Lithuanian Journal of Statistics
Lietuvos statistikos darbai
Vol. 61, 2022, pages 1–15
https://doi.org/10.15388/LJS.2022.29667

Vilnius University Press

# Using PIRLS and TIMSS data for the assessment of efficiency and effectiveness of primary education in post-socialist and old democracy EU member states

**Dovilė Stumbrienė, Rimantas Želvys, Julius Žilinskas, Audronė Jakaitienė**

*Institute of Data Science and Digital Technologies, Vilnius University*
Akademijos str. 4, Vilnius LT-08412, Lithuania

E-mail: dovile.stumbriene@mif.vu.lt, rimantas.zelvys@fsf.vu.lt
E-mail: julius.zilinskas@mif.vu.lt, audrone.jakaitiene@mf.vu.lt

Received March 7, 2022; revised July 15, 2022; published online December 20, 2022

**Abstract.** It is a data-oriented approach to evaluate the performance of a set of decision-making units in the process of transforming resources (inputs) into desired results (outputs). The input indicators are the education expenditure and student/teacher ratio; the output indicators are the standard deviations of scores and percentage of resilient students. The standard deviation of the scores can explain how skills and knowledge are distributed throughout the student population, and the percentage of resilient students indicates to what extent the socioeconomic background precludes or does not preclude student success.

**Keywords:** efficiency; effectiveness; equity; EU countries; Data Envelopment Analysis

## 1 Introduction

Accountability in education is a topic that has been sounded over the last few decades at both the national and international levels. More than ever, governments around the world face increased pressure to ensure that their educational systems deliver the best results in student performance and organise their school networks in a more efficient manner. Efficiency is the use of financial, human, physical, and information resources in such a way that output is maximized for any given set of resource inputs or input is minimized for any given quantity and quality of output. The efficiency estimate shows whether or not the system is operating at full capacity, but does not provide

© 2022 Authors. Published by Vilnius University Press
This is an Open Access article distributed under the terms of the Creative Commons Attribution Licence, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

information on whether the goals are fully achieved. Efficiency can be interpreted as effectiveness at the lowest possible costs. Educational effectiveness can be defined as a measurable facet that refers to the level of goal attainment – the distance between observed outputs and a set of desired goals [22]. Effectiveness involves planning the right strategy and focusing on aligning the outcomes with the declared educational goals.

It would be useful to look at efficiency and effectiveness from the perspective of equity. It is important to determine how efficient education systems are in pursuing the goals of equity and eliminating or at least reducing the impact of social factors in education systems. Equity in education is one of the seventeen Sustainable Development Goals,[2] adopted by the United Nations in September 2015. Goal 4 encourages countries to ensure "inclusive and equitable quality education and promote lifelong learning opportunities for all". As pointed out in the communication from the European Commission [12], "it is a key lever for more effective learning and to reducing barriers to education, in particular, social barriers". Access to schooling (regardless of the student's background) is a prerequisite to achieving equity in education. In this study we examine equity in education by focusing on students' socio-economic status (SES).

The most commonly used theoretical framework in efficiency studies is the basic model of the systems theory CIPO (context-input-process-output) model. OECD and other international organizations commonly apply the model in country reviews on education. From a methodological perspective, frontier techniques are typically applied in efficiency research. Data Envelopment Analysis (DEA) is the frontier method most widely used to measure the efficiency of education at the country level [32]. This approach is for evaluating the performance of a set of decision-making units (in the present study – education systems of EU countries) that convert multiple inputs into multiple outputs. The issue of selecting relevant input and output indicators seems to be one of the key challenges of designing efficiency research. The input indicators in studies of education efficiency using country-level data are financial resources, human resources, and physical resources. Student achievement is the most commonly used output indicator – TIMSS scores at primary education [9, 23]; PISA scores at secondary education [2, 33, 18, 34, 4, 31] and TIMSS scores at secondary education [19, 21]. Kyriakides and Creemers note that it is generally expected in society, that education should achieve high results in different domains of learning and subject areas [25]. However, the issue of equity in education seems to be no less important. Just a few studies on education efficiency at a country level have also considered output indicators representing equity in education. Thieme, Giménez, and Prior added the educational inequality index as the output indicator [34], Gimenez, Thieme, Prior, and Tortosa-Ausina added the standard deviation of the PISA scores [20], and the share of low achievers in TIMSS [21].

The attitude of the EU member states towards the issue of equity is to a certain extent determined by the principles on which national education systems are based (e.g. early differentiation or comprehensiveness) and the current socioeconomic situation of the countries. In this respect, post-socialist countries deserve special attention. More than thirty years have passed since the fall of the Berlin Wall, but the socialist heritage still exercises its influence on education. In other words, the world of

[2] Sustainable Development Goals: https://sdgs.un.org/goals.

post-socialism is not dead [30], and the impact of the past remains strong. In any comparative analysis one should bear in mind the specific model of socialist education in the Central and Eastern European regions. First, school attendance during the socialist times was strictly obligatory, and non-attendance implied serious sanctions for parents. Secondly, social differences, contrary to what the official propaganda said, still existed in socialist societies but were not so explicit as in the neighboring Western countries. Third, both during the socialist and post-socialist periods, the Central and Eastern European region was limited in resources and could allocate less funding than most of the western European countries. For the reasons mentioned above, post-socialist states usually demonstrate a combination of a high level of school attendance in secondary education and a relatively low level of funding. As a consequence, school systems of the new EU member states often fall into the category of efficient ones; however, they encounter their own specific problems. Countries face difficulties in integrating students with special needs, migrants, and national minorities (e.g., the Roma community) because programs of integration into mainstream schools are rather costly and are not always welcomed in post-socialist societies. Researchers [28, 7, 36] argue whether education systems the new EU member states are following the specific pattern of development and constitute a separate post-socialist model, or are they moving towards one of the several well-established European educational models as part and parcel of a more general social welfare regime [24]. Bearing in mind the complexity of education systems, we assume that on different levels of education, one can identify different patterns of policy development. We decided to focus on primary education because the first manifestations of selectivity and segregation could be observed as early as the first phase of formal schooling. As stated by Volante *et al.* [35], only a handful of studies investigated SES achievement inequality at the end of primary school while most were about inequality in secondary school; so, the further research on primary education is needed.

The novelty of the current research is that so far few of the comparative effectiveness and efficiency studies were focused on equity issues. Object of the research is education systems of old democracy and post-socialist EU member states that participated in the IEA TIMSS 2015 and PIRLS 2016 international student achievement studies. The research aims to evaluate the effectiveness and efficiency of primary education from the perspective of equity. The main hypothesis of our research is that post-socialist countries will be rather efficient, but not very effective in striving for equity in education.

## 2 Methodology

Data Envelopment Analysis (DEA) is a data-oriented approach for evaluating the relative performance of a set of decision-making units that convert multiple inputs into multiple outputs [11]. In our case, the decision-making units are EU member states, which participated in the IEA TIMSS 2015 and PIRLS 2016 international student achievement studies. DEA extracts a single summary measure of performance for each decision-making unit, based on comparisons with other homogeneous units. DEA based on optimization methods is different from other methods in that it identifies the optimal ways of performance rather than the averages [27]. As Cooper *et al.* [10] stated, one of the advantages of DEA is its ability to identify sources and amounts of

inefficiency in each input and each output for each decision-making unit. Efficiency can be measured by considering multiple resources (or inputs) that are used to achieve desired results (or outputs) in primary education, while measuring effectiveness, in the DEA setting, it is assumed that all evaluated entities have a 'dummy input' equal to one.

From the perspective of equity, we need to involve the desirable (the larger the better) and undesirable (the smaller the better) output indicators. As pointed out by Zanella, Camanho, and Dias the DEA model with the directional distance function simultaneously expands the desired outputs and reduces the undesired outputs [37]. In this paper, we use the approach based on the directional distance function model proposed by Zanella, Camanho, and Dias [37]. The effectiveness of education systems (uses the unitary level of inputs) is evaluated as follows:

$$\begin{aligned}
&\max \beta_t + \varepsilon \left( \sum_{k=1}^{p} s_k^b + \sum_{l=1}^{q} s_l^y \right) && (1)\\
&\text{s.t.} \sum_{j=1}^{n} b_{kj}\lambda_j = b_{kt} - \beta_t g_b - s_k^b, \quad k = 1, \ldots, p,\\
&\sum_{j=1}^{n} y_{lj}\lambda_j = y_{lt} + \beta_t g_y + s_l^y, \qquad l = 1, \ldots, q,\\
&\sum_{j=1}^{n} \lambda_j = 1, \qquad j = 1, \ldots, n,\\
&\lambda_j, s_k^b, s_l^y \geqslant 0,
\end{aligned}$$

where $y_{lj}$ are desirable outputs, $b_{kj}$ – undesirable outputs. The components of the vector $g = (-g_b, g_y)$ indicate the direction of change for the outputs, for particular values we use $g_b = b_{kt}$, $g_y = y_{lt}$. Positive value for the components is associated with the expansion of desirable outputs, and negative values are associated with the contraction of undesirable outputs. The slack variables $s_k^b$ and $s_l^y$ correspond to undesirable and desirable outputs, $\lambda_j$ are intensity variables. In our computations we use $\varepsilon = 10^{-4}$. The factor $\beta_t$ indicates the extent of the DMU's inefficiency. The effectiveness score for DMU $t$ under assessment is equal to $E_t = \frac{1}{1+\beta_t^*}$; $E_t \in [0; 1]$, here 1 indicates that the education system is effective.

Model for the measurement of effectiveness (1) uses the unitary level of inputs. For the measurement of efficiency, we added the negative values that are associated with the contraction of inputs and used $g = (-g_x, -g_b, g_y)$ which indicate a direction of change (with particular values $g_x = x_{it}$, $g_b = b_{kt}$, $g_y = y_{lt}$) for the inputs and outputs for the measurement of efficiency:

$$\begin{aligned}
&\max \beta_t + \varepsilon \left( \sum_{i=1}^{m} s_i^x + \sum_{k=1}^{p} s_k^b + \sum_{l=1}^{q} s_l^y \right) && (2)\\
&\text{s.t.} \sum_{j=1}^{n} x_{ij}\lambda_j = x_{it} - \beta_t g_x - s_i^x, \quad i = 1, \ldots, m,
\end{aligned}$$

$$\sum_{j=1}^{n} b_{kj}\lambda_j = b_{kt} - \beta_t g_b - s_k^b, \quad k = 1, \ldots, p,$$
$$\sum_{j=1}^{n} y_{lj}\lambda_j = y_{lt} + \beta_t g_y + s_l^y, \quad l = 1, \ldots, q,$$
$$\lambda_j, s_i^x, s_k^b, s_l^y \geqslant 0,$$

where $x_{ij}$ are the inputs used by DMU $t$ to produce desirable outputs $y_{lj}$ and undesirable outputs $b_{kj}$. The efficiency score for DMU $t$ under assessment is equal to $I_t = \frac{1}{1+\beta_t^*}$; $I_t \in [0;1]$, here 1 indicates that the education system is efficient.

To test the robustness of the measures for $E_t$ and $I_t$, we perform analyses on subsamples. This is done by evaluating measures of $E_t$ and $I_t$ excluding one of the DMU (country) from the models. The best scores reached for a DMU $t$ under assessment among sub-samples with each country excluded at a time is denoted by $E_t^r$ and $I_t^r$.

## 3 Data

In order to evaluate the efficiency and effectiveness of primary education from the perspective of equity, data of 15 EU member states, which took part in the IEA TIMSS 2015 and PIRLS 2016 international student achievement studies, have been used. TIMSS assesses mathematics and science achievements of fourth-grade students every four years, whereas PIRLS focuses on the reading achievement of fourth-grade students every five years. The data collected by these international assessments provide comparative information on student achievements in three main domains, as well as background information through a series of questionnaires. This information opens a way for the comparative analysis of equity in primary education.

The TIMSS and PIRLS assessments cover a wide range of topics in mathematics, science, and reading. A matrix-sampling booklet design is used such that each student gets only a subset of item pools. Given the need to report student achievement on a scale that represents the entirety of the assessment framework, TIMSS and PIRLS relied on Item Response Theory scaling to provide accurate measures of student proficiency distributions. To provide unbiased estimates of student achievement, the scaling approach is used to obtain plausible values that represent proficiency in mathematics, science, and reading for all students [17]. Therefore, the result is not expressed through a single score, but is provided through five plausible values for each student in each domain. Aparicio *et al.* [6] discuss the problematic use of output measures in efficiency studies that reflect a distribution of results instead of an exact score.

Most papers on the performance evaluation of education systems at the country level use the score in PISA or TIMSS as the output variable [32]. In order to evaluate efficiency and effectiveness of primary education from the perspective of equity, we considered the output indicators that reflect the equity dimension – ensuring that all students, regardless of their socioeconomic background, with equal opportunities can achieve learning success. The average variance of scores can be the measure of academic inequality. The standard deviation of PIRLS and TIMSS scores can explain how skills and knowledge are distributed in the student population. The standard deviation of the PISA scores was used by Gimenez *et al.* [20].

**Table 1.** Description of output and input indicators used in this study.

| Stage | Indicator | Symbol | Source | Year |
|---|---|---|---|---|
| Output | Standard deviation of PIRLS reading scores | SD(R) | IEA | 2016 |
| | Standard deviation of TIMSS math scores | SD(M) | IEA | 2015 |
| | Standard deviation of TIMSS science scores | SD(S) | IEA | 2015 |
| | Percentage of resilient students in PIRLS reading | Resil(R) | IEA* | 2016 |
| | Percentage of resilient students in TIMSS math | Resil(M) | IEA* | 2015 |
| | Percentage of resilient students in TIMSS science | Resil(S) | IEA* | 2015 |
| Input | Expenditure per 1,000 students in million euro in PPS | Expd | Eurostat | 2015 |
| | Ratio of teachers to 100 students | Ratio | Eurostat | 2015 |

*A student is resilient if they have a socioeconomic index below the first quartile in their country, and their performance in PIRlS 2016 or TIMSS 2015 is at a high or advanced benchmark (our calculations).

As mentioned above, large-scale assessments, such as TIMSS and PIRLS, provide comparative information not only on student achievements but also context information about students, families, and schools. Students acquire knowledge and competencies not only in school but also in their families; it can vary by socioeconomic background (low SES parents arguably have more limited resources to promote knowledge and competencies). The average impact of socioeconomic background on scores can be the measure of social inequality. The measure of the socioeconomic background in TIMSS and PIRLS as the index of home resources for learning was created by IEA based on students' and parents' responses to how many books are in the student's home; whether a student has an internet connection, and/or own room in the home; the highest occupation of either parent and the highest level of education of either parent.

According to this index, a student can be labelled as resilient if he or she have an index of home resources for learning below the first quartile in their country, and his or her performance is at a high or advanced benchmark (score is 550 points or more).[3] Resilient students are those who achieve academic success despite their disadvantaged home backgrounds. The percentage of resilient students in PIRLS and TIMSS can indicate SES-based inequality in primary education. Description of the output indicators used in this study is presented in Table 1.

In our selection of input, indicators were considered as education expenditure per student and student/teacher ratio. The measure of financial resources has been used [3, 8, 5], the student/teacher ratio has been used [9, 1, 2, 33, 4]. We measure education expenditure as the expenditure per 1,000 students in million of euros in PPS (purchasing power standards) in primary education. The indicator was calculated as the ratio between total educational expenditure in primary education (Eurostat) and students enrolled in this educational stage (Eurostat) and multiplied by 1,000. We measure the student/teacher ratio as the ratio of teachers to 100 students. This indicator was calculated as the inverse ratio of students and students to teachers (Eurostat) and multiplied by 100. Description of the input indicators used in this study is presented in Table 1.

Effectiveness and efficiency of primary education from the perspective of equity were assessed of 15 EU member states, which took part in the IEA TIMSS 2015 and

[3] Benchmarks: Low – between 400 and 475; Intermediate – between 475 and 550; High – between 550 and 625; Advanced—above 625.

**Table 2.** Descriptive statistics of output and input indicators.

| | Expd | Ratio | SD(M) | SD(S) | SD(R) | Resil(M) | Resil(S) | Resil(R) |
|---|---|---|---|---|---|---|---|---|
| Post-socialist EU member states | | | | | | | | |
| Average | 4.6 | 7.2 | 75.9 | 77.2 | 4.5 | 18.9 | 23.1 | 24.4 |
| Standard deviation | 1.5 | 1.9 | 7.5 | 10.5 | 6.4 | 6.7 | 6.8 | 7.3 |
| Maximum | 6.7 | 9.7 | 88.0 | 95.1 | 85.2 | 27.6 | 34.1 | 36.7 |
| Minimum | 2.2 | 5.3 | 68.7 | 68.9 | 68.0 | 6.5 | 12.7 | 16.1 |
| Old democracy EU member states | | | | | | | | |
| Average | 6.5 | 7.0 | 68.1 | 67.1 | 67.1 | 20.7 | 20.7 | 27.5 |
| Standard deviation | 0.7 | 0.9 | 5.7 | 5.1 | 5.2 | 8.9 | 10.2 | 9.3 |
| Maximum | 7.8 | 8.1 | 74.3 | 73.3 | 78.0 | 35.2 | 38.6 | 41.6 |
| Minimum | 5.7 | 5.3 | 56.0 | 60.1 | 59.8 | 7.8 | 6.7 | 13.8 |

PIRLS 2016 international student achievement studies: Bulgaria, Czechia, Finland, France, Germany, Hungary, Italy, Lithuania, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden. Data was extracted from EUROSTAT and IEA databases for 15 EU countries for the years 2015 and 2016. Table 2 shows the descriptive statistics of input and output indicators (the dataset used is presented in Table 4 in Appendix). Moreover, Tables 5 and 6 in Appendix present dataset of additional indicators, such as average index of home resources for learning score in PIRLS and TIMSS, average scores in reading, math, and science, as well as percentages of students reaching a high or advanced benchmark in these domains.

The larger average and smaller variation of expenditure are observed in old democracy EU member states compared to post-socialist countries. Sweden spends the largest amount of money per 1,000 students in primary education, three and a half times more than Bulgaria (Table 4). Expenditure per 1,000 students in primary education is high in Finland, Germany, Italy, Slovenia, and the Netherlands. In Bulgaria, there is an extremely low level of funding for primary education. Other post-socialist countries (Hungary, Czechia, and Lithuania) also have a low level of funding.

The average student/teacher ratio in primary education is slightly larger in post-socialist EU countries; however, a larger standard deviation indicates a more heterogeneous situation between post-socialist countries compared to old democracy EU member states. The highest student/teacher ratio in primary education is in Lithuania, while the lowest ratio is in Czechia and France.

The average standard deviation of PIRLS and TIMSS scores is lower in old democracy EU member states and indicates lower academic inequality in these countries compared to post-socialist EU countries. The lowest standard deviation of scores in all domains is observed in the Netherlands, while Portugal has the lowest standard deviation of scores in science. The highest standard deviation of scores in mathematics is in Hungary, while the highest standard deviation of scores in science and reading is in Bulgaria. The larger standard deviation of standard deviation in PIRLS and TIMSS scores is observed in post-socialist countries.

The average percentage of resilient students in mathematics and reading is in old democracy EU member states, while the average percentage of resilient students in science is larger in post-socialist EU countries. The Netherlands has the highest share of resilient students in mathematics, while Finland has the highest share of resilient students in science and reading. That indicates that more students, regardless of their socioeconomic background, can achieve learning success in these countries.

Meanwhile, France has the lowest share of resilient students in all domains, and Slovakia has the lowest share of resilient students in mathematics.

## 4 Results and Discussion

The previous section shows that human and financial resources vary widely among EU countries, as well as outputs of education systems. Reasons may be numerous: high or low social and economic conditions, different educational policies, or similar. This section presents the efficiency and effectiveness estimates of primary education in old democracy and post-socialist EU member states, which participated in the IEA TIMSS 2015 and PIRLS 2016 international student achievement studies.

Efficiency and effectiveness estimates, respectively $I_t$ and $E_t$ (as well as $I_t^r$ and $E_t^r$ for the robust version) at primary education were calculated as arithmetic average of efficiency and effectiveness estimates separately for PIRLS, TIMSS math and TIMSS science. Table 3 provides efficiency and effectiveness estimates with robustness checks to gauge the validity of the results obtained. Scores of efficiency and effectiveness (Fig. 1) are shown as error intervals starting from the core estimate pair $I_t$, $E_t$ and showing how much the scores are larger in the robust evaluation indicating $I_t^r - I_t$ as a horizontal interval and $E_t^r - E_t$ as a vertical interva. As defined in Section 2, estimates can vary from 0 to 1, where 1 indicates that the education system is efficient/effective.

Based on the results obtained, two clusters of countries can be observed: old democracy EU member states are laid out on the upper right side, while post-socialist countries are on the lower left side (Fig. 1). Post-socialist countries demonstrate higher efficiency with a lower level of effectiveness compared to old democracy EU member states. Most probably, a higher efficiency score is not the result of sophisticated policy measures, but limited financial possibilities of the post-socialist country.

**Table 3.** Obtained results of efficiency ($I_t$ and $I_t^r$) and effectiveness ($E_t$ and $E_t^r$). $E_t^r$ and $I_t^r$ – the best scores reached for a DMU $t$ under assessment among sub-samples with each country excluded at a time is denoted.

| | | $I_t$ | $I_t^r$ | $E_t$ | $E_t^r$ |
|---|---|---|---|---|---|
| Post-socialist EU member states | | | | | |
| Bulgaria | BGR | 1.00 | 1.00 | 0.77 | 0.84 |
| Czechia | CZE | 0.90 | 0.97 | 0.88 | 0.94 |
| Hungary | HUN | 0.80 | 0.89 | 0.79 | 0.83 |
| Lithuania | LTU | 0.87 | 0.94 | 0.86 | 0.93 |
| Poland | POL | 0.91 | 0.95 | 0.89 | 0.96 |
| Slovakia | SVK | 0.66 | 0.67 | 0.78 | 0.82 |
| Slovenia | SVN | 0.84 | 0.89 | 0.88 | 0.96 |
| Old democracy EU member states | | | | | |
| Finland | FIN | 0.96 | 1.00 | 0.95 | 1.00 |
| France | FRA | 0.63 | 0.64 | 0.84 | 0.90 |
| Germany | DEU | 0.80 | 0.86 | 0.86 | 0.93 |
| Italy | ITA | 0.78 | 0.83 | 0.91 | 0.95 |
| Netherlands | NLD | 0.89 | 0.93 | 1.00 | 1.00 |
| Portugal | PRT | 0.76 | 0.80 | 0.91 | 0.97 |
| Spain | ESP | 0.75 | 0.78 | 0.88 | 0.95 |
| Sweden | SWE | 0.81 | 0.88 | 0.89 | 0.95 |

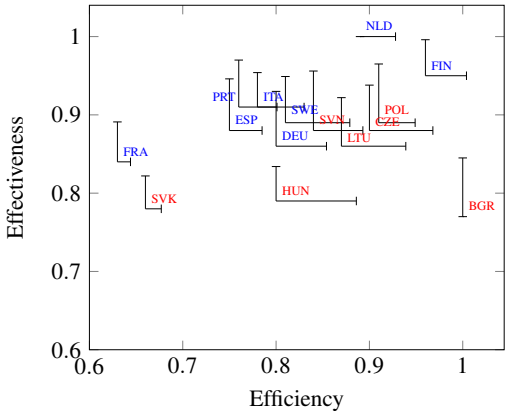


**Fig. 1.** Efficiency vs. effectiveness at primary education of EU countries. *The old democracy EU member states are in blue and the post-socialist countries are in red.*

The Netherlands and Finland are leaders in achieving a high level of effectiveness and efficiency in primary education. Despite the fact that in Finland general government education expenditure 2010–2017 in primary education fell below 2.8 percent and public expenditure per student as a percentage of per capita GDP is below other Nordic countries [14], the country retains a high reputation as one of the most equal societies in educational terms [26]. Finland is the only country where the proportion of low achievers is below 10 percent in the PIRLS 2016 survey. Finland also shows one of the lowest levels of academic segregation in reading literacy (PIRLS 2016) and mathematics (TIMSS 2015) in the fourth grade. The Netherlands has the smallest achievement gap between fourth-graders in the TIMSS 2015 survey in both reading literacy and mathematics [16].

Three post-socialist countries (Slovakia, Hungary, and Bulgaria) demonstrate the lowest effectiveness in terms of equity with different efficiency level (Fig. 1). The main problem groups in these countries seem to be Roma children and students who live in rural areas. Bulgaria appears to be more efficient than the other two countries due to the extremely low level of funding – the expenditure per capita in PPS (purchasing power standard) for the first level of ISCED is 2,274 euros compared to the EU average of 6,248 euros [13]. The education system in Bulgaria is efficient but not effective, which means that the country spends less than most of the other countries – participants of TIMSS 2015 and PIRLS 2016 studies – but the level of equity is low. One of the main groups at risk are the Roma children, which are less likely to attend kindergarten and much more likely to drop out of school [13].

Slovakia's spending expenditure per capita is more than twice compared to Bulgaria's – 5,193 euros in PPS. However, in addition to the international studies of TIMSS 2015 and PIRLS 2016, the national primary student testing of 2018 confirmed large differences in educational outcomes between districts and regions. Students from socially disadvantaged families achieved an average success rate of 22.9 percent in mathematics in these tests, against 60.9 percent among students without a social disadvantage. The grade repetition rate is 15 times higher among students from socially disadvantaged environments and marginalized Roma communities si-

multaneously, 14.9 percent against 1 percent among other students.[4] The education system of the country is not sufficiently inclusive: segregation of the Roma students seems to be a major problem in primary schools [15].

Efficiency score in primary education of Hungary stands in the middle of Slovakia and Bulgaria. Rado [29] notes that the Hungarian education system is very selective even at the point of entry to schooling. A large number of small schools not only opens wide the door to selective school choice, but also increases the quality gap between schools. Beyond the unequal distribution of pupils with different backgrounds around different schools, the selection also distributes all of the preconditions of a high quality education unevenly. One of the problem areas in Hungary is the segregation of Roma pupils. According to Rado [29], the most important indicator of the degree of segregation of Roma pupils is the proportion of ghetto schools (schools in which more than 50 percent of pupils are Roma). Proportion of Roma ghetto primary schools in Hungary increased from 10.9 percent in 2006 to 14.9 percent in 2016. One of the outcomes was the streaming of higher status pupils to "better" schools.

The present study could not reveal a full picture of equity among the EU member states in primary education due to the fact that some EU countries did not participate in TIMSS 2015 and PIRLS 2016 fourth grade student achievement studies and therefore could not be included in comparative analysis.

## 5 Conclusions

Research findings lead to the conclusion that old democracy and post-socialist EU member states that participated in the PIRLS 2016 and TIMSS 2015 studies move towards different positions for ensuring equity in primary education. Post-socialist countries demonstrate higher efficiency with a lower level of effectiveness compared to old democracy EU member states. However, post-socialist countries do not represent a single Central and Eastern European position for ensuring equity in primary education. Some of the post-socialist countries demonstrate high efficiency without achieving a high level of effectiveness. We assume that most probably efficiency is achieved not by any sophisticated policy measures, but just by limited financial possibilities of the post-socialist country.

The study also reveals cases in which both efficiency and effectiveness levels are low. Data signals that countries should review their policies of striving for equity to secure education possibilities for socially sensitive parts of the population. During the socialist period, dominant ideology declared the goal of creating an equitable society, and free universal access to education was considered as one of the means to achieve the goal. However, neoliberal post-socialist transformations did not consider equity issues as one of the reform priorities. Eventually, social segregation and minority education became one of the problem issues of the new EU member states. Apparently, policy makers in these countries have taken for granted the market-oriented educational discourse, promoted by neoliberally-oriented Western experts. The market approach in education envisages competition, which results in emerging differences between the "winners" and the "losers". The study reveals that equity in education is one of the key challenges faced not only by old western European democracies, but

[4] Spending review on groups at risk of poverty or social exclusion. Preliminary report: https://www.minedu.sk/data/att/14208.pdf.

also by countries that have a long-standing tradition of relatively equitable socialist education.

However, the old democracy EU member states do not follow the common policy framework to ensure equity in primary education. Two old democracy EU member states (the Netherlands and Finland) demonstrate that countries can be both effective and efficient in seeking equity. While France stands in the opposite corner and shows low levels of effectiveness and efficiency to ensure equity in primary education.

Although researchers in similar effectiveness and/ or efficiency studies often apply an input indicator of the student/teacher ratio, it appears to be problematic due to methodological differences. For example, in Lithuania, contrary to some other countries, support staff, such as teacher assistants or speech therapists, is not reflected in overall statistics. There are similar discrepancies in statistical data on full-time and part-time employees. An alternative option is to use a single input indicator – expenditure per student in PPS – assuming that it also includes costs of the teaching corps.

## Acknowledgements

This research is funded by the European Social Fund according to the activity "Improvement of researchers" qualification by implementing world-class R&D projects' of Measure No.09.3.3-LMT-K-712. The project No. DOTSUT-39 (09.3.3-LMT-K-712-01-0018) / LSS-250000-57.

## Appendix

**Table 4.** Dataset of output and input indicators.

| | Expd | Ratio | SD(M) | SD(S) | SD(R) | Resil(M) | Resil(S) | Resil(R) |
|---|---|---|---|---|---|---|---|---|
| Post-socialist EU member states | | | | | | | | |
| Bulgaria | 2.2 | 5.6 | 82.7 | 95.1 | 85.2 | 27.6 | 24.8 | 17.7 |
| Czechia | 4.0 | 5.3 | 69.9 | 69.7 | 68.0 | 18.3 | 22.7 | 28.7 |
| Hungary | 4.0 | 8.9 | 88.0 | 82.8 | 74.6 | 15.7 | 20.9 | 19.2 |
| Lithuania | 4.3 | 9.7 | 71.2 | 69.2 | 68.9 | 23.3 | 18.8 | 25.4 |
| Poland | 5.5 | 9.0 | 71.3 | 68.9 | 72.0 | 21.5 | 28.0 | 36.7 |
| Slovakia | 5.7 | 5.8 | 79.6 | 85.0 | 81.1 | 6.5 | 12.7 | 16.1 |
| Slovenia | 6.7 | 6.3 | 68.7 | 69.6 | 71.9 | 19.5 | 34.1 | 26.9 |
| Old democracy EU member states | | | | | | | | |
| Finland | 7.1 | 7.4 | 66.7 | 64.6 | 67.1 | 29.3 | 38.6 | 41.6 |
| France | 5.7 | 5.3 | 74.3 | 72.8 | 69.4 | 7.8 | 6.7 | 13.8 |
| Germany | 6.8 | 6.5 | 65.4 | 69.7 | 78.0 | 21.8 | 26.8 | 24.3 |
| Italy | 6.7 | 8.1 | 71.6 | 66.5 | 65.0 | 15.0 | 16.4 | 35.1 |
| Netherlands | 6.4 | 6.0 | 56.0 | 60.2 | 59.8 | 35.2 | 20.4 | 29.2 |
| Portugal | 5.7 | 7.3 | 72.5 | 60.1 | 65.2 | 25.3 | 10.6 | 20.1 |
| Spain | 6.0 | 7.3 | 69.2 | 69.3 | 65.1 | 14.2 | 18.3 | 21.0 |
| Sweden | 7.8 | 7.8 | 69.1 | 73.3 | 67.1 | 17.0 | 27.7 | 34.6 |

Expd – expenditure per 1,000 students in million euro in PPS; Ratio – ratio of teachers to 100 students; SD(R/M/S) – standard deviation of PIRLS reading/ TIMSS math/ TIMSS science scores; Resil(R/M/S) – percentage of resilient students in PIRLS reading/ TIMSS math/ TIMSS science.

**Table 5.** Additional dataset of PIRLS 2016 international student achievement study for each analysed country.

| | *N* | Index | S.E. | Score | S.E. | High | S.E. |
|---|---|---|---|---|---|---|---|
| Post-socialist EU member states | | | | | | | |
| Bulgaria | 4,281 | 9.8 | (0.09) | 552 | (4.2) | 55 | (2.2) |
| Czechia | 5,537 | 10.5 | (0.05) | 543 | (2.1) | 49 | (1.3) |
| Hungary | 4,623 | 10.6 | (0.09) | 554 | (2.9) | 56 | (1.7) |
| Lithuania | 4,317 | 10.2 | (0.05) | 548 | (2.6) | 52 | (1.6) |
| Poland | 4,413 | 10.4 | (0.05) | 565 | (2.1) | 61 | (1.3) |
| Slovakia | 5,451 | 10.1 | (0.05) | 535 | (3.1) | 47 | (1.4) |
| Slovenia | 4,499 | 10.6 | (0.04) | 542 | (2.0) | 49 | (1.3) |
| Old democracy EU member states | | | | | | | |
| Finland | 4,896 | 11.2 | (0.03) | 566 | (1.8) | 62 | (1.3) |
| France | 4,767 | 10.6 | (0.05) | 511 | (2.2) | 30 | (1.3) |
| Germany | 3,959 | 10.8 | (0.06) | 537 | (3.2) | 47 | (1.4) |
| Italy | 3,940 | 9.7 | (0.05) | 548 | (2.2) | 52 | (1.7) |
| Netherlands | 4,206 | 11.0 | (0.05) | 545 | (1.7) | 48 | (1.3) |
| Portugal | 4,642 | 10.1 | (0.05) | 528 | (2.3) | 38 | (1.3) |
| Spain | 14,595 | 10.3 | (0.04) | 528 | (1.7) | 39 | (0.9) |
| Sweden | 4,525 | 11.4 | (0.05) | 555 | (2.4) | 57 | (1.6) |

*N* – number of students assessed; Index – average index of home resources for learning score; Score – average score; High – percentages of students reaching a high or advanced benchmark (score is 550 points or more).

**Table 6.** Additional dataset of TIMSS 2015 international student achievement study for each analysed country.

| | *N* | Index | S.E. | Score(M) | S.E. | High(M) | S.E. | Score(S) | S.E. | High(S) | S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Post-socialist EU member states | | | | | | | | | | | |
| Bulgaria | 4,228 | 9.4 | (0.1) | 524 | (5.3) | 40 | (2.6) | 536 | (5.9) | 50 | (2.5) |
| Czechia | 5,202 | 10.5 | (0.0) | 528 | (2.2) | 38 | (1.4) | 534 | (2.4) | 43 | (1.4) |
| Hungary | 5,036 | 10.4 | (0.1) | 529 | (3.2) | 44 | (1.5) | 542 | (3.3) | 50 | (1.5) |
| Lithuania | 4,529 | 10.2 | (0.1) | 535 | (2.5) | 44 | (1.5) | 528 | (2.5) | 39 | (1.6) |
| Poland | 4,747 | 10.4 | (0.0) | 535 | (2.1) | 44 | (1.4) | 547 | (2.4) | 51 | (1.4) |
| Slovakia | 5,773 | 10 | (0.1) | 498 | (2.5) | 26 | (1.1) | 520 | (2.6) | 40 | (1.4) |
| Slovenia | 4,445 | 10.7 | (0.1) | 520 | (1.9) | 34 | (1.4) | 543 | (2.4) | 49 | (1.4) |
| Old democracy EU member states | | | | | | | | | | | |
| Finland | 5,015 | 11.2 | (0.1) | 535 | (2.0) | 43 | (1.3) | 554 | (2.3) | 54 | (1.4) |
| France | 4,873 | 10.6 | (0.1) | 488 | (2.9) | 21 | (1.3) | 487 | (2.7) | 20 | (1.2) |
| Germany | 3,948 | 10.5 | (0.1) | 522 | (2.0) | 34 | (1.3) | 528 | (2.4) | 40 | (1.7) |
| Italy | 4,373 | 9.6 | (0.1) | 507 | (2.6) | 28 | (1.3) | 516 | (2.6) | 32 | (1.5) |
| Netherlands | 4,515 | : | : | 530 | (1.7) | 37 | (1.3) | 517 | (2.7) | 30 | (1.5) |
| Portugal | 4,693 | 9.9 | (0.1) | 541 | (2.2) | 46 | (1.3) | 508 | (2.2) | 25 | (1.2) |
| Spain | 7,764 | 10.4 | (0.1) | 505 | (2.5) | 27 | (1.1) | 518 | (2.6) | 34 | (1.3) |
| Sweden | 4,142 | 11.3 | (0.1) | 519 | (2.8) | 34 | (1.6) | 540 | (3.6) | 47 | (2.1) |

*N* – number of students assessed; Index – average index of home resources for learning score; Score(M/S) – average score of math/science; High(M/S) – percentages of students reaching a high or advanced benchmark (score is 550 points or more) in math/science assessment.

## References


[1] A. Afonso, M.St. Aubyn. Non-parametric approaches to education and health expenditure efficiency in the OECD. Mimeo, 2003.

[2] A. Afonso, M.St. Aubyn. Cross-country efficiency of secondary education provision: a semi-parametric analysis with non-discretionary inputs. *Econ. Model.*, **23**(3):476–491, 2006.

[3] T. Agasisti. Performances and spending efficiency in higher education: a European comparison through non-parametric approaches. *Educ. Econ.*, **19**(2):199–224, 2011.

[4] T. Agasisti. The efficiency of public spending on education: an empirical comparison of EU countries. *Eur. J. Educ.*, **49**(4):543–557, 2014.

[5] T. Agasisti, R. Hippe, G. Munda. Efficiency of investment in compulsory education: empirical analyses in Europe. Technical report, Joint Research Centre (Seville site), 2017.

[6] J. Aparicio, J.M. Cordero, L. Ortiz. Plausible values and their use in efficiency analyses with educational data. *Appl. Econ.*, **54**(29):3340–3352, 2022.

[7] M. Beblavy, A.-E. Thum, M. Veselkova. *Education Policy and Welfare Regimes in OECD Countries: Social Stratification and Equal Opportunity in Education*. 2011.

[8] P. Bogetoft, E. Heinesen, T. Tranæs. The efficiency of educational production: a comparison of the Nordic countries with other OECD countries. *Econ. Model.*, **50**:310–321, 2015.

[9] B. Clements. How efficient is education spending in Europe? *Eur. Rev. Econ. Finance*, **1**(1):3–26, 2002.

[10] W.W. Cooper, L.M. Seiford, K. Tone. *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, volume 2. Springer, 2007.

[11] W.W. Cooper, L.M. Seiford, J. Zhu. *Handbook on Data Envelopment Analysis*. Springer Science & Business Media, 2011.

[12] European Commission. *Rethinking education: investing in skills for better socio-economic outcomes*. European Commission Strasbourg, 2012.

[13] European Commission. *Education and training monitor 2019. Bulgaria.* Publication Office of the European Union, Luxembourg, 2019.

[14] European Commission. *Education and training monitor 2019. Finland.* Publication Office of the European Union, Luxembourg, 2019.

[15] European Commission. *Education and training monitor 2019. Slovakia.* Publication Office of the European Union, Luxembourg, 2019.

[16] European Commission, EACEA and Eurydice. *Structural indicators for monitoring education and training systems in Europe – 2020: Overview of major reforms since 2015. Eurydice Report.* Publication Office of the European Union, Luxembourg, 2020.

[17] P. Foy, B. Fishbein, M. von Davier, L. Yin. Implementing the TIMSS 2019 scaling methodology. *Methods and Procedures: TIMSS*, pp. 12–1, 2019.

[18] F. Giambona, E. Vassallo, E. Vassiliadis. Educational systems efficiency in European Union countries. *Stud. Educ. Eval.*, **37**(2-3):108–122, 2011.

[19] V. Giménez, D. Prior, C. Thieme. Technical efficiency, managerial efficiency and objective-setting in the educational system: an international comparison. *J. Oper. Res. Soc.*, **58**(8):996–1007, 2007.

[20] V. Giménez, C. Thieme, D. Prior, E. Tortosa-Ausina. An international comparison of educational systems: a temporal analysis in presence of bad outputs. *J. Product. Anal.*, **47**(1):83–101, 2017.

[21] V. Giménez, C. Thieme, D. Prior, E. Tortosa-Ausina. Comparing the performance of national educational systems: inequality versus achievement? *Soc. Indic. Res.*, **141**(2):581–609, 2019.

[22] B. Golany, E. Tamir. Evaluating efficiency-effectiveness-equality trade-offs: a Data Envelopment Analysis approach. *Manage Sci.*, **41**(7):1172–1184, 1995.

[23] E.A. Hanushek, J.A. Luque. Efficiency and equity in schools around the world. *Econ. Educ. Rev.*, **22**(5):481–502, 2003.

[24] G.M. Hega, K.G. Hokenmaier. The welfare state and education: a comparison of social and educational policy in advanced industrial societies. *German Policy Studies*, **2**(1):143–173, 2002.

[25] L. Kyriakides, B.P.M. Creemers. Can schools achieve both quality and equity? Investigating the two dimensions of educational effectiveness. *J. Educ. Stud. Plac. Risk (JESPAR)*, **16**(4):237–254, 2011.

[26] OECD. *Equity in Education: Breaking Down Barriers to Social Mobility*. OECD Publications, Paris, 2018.

[27] Y.A. Ozcan. *Health Care Benchmarking and Performance Evaluation*. Springer, 2008.

[28] T. Peter, J.D. Edgerton, L.W. Roberts. Welfare regimes and educational inequality: a cross-national exploration. *Int. Stud. Sociol. Educ.*, **20**(3):241–264, 2010.

[29] P. Radó. Social selection in education: the wider context of the segregation of roma pupils in hungary. *CEU Center for Policy Studies. CPS Working Papers*, **4**, 2020.

[30] I. Silova. *Rediscovering Post-Socialism in Comparative Education*. Emerald Group Publishing Limited, 2010.

[31] A.A. Šonje, M. Deskar-Škrbić, V. Šonje. Efficiency of public expenditure on education: comparing Croatia with other NMS. In *12th Annual International Technology, Education and Development Conference*, 2018.

[32] D. Stumbriene, A.S. Camanho, A. Jakaitiene. The performance of education systems in the light of Europe 2020 strategy. *Ann. Oper. Res.*, **288**(2):577–608, 2020.

[33] D. Sutherland, R. Price, F. Gonand. Improving public spending efficiency in primary and secondary education. *OECD J. Econ. Stud.*, **2009**(1):1–30, 2010.

[34] C. Thieme, V. Giménez, D. Prior. A comparative analysis of the efficiency of national education systems. *Asia Pac. Educ. Rev.*, **13**(1):1–15, 2012.

[35] L. Volante, S. Schnepf, J. Jerrim, D. Klinger. *Socioeconomic Inequality and Student Outcomes*, volume 4 of *Education Policy & Social Inequality*. 2019.

[36] L. Žalimienė, R. Lazutka, D. Skučienė, J. Aidukaitė, J. Kazakevičiūtė, J. Navickė, V. Ivaškaitė-Tamošiūnė. *Socialinis teisingumas švietime: teorinė samprata ir praktinis vertinimas*. Švietimo aprūpinimo centras, Vilnius, 2011.

[37] A. Zanella, A.S. Camanho, T.G. Dias. Undesirable outputs and weighting schemes in composite indicators based on Data Envelopment Analysis. *Eur. J. Oper. Res.*, **245**(2):517–530, 2015. https://doi.org/10.1016/j.ejor.2015.03.036.

REZIUMĖ

**Efektyvumo ir našumo vertinimas pradiniame ugdyme naudojant PIRLS ir TIMSS duomenis**

*D. Stumbrienė, R. Želvys, J. Žilinskas, A. Jakaitienė*

Straipsnyje pristatomi ES šalių pradinio ugdymo efektyvumo ir našumo vertinimo rezultatai, remiantis švietimo lygybės aspektu. Šis aspektas buvo analizuotas tik keliuose švietimo našumo tyrimuose. Šio tyrimo tikslas – įvertinti ES šalių, kurios dalyvavo IEA TIMSS 2015 ir PIRLS 2016 tyrimuose, pradinio ugdymo efektyvumą ir našumą, remiantis švietimo lygybės aspektu. Švietimo našumo modelis yra paremtas indėlių ir rezultatų santykio modeliavimu, aprašant gamybinę švietimo funkciją. Švietimo našumo tyrimuose empirinis našumo įvertis dažniausiai apskaičiuojamas naudojant neparametrinį metodą – duomenų apgaubties analizę. Šiame tyrime išteklių rodikliais pasirinktos švietimo išlaidos ir mokinių–mokytojų santykis, o rezultatų rodikliais – mokinių pasiekimų standartinis nuokrypis ir socialiai atsparių mokinių dalis TIMSS 2015 ir PIRLS 2016 tyrimuose. Mokinių pasiekimų standartinis nuokrypis nurodo, kaip mokinių akademiniai įgūdžiai ir žinios pasiskirsto tarp šalies mokinių. Šis rodiklis naudojamas akademinei nelygybei pradiniame ugdyme identifikuoti. Socialiai atsparių mokinių dalis nurodo, kokią įtaką mokinio priklausymas socialiai jautriai grupei daro jo akademiniams pasiekimams. Šis rodiklis naudojamas socialinei nelygybei pradiniame ugdyme identifikuoti. Pagrindinis skirtumas tarp našumo ir efektyvumo vertinimo yra tai, kad skaičiuojant efektyvumo įvertį, vertinami tik rezultatų rodikliai, neatsižvelgiant į išteklių rodiklius. Atlikto empirinio tyrimo rezultatai rodo, kad ES šalys nesivadovauja bendra politika, užtikrindamos pradinio ugdymo lygybę savo šalyse. Kai kurios šalys pasižymi aukštu efektyvumo ir našumo lygiu, tačiau yra ir tokių šalių, kuriose ir efektyvumo lygis, ir našumo lygis yra žemi. Tyrimo rezultatai patvirtino hipotezę, kad postsocialistinėms šalims būdingas gana aukštas našumo lygis, tačiau gana žemas efektyvumo lygis, užtikrinant lygybę pradiniame ugdyme.

*Raktiniai žodžiai*: efektyvumas; našumas; lygybė; ES šalys; duomenų apgaubties analizė