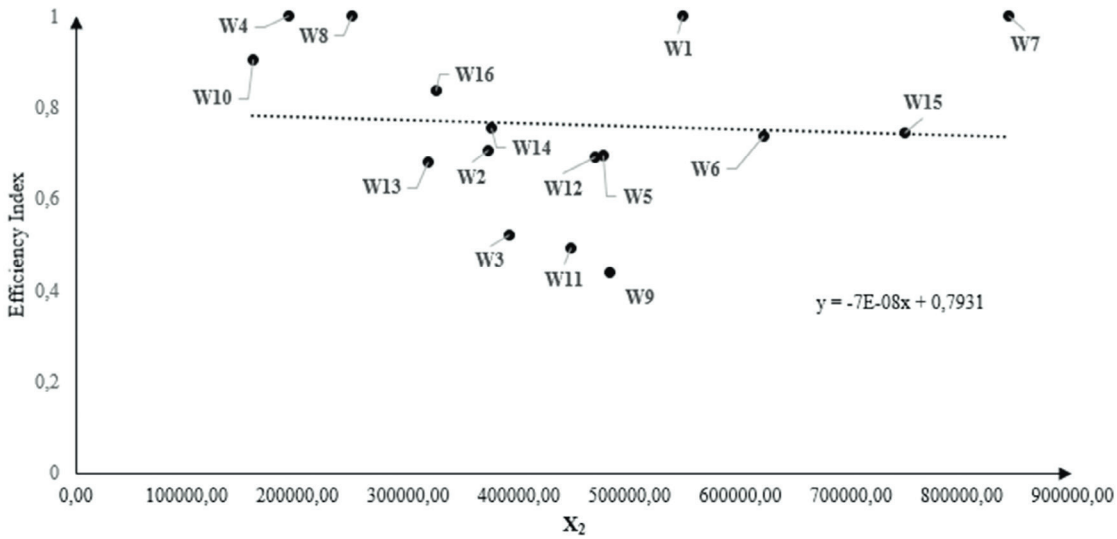

Fig. 4. *Scatter plot — education system efficiency index vs. expenditure of powiat budgets for education and upbringing (in PLN thousand) (source: own study based on the conducted research)*

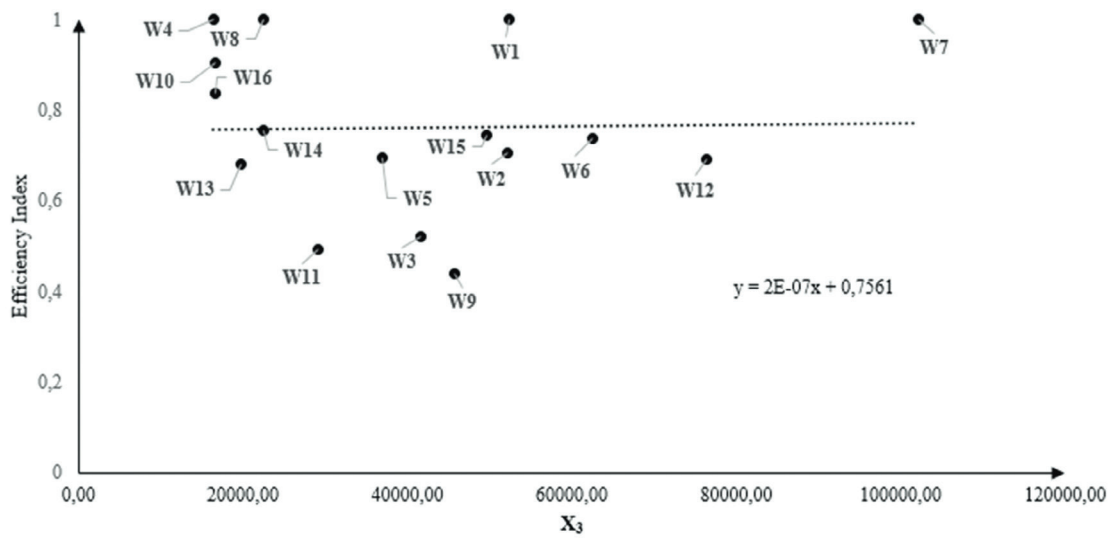

Fig. 5. *Scatter plot — education system efficiency index vs. expenditure of voivodeship budgets on education and upbringing (in PLN thousand) (source: own study based on the conducted research)*

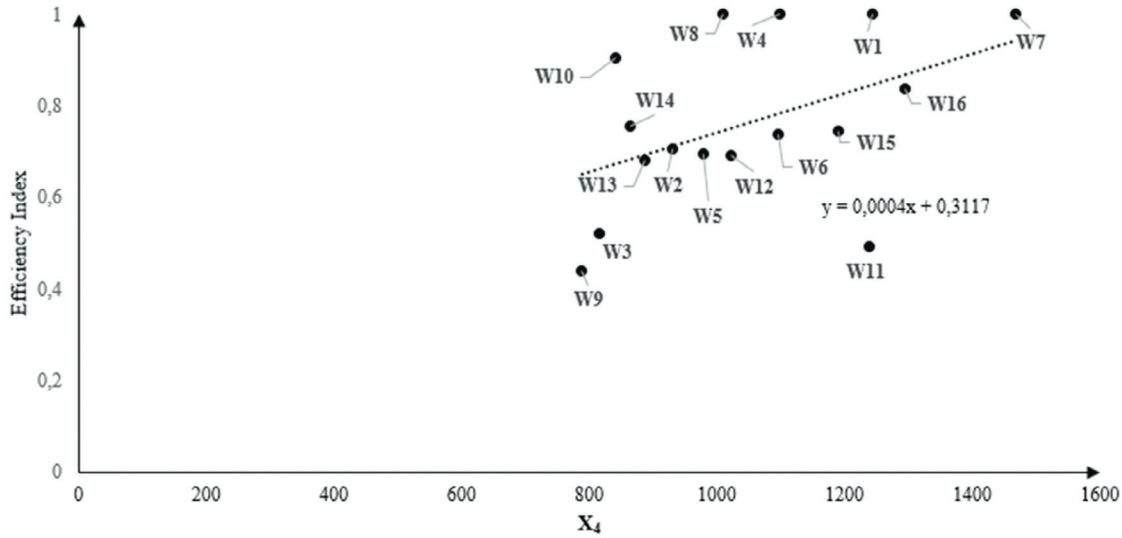

Fig. 6. *Scatter plot — education system efficiency index vs. number of the SME sector companies per 10,000 residents (source: own study)*

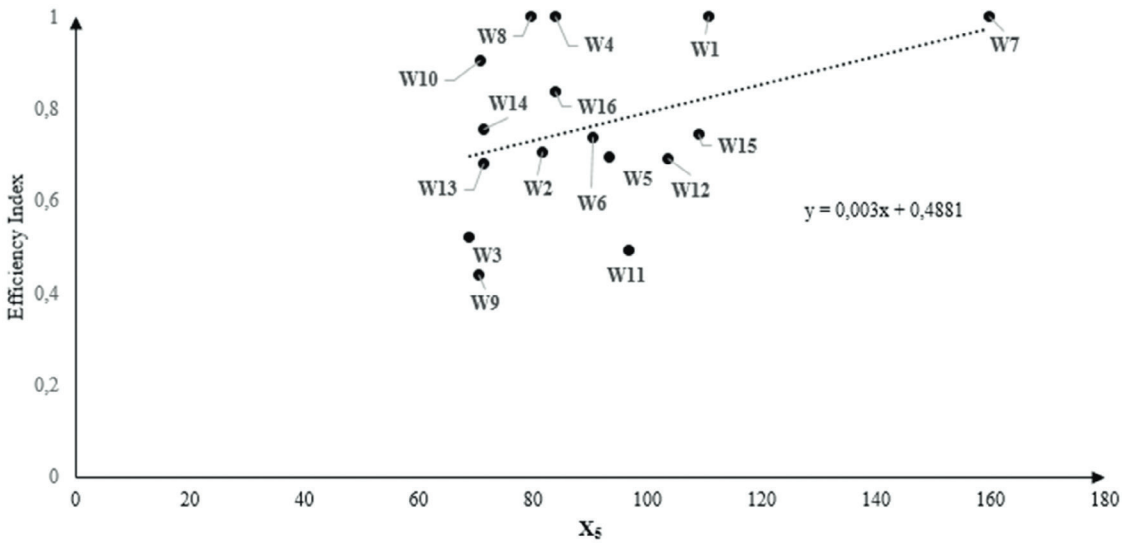

Fig. 7. *Scatter plot — education system efficiency index vs. GDP per capita (source: own study based on the conducted research)*

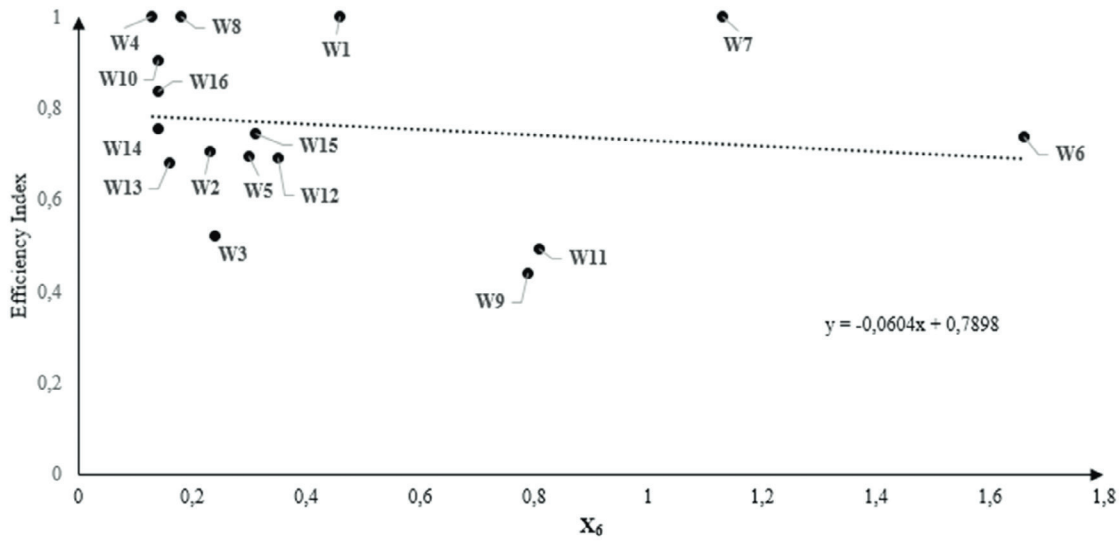

Fig. 8. *Scatter plot — education system efficiency index vs. expenditure of enterprises on research and development (R&D) in relation to GDP (in %) (source: own study based on the conducted research)*

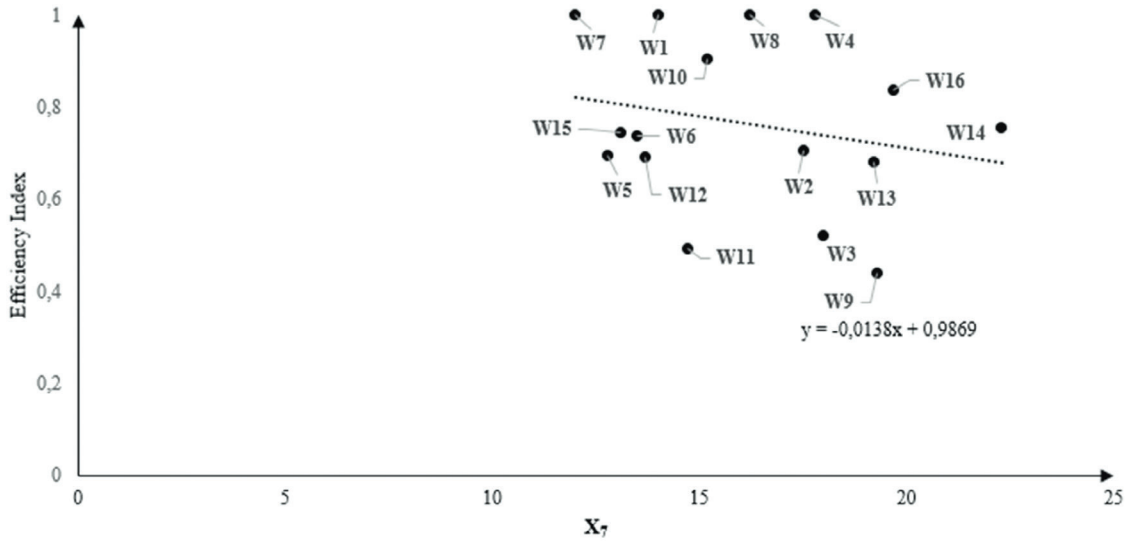

Fig. 9. *Scatter plot — education system efficiency index vs. percentage of persons not in employment, education or training at the age of 15–29 (in %) (source: own study based on the conducted research)*

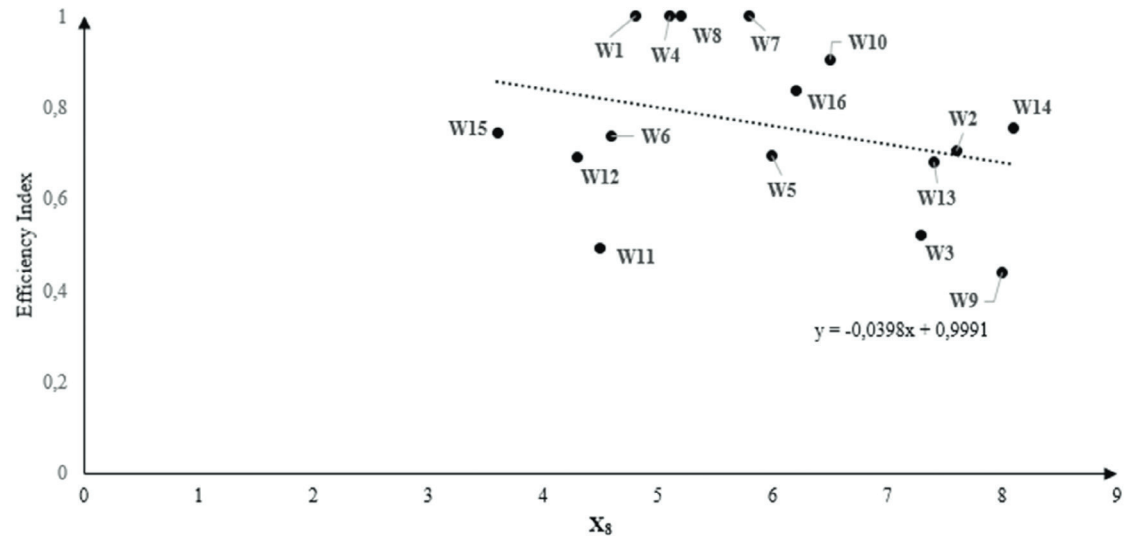

Fig. 10. *Scatter plot — education system efficiency index vs. percentage of registered unemployed in the productive age (in %) (source: own study based on the conducted research)*

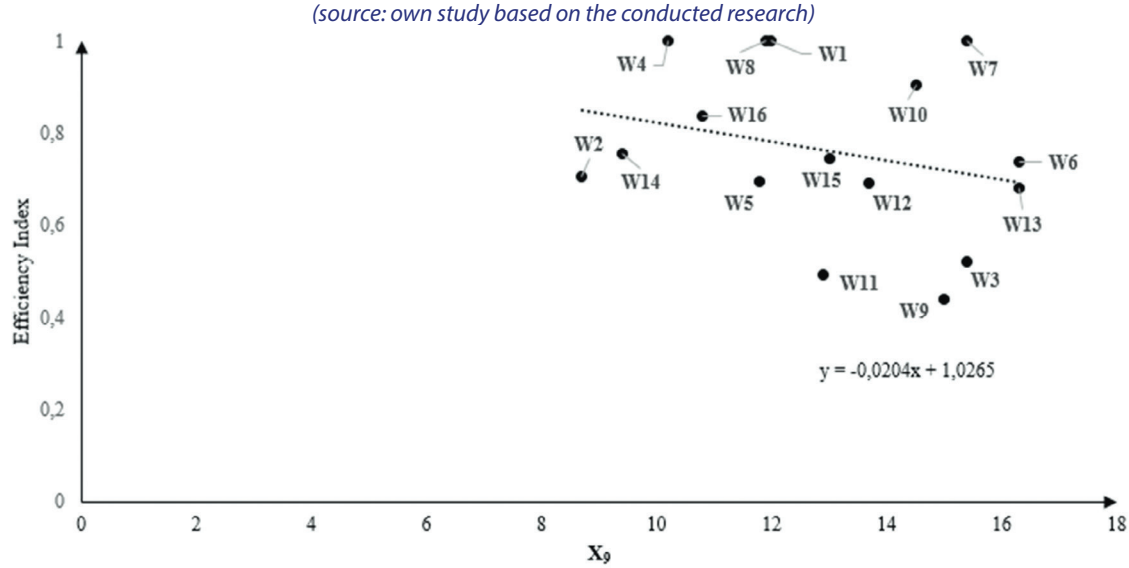

Fig. 11. *Scatter plot — education system efficiency index vs. percentage of registered unemployed with higher education (in %) (source: own study based on the conducted research)*

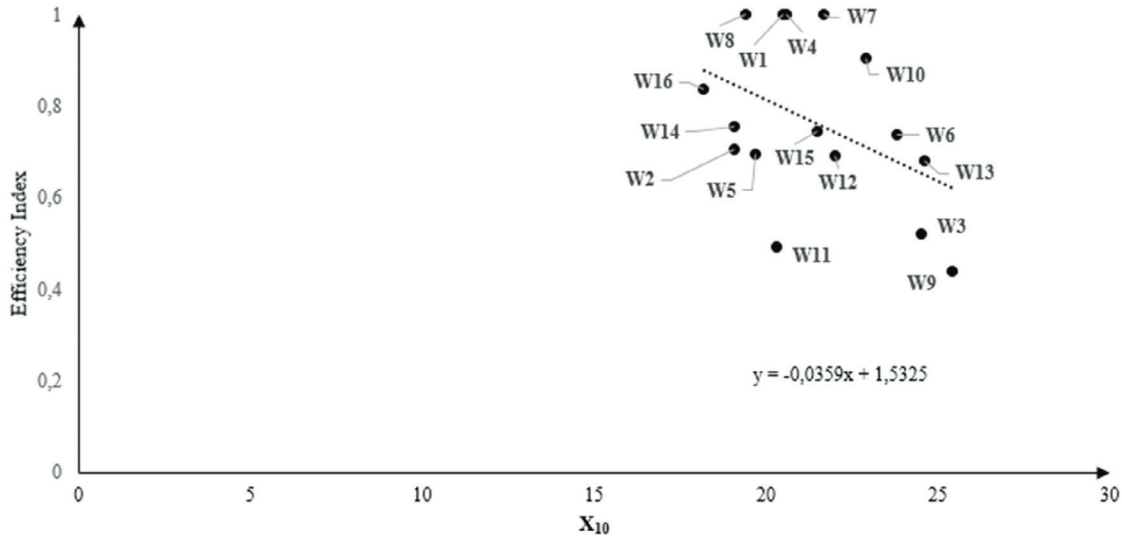

Fig. 12. *Scatter plot — education system efficiency index vs. percentage of registered unemployed with post-secondary education and vocational average (in %) (source: own study based on the conducted research)*

tem efficiency indicator in a given voivodeship, the smaller the research and development (R&D) expenditure in relation to GDP (in %), the lower the percentage of people not in employment, education or training, aged 15–29 years (NEET), the lower the percentage of registered unemployed in productive age, the lower the percentage of registered unemployed with higher education and the lower the percentage of registered unemployed with post-secondary and secondary vocational education. Therefore, hypothesis 1, which assumed the higher the indicator of the efficiency of the education system in a given province, the better the labour market economic indicators in the province was verified positively. It is also worth mentioning that the smallest correlations occurred between the indicators of the efficiency of the education system and the expenditure of budgets of municipalities, powiats and voivodeships on education and upbringing (in PLN thousand). This may indicate that the adopted distribution of funds includes other variables than those taken into account by the authors in the efficiency model.

Conclusions

In this article, we made an attempt to assess the technical efficiency of the lower level (primary and secondary) education system and higher (tertiary) education (together and separately) in particular voivodeships of Poland in 2016. We aimed to find out if there is a correlation between the efficiency of the education system in a given province and the labour market economic indicators in the province. The study used the non-radial SBDDF model, which until now has been used sporadically to measure school performance. The obtained results indicated that the fully effective voivodeships in the field of the education system were: Lower Silesia, Lubusz, Masovian, Opole, Pomeranian, and Greater Poland. In turn, the fully effective voivodeships in the field of the higher education system were: Lower Silesia, Lubusz, Masovian, Opole, Warmian-Masurian, Lesser Poland, and Subcarpathian. The most remarkable result to emerge from the data is that there is a definite positive correlation between the efficiency of the education system and the economic situation of the labour market. The study showed that the higher the indicator of the efficiency of the education system in a given province, the higher the number of companies in the SME sector per 10,000 inhabitants, the higher the GDP per capita (in current prices) and the lower the rates of unemployment in the province.

This paper has highlighted the importance of conducting regional analyses in terms of the efficiency of the education system. Our study provides encouragement for a new non-radial SBDDF model. These findings add to a growing body of literature on efficiency of the education system (primary, secondary and tertiary) in terms of regions.

Of course, one should bear in mind the limitations of the tests and the method itself. The conducted research concerned 16 voivodeships, which forced a compromise in the number of diagnostic variables included. As a result, the main advantage of the DEA method, which is efficiency testing, taking into account many inputs and outputs, was used to a limited extent. In addition, both inputs and outputs included only quantitative aspects of the functioning of the education system.

However, we are aware that the model used, as well as the method of analysis, have the characteristics of novelty on an international scale.

It is recommended to continue research on the efficiency of the education system in a regional perspective, including using a dynamic approach (e. g. Dynamic SBM — DSBM). In addition, it is worth considering extending the set of variables to those relating to the qualitative aspects of the functioning of schools.

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