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ASSESSMENT OF PUBLIC EDUCATION EXPENDITURE EFFICIENCY ACROSS LITHUANIAN MUNICIPALITIES

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Abstract

Efficiency of education expenditure is the ability to maximize the educational achievement given the resources invested. Although public education expenditure tends to increase, yet this does not necessarily guarantee high quality of education services. This study aims to assess public education expenditure efficiency of Lithuanian municipalities and to identify the factors explaining its variations. The study used data for 2013-2019 from 60 Lithuanian municipalities. Corrected Ordinary Least Squares method was employed for public education expenditure efficiency assessment and regression analysis was used to determine its influencing factors. Inputs included financial (public expenditure for education and maintenance) and nonfinancial (composition of teachers, occupied area, etc.) variables. Passing ratio of Lithuanian (national) language and math exams were used as efficiency outputs. The context variables represented environmental factors of educational achievements, such as number of business entities, users of social housing, libraries, and culture centres as well as municipalities' overall financial autonomy. Results of the research are ambiguous. When assessed by the overall passing of the exams, the efficiency was high, scoring 86-90%. But when evaluated by passing exams with the highest scores, it did not even reach 40%. Two types of public expenditure were identified as the most influential factors - public expenditure for education with the negative trend, and municipality own financing with the positive influence on the public education expenditure efficiency. Such results support the decentralization of public education expenditure management and call for alternative output measures in the Lithuanian public education system.

JEL classification: D61, H75, I22

Keywords: Public Expenditure Efficiency; Expenditure on Education; Municipal Finances

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Introduction

Education is one of the key areas where public resources are allocated. As a result, an efficient use of such resources is expected, which subsequently should yield sustainable outcomes, such as economic growth or wealth accumulation. Economic growth-related research (Afonso & St. Aubyn, 2005) proved a positive education impact on economic growth. In addition to the economic effects associated with education there are notable non-economic benefits (Gavurov et al., 2017), such as improved life-satisfaction and happiness, health, and life expectancy. A systematic literature review conducted by Benos and Zotou (2014) across 989 previous studies documented generally positive effect of education on gross domestic product (GDP). Interestingly, a study by Coman et al. (2023) on the effect of education on GDP across Central and Eastern European countries concluded on the lack of long-term cointegration between those two variables in Lithuania. This suggests that although Lithuania allocates relatively sufficient funding to sustain its education system, outputs of the education are lower than those of other countries. Moreover, since 2008, European countries have experienced a decrease in public education financing as a percentage of their GDP and Lithuania is among the three European Union countries with the greatest decrease, at 1.5% over the last 15 years. According to Eurostat in 2019 public education expenditure (excluding early childhood) relative to GDP in Lithuania was 3.8%, compared to 4.43% in Latvia (data for Estonia is not available), 4.67% in Poland, 4.5 % in the Czech Republic and an average of 4.76% for all European Union countries (see: Coman et al., 2023) for further analysis of public education spending in Central and Eastern Europe and its effect on gross domestic product).

In light of decreasing financing, to maintain or even increase educational attainments, such as graduation exam passing rate and scores, Lithuania must employ their limited financial resources more effectively. A study by the Organization for Economic Cooperation and Development (OECD, 2017) on the Lithuanian educational system, among other aspects, also recommended that to improve the quality of higher education and to achieve efficiency of public expenditure a comprehensive consolidation of public higher education is needed. Actions are needed not only on a national but more importantly on a municipal level. An analysis of the Lithuanian education system (Municipal Debt Restructuring, 2020) revealed that even with the same public financing policy, educational attainments differ significantly across different municipalities. For example, Lithuanian municipalities differ significantly in education expenditure per student and hourly rate of a teacher. This suggests that some local units are managing their educational funds more efficiently than others and it is likely that higher efficiency is influenced by municipality-specific variables, such size and availability of cultural and educational infrastructure, municipality economic development and financial autonomy, etc. Therefore, it is not only relevant to assess the level of public expenditure efficiency but also to identify the variables that contribute to the success of the municipalities. By recognizing the factors that lead to better educational outcomes, other municipalities can replicate their success, and ensure that the decreasing resources are allocated wisely.

The aim of the research was to assess public education expenditure efficiency of Lithuanian municipalities and to identify the factors explaining efficiency variations among the municipalities. The research used data from 60 Lithuanian municipalities and covered the period of 2013-2019. Corrected Ordinary Least Squares (COLS) method was employed to assess the efficiency of education expenditure across Lithuanian municipalities while regression analysis identified statistically significant factors explaining the efficiency variations among the municipalities.

The article is structured as follows. The first section reviews the literature on public education expenditure and its efficiency assessment. The second section firstly overviews the Lithuanian education system and then describes research methods for the evaluation of public education expenditure efficiency across Lithuanian municipalities and its influencing factors, presents the research sample and limitations. The third section provides the research results while the fourth section discusses our findings and their implications. The fifth section concludes the study.

Literature review

Efficiency of public education expenditure

There is a large number of studies analysing the efficiency of public spending with rather diverse methods, data, and scope (Arias-Ciro, 2020). However, theoretical guidance of education efficiency has been relatively limited, and the term is not uniformly defined (Kosor, 2013). Only recently have a few reviews summarizing findings of previous research been published (De Witte & Lopez-Tores, 2017, Arias-Ciro, 2020). In most of the studies education efficiency is estimated by linking inputs of the education system with its outputs aiming to assess whether the education system makes the best possible use of the resources (De Witte & Lopez-Tores, 2017). Although efficiency assessment seems to have a common approach, the complexity, and specifics of education systems across countries, differences in socio-economic, political, and other fac-

tors result in a wide variety of inputs, outputs and assumptions used. At local government level (which is still under-researched) efficiency measurement with the selection of variables is even more complex task, due to the difficulty in collecting data and measuring local services (Balaguer-Coll et al., 2013).

Education efficiency related studies commonly concentrate either on allocative or on technical efficiency evaluation. Allocative efficiency is assessed by exploring how the composition of resources should at a given expenditure level be reallocated to expand the level or quality of educational services. Technical efficiency is seen as the extent to which the education system could expand its activities without engaging additional resources, or, vice versa, how much the resources could be contracted without reducing the activities or their quality level (Blank, 2000). Gimenez et al. (2017) also emphasize the importance of social-economic conditions in each assessed country.

In this paper we concentrate on technical efficiency and define it similarly to Gavurova et al. (2017) as maximizing the educational outcomes given the resources available in the educational system and considering the social-economic conditions of the area (municipalities in our case).

Review of previous research

Education expenditure efficiency has been explored at various teaching levels (i.e., primary, high or higher education) and geographical regions. As discussed by Agasisti and Zoido (2018), most of the studies focus on OECD countries or specific country groups characterized by similar socio-economic environment and availability of comparable data. Leading researchers in across-country studies are Afonso (2005a, 2005b, 2006, 2010, 2013) and Agasisti (2014, 2018, 2019) who conducted multiple studies assessing public education efficiency in Europe, OECD countries or in international setting. Miningou (2019) explored quality of education and the efficiency of public expenditure in 130 countries, Cordero et al. (2018) in 36 countries participating in Programme for International Student Assessment (PISA), Prasetyo and Zuhdi (2013) in 81 countries, Aristovnik (2013) conducted research in Eastern Europe while Gavurova et al. (2017) used secondary data of PISA and governmental spending to assess public education efficiency across European countries. Comparative research on education expenditure efficiency differences across countries commonly relies on inputs and outcomes of education systems provided in world educational databases, which then may be used as a benchmark and provide valuable information for national education policies (Hužvar & Rigova, 2016).

The empirical literature also contains studies that assess efficiency of education expenditure of a specific-country or its region (Table 1 in Appendix). For instance, Tu et al. (2018) evaluated efficiency of preschool education and its influencing factors in 31 provinces of China. Melo-Becerra et al. (2020) estimated the local efficiency of the public expenditure of education in Colombia estimating disperse variations in efficiency levels (between 26% and 98%). Wanke et al. (2021) explored the relationship between efficiency measures in the education production function and various official managerial indicators used in Brazil. Kutlar et al. (2012) conducted an analysis on the economic effectiveness of 27 municipalities in Turkey, which also included efficiency of public education. Solihin et al. (2005) analysed the efficiency and effectiveness of local government expenditure on the education sector in 28 districts of East Java. Blackburn et al. (2014) applied the public sector Data Envelopment Analysis (DEA) model to estimate the efficiency of 1650 primary and 400 secondary schools in New South Wales (Australia) estimating a moderate level (approximately 82%) expenditure efficiency, while Wanke et al. (2016) extended analysis of this region applying a two-stage network DEA model. Surprisingly, there is very little research assessing the efficiency of education expenditure of individual European countries. Vitek and Martinkova (2015) used a set of effectiveness and efficiency variables and analysed descriptive statistics of primary education in the Czech Republic. Kyriakides et al. (2019) explored efficiency of educational investments across all public schools in Cyprus. Aparicio et al. (2018) explored main drivers of productivity changes at especially vulnerable public schools in Catalonia during the period of global financial crisis (years 2009-2013), Scippacercola and Ambra (2014) analysed the situation in secondary schools of the Cambria region.

Studies based on a single country commonly use school-level or municipality-level data, employing more diverse methods beyond just DEA (e.g. multilevel regression analysis and discriminant function analysis by Kyriakides et al., 2019 or Hicks-Moorsteen index by Aparicio et al., 2018). When it comes to the inputs, educational expenditure per student stands out as the most frequently used metric (Blackburn et al., 2014; Aparicio et al., 2018; Vitek & Martinkova, 2015; Kutlar et al. 2012; Aristovnik, 2013; Arias & Torres, 2017). Among the non-financial inputs, number of teachers per student (Aparicio et al., 2018; Kutlar et al., 2012; Scippacercola & Ambra, 2014), investments in premises (Tu et al., 2018) and occupied area related measures (Scippacercola & Ambra, 2014; Kyriakides et al., 2019) are the most commonly used. Local administrative units-related research usually relies on results of national exams as output variables (see: Table 1) in contrast to standardized international tests (e.g. PISA used for across country analysis). As discussed by Wanke et

al. (2016) several studies have also provided supportive evidence that efficiency of public education is affected by contextual variables, such as school type, teacher characteristics and family characteristics (e.g. Scippacercola & D'Ambra, 2014). In the assessment of the efficiency of higher education within a single country/region, studies tend to focus on understanding the drivers of higher efficiency levels in terms of costs (expenditures, funds, resources, etc.) and learning (academic achievement, etc.) (Wanke et al., 2016). Depending on the method used, the actual level of efficiency may be reported as a ratio (Melo-Becerra et al., 2020; Blackburn et al., 2014) or assessed within a contextual framework (Wanke et al., 2016; Solihin et al., 2005). Review of previous studies highlights that a lack of comparable time series data is the key constraint for single country-studies. Moreover, the variety of input and output variables and research methods used makes it challenging to compare their results directly. Nevertheless, such studies bring valuable policy implications, empowering policymakers to make supported decisions and implement targeted reforms.

Building on the findings of previous studies within the aim of this study we hypothesize that:

H_1: The efficiency level of higher education expenditure is moderate.

H_2: Financial inputs have a statistically significant and positive effect on the efficiency of public education.

H_3: Non-financial inputs have a statistically significant and positive effect on the efficiency of public education.

Research methodology

Overview of the Lithuanian education system

Lithuanian educational institutions are divided into public (state/municipal) and private schools, which could be either partially financed by the state or fully self-financed. This study covers state/municipal primary schools, secondary-education schools and gymnasiums (thereafter referred to as public high schools). Public high schools are in every municipality, and have the same financing model, constituting a comparable sample.

In Lithuania, higher education is publicly funded at all levels, achieved through state donations. Two types of funds—educational funds and maintenance funds—are available for public high school financing. Under the current system, the main part of educational funds is allocated to a class (as a teaching unit), so the amount of funding received by a school depends on the number of classes in that school, but not on the number of students in the class. Number of students in a class depends on the population density in the region (therefore it is higher in the cities) and popularity of the school. A much smaller part of educational funds referred to as expenditure for other teaching needs (educational support, management, and teaching tools) is allocated per student, so the funding received by a school is dependent on the number of students in a class. Maintenance-related expenditure must be covered by the school's owner, which in the case of public high schools is the municipality.

Method for public education efficiency assessment

Various non-parametric or parametric estimation techniques for public education expenditure efficiency measurement were used in previous research (Haelermans & Ruggiero, 2013). Data Envelopment Analysis (DEA) is the most popular non-parametric method widely used at all education levels, while Stochastic Frontier Analysis (SFA) and Corrected Ordinary Least Squares (COLS) are two the mostly used parametric methods (Baba et al., 2021). DEA method is one of the most popular methods (Blackburn et al., 2014; Prasetyo & Zuhdi, 2013; Gavurova et al., 2017; Agasisti & Zoido, 2018; Mota & Meza, 2020) because it allows analysing of multiple inputs, and outputs and does not require a specific functional form (Lampe & Hilgers, 2015). However, as it is discussed by Cook et al. (2014) using DEA may have some issues if selected variables are mixed and expressed in different ways: percentages, indexes or remaining raw. Differently from the non-parametric methods, SFA is not deterministic but a stochastic model, which is usually preferred because of its ability to differentiate between inefficiency and noise (Scippacercola & Ambra, 2014; Muvawala & Hisali, 2012; Miningou, 2019). Use of traditional SFA requires use of multiple inputs or outputs and applying a specific functional form (Lampe & Hilgers, 2015). SFA also has limitations as it requires specific assumptions about the distribution of the error term, and independence between the inefficiency and random error (Gomez-Deniz & Perez-Rodriguez, 2017). In our study we chose to use the COLS method. Similar to DEA, it is a deterministic approach, meaning that no statistical noise is allowed in the model; it is also parametric as SFA (Narbon-Perpina & De Witte, 2018), which determines the frontier based on a specific functional form using econometric techniques. COLS method is defined as a shifted average function which requires two main steps: to estimate the error term and then to shift the frontier up by the amount of the largest residual (Vasanthi et al., 2017). COLS method is more suitable for smaller datasets (Alarenan et al., 2019) which is relevant for Lithuania since the dataset is relatively small and the selected variables are expressed at different scales. The usage of the parametric methods also allows for choosing the functional form of function between the more restricted Cobb-Douglas and the most

frequently used functional form in efficiency analysis – translog (Lampe & Hilgers, 2015). In our study, the more flexible log-linear function was used and equations referring to Vasanthi et al. (2017) and Alarenan et al. (2019) were applied.

The first step in COLS application involved estimation of the residuals using equation (1).

$$lnER_{i,t} = \beta_0 + \beta_1 \bullet lnME_{i,t} + \beta_2 \bullet lnEE_{i,t} + \beta_3 \bullet lnTT_{i,t} + \beta_4 \bullet YT_{i,t} + \beta_5 \bullet lnTA_{i,t} + \beta_6 \bullet lnLA_{i,t} + \beta_7 \bullet lnFP_{i,t} + \beta_8 \bullet lnSP_{i,t} + \theta_t + \varepsilon_{i,t} \quad (1)$$

where ER defines the output measure in municipality i at year t (exam results), $Me_{i,t}$ – school maintenance expenditure in thousand euros, $EE_{i,t}$ – educational expenditure in thousand euros, $TT_{i,t}$ – teachers per pupil, $YT_{i,t}$ – part of young teachers, %, $TA_{i,t}$ – total school area in square meters, $LA_{i,t}$ – learning area in square meters, $FB_{i,t}$ – part of foreign pupils, %, $SP_{i,t}$ – part of pupils with special needs, % in municipality i at year t. β_0 is an intercept, β_1 - β_8 regression coefficients, θ_t – time dummies, $\varepsilon_{i,t}$ – idiosyncratic error.

The second step estimated the maximum residual using equation (2).

$$\varepsilon_{\max} = \max(\varepsilon_{i,t}) \quad (2)$$

Then the new COLS intercept was estimated by using equation (3).

$$b_{COLS} = b_0 + \varepsilon_{\max} \quad (3)$$

Finally, the efficiency coefficients were estimated by using equation (4).

$$E_{it} = \exp(-b_{COLS}) \quad (4)$$

where E_{it} are estimated efficiency coefficients in municipality i at year t, which values lie between 0 and 1, meaning the higher value associated with higher efficiency.

Methods for identification of efficiency determinants

The second objective of the paper was to identify whether and which intrinsic variables (the inputs of efficiency model) as well as other variables (controls) affect the public education expenditure efficiency in municipalities. For that purpose, equation (5) was applied.

$$lnE_{i,t} = \beta_0 + \beta_1 \bullet lnOF_{i,t} + \beta_2 \bullet lnSH_{i,t} + \beta_3 \bullet lnBE_{i,t} + \beta_4 \bullet lnLB_{i,t} + \beta_5 \bullet lnCC_{i,t} + \theta_t + \varepsilon_{i,t} \quad (5)$$

where $E_{i,t}$ defines the efficiency in municipality i at year t, $OF_{i,t}$ – municipalities own funds measured as a part of all income, %, $SH_{i,t}$ - individuals who were on lists for social housing per 1 thousand inhabitants, $BE_{i,t}$ - the number of business entities per 1 thousand inhabitants, $LB_{i,t}$ - the number of libraries per 1 thousand inhabitants, $CC_{i,t}$ - the number of culture centres per 1 thousand inhabitant, β_0 is an intercept, β_1 - β_5 regression coefficients, θ_t – time dummies, $\varepsilon_{i,t}$ – idiosyncratic error.

To test the validity of OLS models Breusch-Pagan heteroscedasticity test and Wooldridge serial correlation test were performed for all models. The main validity testing results are presented along with the results of our models, while more detailed information can be presented upon request.

Research variables

Research variables used in this study are summarized in Table 2 along with their descriptive statistics.

Outputs. In line with the previous research, we chose to use graduation exam passing rates and scores as the output measures. In this study two exams (Mathematics and Lithuanian language) were chosen and two output measures for each exam were used – overall exam passing ratio - MEP (mathematics exam pass) and LEP (Lithuanian exam pass) and exam passing with the highest score ratio (86-100 out of 100) – namely, MEP86-100 and LEP86-100.

Inputs chosen for our analysis represent two financial and six qualitative inputs. Education expenditure (EE) is measured in euros per student and represents national transfers to the schools (through municipality budgets) for educational purposes (e.g. for teaching staff salaries). This type of funding, as explained above, is allocated to schools according to the predetermined formula based on the number of classes in a school except for schools with foreign speaking pupils and pupils with special needs (then more funds are allocated). The level of public financing differs considerably across separate municipalities ranging from 274.78 Euro per pupil to as high as 3742.9 Euro per pupil, with standard deviation of 271.52 Euro per pupil.

Table 2: Descriptive statistics of research variables

Variables		Min	Max	Mean	St. dev.
Output					
E	LEP, %	62.50	100.00	89.03	5.37
	LEP 86-100, %	0.00	60.00	9.37	4.92
	MEP, %	56.90	100.00	87.48	7.39
	MEP 86-100, %	0.00	23.33	6.27	4.09

Variables		Min	Max	Mean	St. dev.
Input					
ME	Maintenance expenditure per pupil, Euro	274.78	3742.9	764.14	271.52
EE	Education expenditure per pupil, Euro	1423.8	2709.9	1820.1	231.03
TT	Number of teachers per pupil	0.09	0.23	0.12	0.02
YT	Share of teachers up to 29 years old, %	0.00	50.00	3.76	6.87
TA	Total school area per pupil, sq. m.	9.66	41.88	16.34	4.30
LA	Total learning area per pupil, sq. m.	3.82	12.17	6.02	1.39
FP	Share of foreign pupils, %	0.00	3.65	0.19	0.36
SP	Share of special needs pupils, %	1.65	46.50	14.58	5.72
Context variables					
OF	Own funds as share of all income, %	4.40	38.7	11.19	5.28
SH	Individuals listed for social housing per 1000 inhabitants	1.33	43.24	7.61	4.43
BE	Number of business entities per 1000 inhabitants	11.67	76.85	23.74	11.11
LB	Number of libraries per 1000 inhabitants	0.06	1.46	0.74	0.38
CC	Number of culture centres per 1000 inhabitants	0.01	1.21	0.38	0.27

Source: Author's own work.

Maintenance expenditure (ME) covers salaries of the maintenance staff, utility expenses, student transportation, expenditures for repairs, etc. School maintenance expenditures are covered by municipalities and are decided upon more flexibly according to the needs of separate schools within a municipality. This type of expenditure varies across municipalities less than educational expenditure, but the differences are still considerable and indicate that schools have to seek educational attainments with different financial inputs.

The teachers per pupil ratio (TT) ranges from 0.09 to 0.23 in the analysed period and is one of the qualitative indicators indicating the size of classes (according to the number of pupils) representing the level of individual attention given to a pupil which eventually may influence the pupil's educational outcomes.

The share of teachers up to 29 years old (YT) is not a very common indicator in education efficiency research, yet it is a very relevant measure for Lithuania as the aging of teaching personnel is and will remain a significant problem for many municipalities. As presented in Table 1 on average Lithuanian schools have less than 4% of teachers age 29 or younger (and some schools do not have them at all).

Part of foreign pupils (FP) and part of pupils with special needs (are variables that represent both the more difficult and complex teaching environment as well as different financing schemas. Classes with foreign or special needs pupils have access to special donations or additional teaching staff. The share of foreign pupils in Lithuanian municipalities is considerably low; however, the share of pupils with special needs is much higher and varies more considerably across municipalities (up to 46%).

Two indicators - total school area in square meters (and learning area in square meters) were included in the model to represent the infrastructure of schools which they have available for the educational process. The infrastructural variables also demonstrate big differences across municipalities.

Efficiency measures. In this study four efficiency estimates E1, E2, E3, and E4 were calculated for four distinct output measures. E1 represents public high education efficiency when output is measured by the passing rate of Lithuanian language exam. E2 – for Lithuanian exam passing with the highest score (86-100). The remaining two efficiency estimates are based on the mathematics exam results, E3 – for mathematics exam passing rate and E4 – mathematics exam passing with the highest score (86-100).

Context variables. To better understand public education expenditure efficiency, in our research we decided to use five additional context variables. These variables are not directly connected to the educational process or its financing schemas but are recognized in previous research as important environmental factors of educational achievements (e.g. Agasisti & Dal Bianco, 2006). Individuals who were on lists for social housing per 1 thousand inhabitants (SH) and the number of business entities per 1 thousand inhabitants (BE) were chosen to represent the current economic situation in the municipality region. The number of libraries per 1 thousand inhabitants (LB) and the number of culture centres per 1 thousand inhabitants (CC) indicate the possibilities for learning outside the school environment, as libraries and culture centres not only give access to books and computers, but also host a variety of cultural and educational events. The variable of munici-

palities' own tax income, measured as a % share of all income, (OF) reflects the level of municipalities' overall financial autonomy.

Sample and data sources

This study used unbalanced panel data of 60 municipalities in Lithuania. The data period covered a period of 2013 - 2019. Statistical data is collected from the Lithuanian Department of Statistics database (2022), except data of separate Quality of Life indicators from the control variable section. This data was obtained from the Open Lithuanian finance (2022) database.

Results

Efficiency of education expenditures across Lithuanian municipalities

The first step of efficiency calculations was to conduct regression analysis (equation 1). The results of regression analysis (with standard errors) are presented in Table 3.

Table 3: OLS model results (with standard errors)

Variables	LEP	LEP86-100	MEP	MEP86-100
Constant	6.1544 (0.5291)	19.9942*** (5.0850)	6.8872*** (0.6742)	15.4367*** (5.7310)
Maintenance expenditure per pupil	-0.0232 (0.0183)	0.3589** (0.1777)	0.0179 (0.0233)	0.3180 (0.1990)
Education expenditure per pupil	-0.2050*** (0.0719)	-2.8754*** (0.6923)	-0.3762*** (0.0915)	-1.9938** (0.7774)
Number of teachers per pupil	0.0542 (0.0384)	-0.2489 (0.3706)	-0.0447 (0.0490)	0.0543 (0.4222)
Share of young teachers < 29 years, %	-0.0080** (0.0040)	-0.0382 (0.0390)	0.0094* (0.0051)	-0.0058 (0.0438)
Total school area per pupil, sq. m.	0.0306 (0.0255)	0.2811 (0.2446)	0.0595* (0.0324)	-0.0058 (0.2759)
Total learning area per pupil, sq. m.	-0.0497* (0.0272)	-0.2402 (0.2616)	-0.0053 (0.0347)	-0.6347** (0.2947)
Share of foreign pupils, %	-0.0076** (0.0035)	-0.0502 (0.0339)	0.0172*** (0.0045)	0.1241*** (0.0380)
Share of special needs pupils, %	0.0412*** (0.0091)	0.1308 (0.0874)	0.0260** (0.0116)	0.2343** (0.0982)
R Squared	0.1929	0.1840	0.5404	0.3852
Breusch-Pagan test (Prob > chi2)	< 0.0100	< 0.0100	< 0.0100	0.1300
Wooldridge test (p-value)	0.0900	< 0.0100	< 0.0100	< 0.0100

*** Shows the statistical significance at 99%, ** shows the statistical significance at 95%, and * shows the statistical significance at 90% level. Standard errors are represented in the brackets. Statistically significant impact is highlighted in bold.

Source: Author's own work.

The validity of all OLS models was tested using Breusch-Pagan heteroscedasticity test and Wooldridge serial correlation. Data analysis showed the presence of heteroscedasticity in most of the models and the evidence of serial correlation in several models. To deal with these issues, heteroskedasticity and autocorrelation (HAC) robust standard errors were included in all the models. The results of regression analysis (with HAC robust standard errors) indicating significant input variables are presented in Table 4.

Table 4: OLS model results (with HAC robust standard errors) used to calculate efficiency

Variables	LEP	LEP86-100	MEP	MEP86-100
Constant	6.1544*** (0.5321)	19.9942*** (6.5794)	6.8872*** (0.6507)	15.4367** (6.3207)
Maintenance expenditure per pupil	-0.0232 (0.0203)	0.3589 (0.2095)	0.0179 (0.0234)	0.3180 (0.2473)
Education expenditure per pupil	-0.2050*** (0.0658)	-2.8754*** (0.8754)	-0.3762*** (0.1005)	-1.9938** (0.9174)
Number of teachers per pupil	0.0542 (0.0451)	-0.2489 (0.4987)	-0.0447 (0.0680)	0.0543 (0.4932)
Share of young teachers <29 years, %	-0.0080** (0.0038)	-0.0382 (0.0389)	0.0094 (0.0054)	-0.0058 (0.0434)
Total school area per pupil, sq. m.	0.0306 (0.0226)	0.2811 (0.2501)	0.0595 (0.0653)	-0.0058 (0.3478)
Total learning area per pupil, sq. m.	-0.0497** (0.0238)	-0.2402 (0.2885)	-0.0053 (0.0167)	-0.6347* (0.3630)
Share of foreign pupils, %	-0.0076** (0.0035)	-0.0502 (0.0366)	0.0172*** (0.0045)	0.1241*** (0.0398)
Share of special needs pupils, %	0.0412*** (0.0138)	0.1308 (0.1400)	0.0260** (0.0123)	0.2343** (0.1184)
R Squared	0.1929	0.1840	0.5404	0.3852

*** Shows the statistical significance at 99%, ** shows the statistical significance at 95%, and * shows the statistical significance at 90% level. HAC robust standard errors are represented in the brackets. Statistically significant impact is highlighted in bold.

Source: Own elaboration.

The next step of our analysis was to calculate the efficiency coefficients E1, E2, E3 and E4, using equations 2, 3, and 4. The average efficiency coefficients E1, E2, E3 and E4 and their descriptive statistics are presented in Table 5 (the histograms of the frequency distributions of all four efficiency measures showed normal distributions). The evaluation efficiency level (for testing H_1 hypothesis) was performed based on the study by Melo-Becerra et al. (2020) and Blackburn et al. (2014). Efficiency coefficients above 80% were treated as indicators of high efficiency, between 50 and 80 % – as of moderate efficiency and below 50 – as of low efficiency.

Table 5: Descriptive statistics of efficiency coefficients

	Efficiency				
Variable	Obs.	Mean	St. Dev.	Min	Max
E1 (LEP)	222	0.9043	0.0441	0.6611	1
E2 (LEP86-100)	221	0.3748	0.1613	0.0435	1
E3 (MEP)	222	0.8643	0.0544	0.6735	1
E4 (MEP86-100)	218	0.3174	0.1564	0.0318	1

Source: Author's own work.

According to our estimations, the same inputs result in different efficiency levels for different output measures. When assessed by the overall passing rate of the Lithuanian (LEP) and mathematics (MEP) exams, the efficiency scores were high averaging 90% and 86% respectively. But when evaluating efficiency by passing the exams with the highest scores (LEP86-100 and MEP86-100), the results did not even reach 40% (37% for the Lithuanian exam and 32% for mathematics). Notably, the efficiency levels for the mathematics exam are lower than for the Lithuanian language exam.

Factors explaining efficiency of public education expenditure across Lithuanian municipalities

Two sets of variables are used to identify the determinants of public education efficiency – input variables and context variables including both financial and non-financial measures. The results of regressions used for

calculation of efficiency measures (equation 1) were further interpreted for identification of factors explaining efficiency of public education expenditure across Lithuanian municipalities. As presented in Table 3, all four outputs (LEP, LEP86 - 100, MEP, MEP86 - 100) used to calculate efficiencies, had negative statistically significant dependency on the educational expenditure (EE). Interestingly, LEP results were also negatively influenced by share of young teachers (YT), total learning area per pupil (LA) and share of special needs pupils (SP), and positively influenced by the share of foreign pupils (FP). Regarding mathematics, both MEP and MEP86 - 100 were positively influenced by the share of foreign pupils (FP), and the share of special need pupils (SP). None of these inputs influenced LEP86 - 100 results.

Equation 5 was used to evaluate whether context variables had any influence on the efficiency levels. Results of regression analysis for the context variables (with standard errors) are presented in Table 6, while the results of regression (with HAC robust standard errors) indicating significant context variables are presented in Table 7.

Table 6: Regression results for context variables (with standard errors)

Variables	E1	E2	E3	E4
Constant	-0.1938*** (0.0707)	-0.5065 (0.6577)	-0.4283*** (0.0892)	-2.5831*** (0.7557)
Own funds as share of all income	0.0284** (0.0114)	0.5542*** (0.1058)	-0.0028 (0.0144)	-0.0419 (0.1240)
Individuals listed for social housing per 1000 inhabitants	0.0083 (0.0077)	-0.0007 (0.0706)	0.0076 (0.0097)	0.0398 (0.0828)
Number of business entities per 1000 inhabitants	0.0493** (0.0203)	0.2595 (0.1888)	0.0955*** (0.0256)	0.3378 (0.2186)
Number of culture centres per 1000 inhabitants	0.0000 (0.0044)	0.0343 (0.0406)	0.0169*** (0.0056)	-0.0560 (0.0476)
Number of libraries per 1000 inhabitants	0.0143** (0.0072)	0.0664 (0.0670)	-0.0010 (0.0091)	-0.0013 (0.0781)
R Squared	0.0884	0.1637	0.1070	0.1053
Breusch-Pagan test (Prob > chi2)	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Wooldridge test (p-value)	0.3900	0.2100	< 0.0100	< 0.0100

*** Shows the statistical significance at 99% and ** shows the statistical significance at 95% level. Standard errors are represented in the brackets. Statistically significant impact is highlighted in bold.

Source: Own elaboration.

Table 7: Regression results for context variables (with HAC robust standard errors)

Variables	E1	E2	E3	E4
Constant	-0.1938*** (0.0714)	-0.5065 (0.6063)	-0.4283*** (0.0962)	-2.5831*** (0.7525)
Own funds as share of all income	0.0284*** (0.0107)	0.5542*** (0.1032)	-0.0028 (0.0152)	-0.0419 (0.1073)
Individuals listed for social housing per 1000 inhabitants	0.0083 (0.0079)	-0.0007 (0.0656)	0.0076 (0.0089)	0.0398 (0.0781)
Number of business entities per 1000 inhabitants	0.0493** (0.0203)	0.2595 (0.1751)	0.0955*** (0.0273)	0.3378 (0.2338)
Number of culture centres per 1000 inhabitants	0.0000 (0.0037)	0.0343 (0.0345)	0.0169*** (0.0052)	-0.0560 (0.0432)
Number of libraries per 1000 inhabitants	0.0143** (0.0064)	0.0664 (0.0693)	-0.0010 (0.0099)	-0.0013 (0.0861)
R Squared	0.0884	0.1637	0.1070	0.1053

*** Shows the statistical significance at 99% and ** shows the statistical significance at 95% level. HAC robust standard errors are represented in the brackets. Statistically significant impact is highlighted in bold.

Source: Own elaboration.

The obtained results (Table 7) show that the financial autonomy of municipalities (measured as share of own funds in all income) had a positive and significant effect on efficiency measured by LEP and LEP86 - 100. The number of operating business entities in a municipality has a positive effect on the efficiency measured by LEP and MEP, the number of cultural centres –by MEP while the number of libraries - measured by LEP.

Discussion

Our study provides valuable yet ambiguous insight into the efficiency of public education expenditure of Lithuanian municipalities. Our first hypothesis that the efficiency level of higher education expenditure is moderate was rejected. In the case where educational attainments were measured by the overall passing of national exams, the scores of 86-90% suggest that public education expenditure efficiency is high if evaluated from the perspective of its main aim – i.e., to provide broad scope higher education. Comparable results were also reported by Melo-Becerra et al. (2020) for some Colombian municipalities and Blackburn et al. (2014) for Australian schools, however the results should be compared with caution due to different variables and the different object of the assessment in Blackburn et al. (2014) study. On a broader perspective, results of our study bring interesting insights. Despite decreasing and below EU average public education expenditure (Coman et al., 2023), Lithuania has demonstrated remarkable efficiency in utilizing educational funds.

The results of the efficiency assessment were discouraging and leading to the rejection of the first hypothesis when looking from the passing exams with the highest grades perspective. In this case the efficiency levels were low (32-37%). Interestingly, we also conducted additional analysis on municipality clusters (big cities, villages, resorts, and others) and the results were consistent with the entire sample. This heterogeneity in efficiency measures suggests that some municipalities may be able to improve their educational outcomes without increasing their resources. Actually, we observed variations among different municipalities in the output variables when schools in some municipalities show much higher educational attainment results than the others. Such variation among the local units is not an exception in our analysed country. They were also observed across Colombian municipalities (Melo-Becerra et al., 2020). This pattern is not unique to Lithuania. For example, it has been previously observed in Colombian municipalities (Melo-Becerra et al., 2020). From a broader perspective, our study supports OECD (2017) conclusions and recommendations that the ineffective allocation of funds, particularly when assessing efficiency based on top exam scores, impedes the correlation between educational investment and economic growth in Lithuania. This points to a critical area for improvement that directly impacts national GDP.

While analysing the data for output variables, we also observed that the passing rate as well as attaining of the highest scores is considerably lower in the exam of mathematics than the exam of Lithuanian language. Such results are not in line with previous research (e.g. Gavurova et al., 2017), where results in mathematics were higher than reading skills. In the case of Lithuania, official reports and studies have been repeatedly indicating the lack of qualified teachers in mathematics, forecasting this deficit to increase even more in the future (OECD, 2015 and 2017; Municipal Debt Restructuring, 2020).

The second hypothesis of our study, which questioned whether public education expenditure has a significant and positive impact on public education efficiency was rejected. Three variables directly representing expenditure were used in our analysis – educational expenditure and maintenance expenditure (as education-related input variables) and municipality own resources (as a content variable representing municipalities' financial independence). We found that only the financial autonomy of municipalities is a significant determinant for the efficiency measured by the scores of Lithuanian exams (both the overall and with the highest scores). Also, our study did not find significant evidence of the influence of maintenance expenses on the efficiency of public education. Similar results were observed by Wanke et al. (2016) in primary and secondary schools of Australia. Unexpectedly, in our study the educational expenditures had a significant and negative effect on the efficiency of public education in municipalities measured by all 4 types of educational attainments. This indicates shocking evidence that the more expenditure is allocated to the schools of a certain municipality the worse national exam scores in that municipality are. Such findings present new evidence on the shortcomings of Lithuanian public education expenditure allocation formulas and were not previously reported by other studies on municipality level efficiency assessment. On one hand, such results may be explained by the peculiarities of the national educational expenditure allocation system. Even though the national formula for resource allocation in Lithuania is the same across all municipalities, the level of educational expenditure varies considerably across municipalities. This is influenced by the size of schools, size of classrooms, qualification of personnel as well as other funds allocation criteria. Although more in depth analysis on the national public education expenditure allocation system is needed, our results suggest that the current resources allocation system is not the most effi-

cient in enabling the pupils to seek the highest academic achievements. On the other hand, such a negative effect could indirectly explain why Lithuania, having public education funding per GDP lower than the European Union average, also lags behind in the long-term relationship between public education spending and economic growth (Coman et al., 2023).

Our study also involved the analysis of the influence of non-financial variables on the efficiency of public education in Lithuanian municipalities. The third hypothesis stating that non-financial inputs have a statistically significant and positive effect on the efficiency of public education brought mixed results requiring further investigation. Interestingly, three of our nonfinancial input variables (share of young teachers, total learning area per pupil, and number of foreign pupils) demonstrated a negative effect on the public education efficiency measured by the overall passing of the Lithuanian exam. The effect of the same variables on the other efficiency measures was not statistically significant, except for the variable of number of foreign pupils, which demonstrated a positive effect on the educational attainments in mathematics. A number of foreign pupils who might experience difficulties learning the Lithuanian language is a rational explanation of the lower efficiency of the overall passing of the Lithuanian exam. However, similar to our comment on financial variables, a negative effect of having young teachers and more learning space calls for immediate enquiries into the issue. On the other hand, findings related to teachers' experience are consistent with previous results. For example, it proved to be an important determinant of the efficiency of primary and secondary education in Australia (Wanke et al., 2016). As for the contextual variables, a rather robust positive effect on the efficiency of public education (measured by the overall passing of the exams) was observed for the number of business entities. Furthermore, the number of cultural objects (culture centres and libraries) were also found to influence the results of public education efficiency (but only for efficiency measured by the overall passing of the math exam). This is in line with the findings of Agasisti (2014), suggesting that economically and culturally stronger municipalities create more favourable conditions in which to seek higher educational attainments.

Our findings demonstrate several policy implications. Based on our results we advocate for the change in the national public expenditure allocation model and for greater autonomy of Lithuanian municipalities in decision-making regarding educational expenditure. Financial autonomy for municipalities in education spending can yield several benefits, including closer alignment with local needs, increased accountability and transparency, improved efficiency, and better use of resources. Such autonomy would empower municipalities to identify areas where funds are being wasted and redirect them towards more effective uses, enabling them to make higher quality decisions. Additionally, municipalities would be better positioned to utilise their resources efficiently and deliver education services more effectively (Kopańska, 2018). Ultimately, this autonomy could lead to increased public trust and support for education spending. Overall, studies on the effectiveness of education expenditure are important in both the national and Central and Eastern European contexts and holds significant practical value. In the European context, Lithuania continues to demonstrate below-average efficiency of public education expenditure (Aristovnik, 2013; Gavurova, et al., 2017), prompting immediate actions. The results of our study aim to contribute to increasing the efficiency of public spending in education. Since education costs in municipalities make up the largest part of expenditure (more than half of all costs), their more effective utilization would enhance the efficiency, competitive advantage and economic productivity of the entire country. In Central and Eastern Europe, many countries face social integration challenges related to national minorities, economic inequalities, and other social issues. Education can be a vital tool to address these challenges, while effectiveness studies can assist countries to better understand how their education spending can promote social inclusion.

Conclusions

This research provides valuable evidence of the efficiency of public education expenditure across Lithuanian municipalities and identifies financial and non-financial factors that explain the scores of overall exam results and top-tier exam results and therefore the efficiency variations among the municipalities.

The results of the research are ambiguous. When assessed by the overall passing scores of mathematics and Lithuanian (national) language exams, the efficiency of the educational system was found to be as high as 86-90%. However, when evaluated by the passing of both exams with the highest scores, the efficiency was found to be below average ranging between 32-37%. Our research has assessed the influence of financial and nonfinancial inputs, as well as contextual measures on the efficiency of public education. Two types of financial variables were found to be statistically significant. Educational expenditure, which is a state donation allocated to a school by municipality based on the number of classes, had a negative impact on the results of all assessed exams. In contrast, municipality own funding, representing municipalities' financial autonomy, had a positive influence on public education efficiency when assessed by the scores of Lithuanian ex-

ams. Regarding nonfinancial variables, the share of foreign pupils and pupils with special needs had the most significant impact on exam scores. Furthermore, the number of business entities and cultural objects (culture centres and libraries) were also found to influence the results of public education efficiency, but the influence of nonfinancial factors was evident only for the specific output measures.

Lithuanian public education expenditure, decreasing and below the EU average, demonstrates high efficiency when providing general education. However, when assessing efficiency based on top educational attainments, it shows ineffective allocation of funds and critical areas for improvement that directly impact the national GDP. Results of our study support the decentralization of public education expenditure management and call for alternative output measures in Lithuanian public education system. They can be used to make informed education and public finance policy decisions aiming to improve public education expenditure efficiency in Lithuania.

One of the limitations of this study relates to the specifics of the Lithuanian public education system and its financing model. This makes it more difficult to apply methods and variables used in other studies to the Lithuanian context. Also, it makes it more difficult to compare our findings to the other studies. Another limitation of this research is related to the availability of reliable municipality level information on the input and context variables for the entire research period. Use of other input and output variables could lead to different efficiency measurements.

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Appendix

Table 1: An overview of single country/region research

Authors (year)	Scope	Method	Inputs	Output	Results
Vitek and Martinkova (2015)	Primary schools in the Czech Republic	Descriptive statistics	Expenditure per student, salaries of teachers, numbers of pupils, use of facilities	Language, mathematics and natural science results of less successful students	Overall assessment of efficiency is difficult due to the lack of time series data. Cost efficiency is overall positive and improving.
Kyriakides et al. (2019)	Public schools in Cyprus	Multilevel regression analysis and Discriminant function analysis	Educational investment	Overall achievement in the Pancyprian examinations	Educational investment had a positive effect on the effectiveness status of a school if invested in least effective schools.
Aparicio et al. (2018)	298 Catalan public primary schools	Hicks-Moorsteen total factor productivity change index	Expenditure per student, number of teachers, maternal educational level	Average grade in the sixth grade for Catalan, Spanish and English	During 2009-2014 (the crisis period) schools improved their total factor productivity by raising academic achievement despite cutbacks in resources.
Scippacercola and Ambra (2014)	Secondary schools in Cambria	Stochastic Frontier Analysis and Tobit model	Multiple structural, financial, technological, human resources, and environmental variables	Production frontier	The production inputs (number of teachers per 100 students and the number of students per class) have a significant impact. The financial variables (extra revenue funds) and the structural variables (the total area of the classes and the presence of school libraries) are not significant.
Melo-Becerra et al. (2020)	Colombian municipalities	Stochastic Frontier Analysis	Multiple factors representing institutional environment and fiscal autonomy	Enrolment in upper secondary education, the public-school quality and the average math score	The efficiencies vary between 26% and 98%. Differing regional patterns are observed for the cases of education quality and enrolment.
Tu et al. (2018)	31 provinces of China	Two-step Data Envelopment Analysis and Tobit	Public expenditure on personnel, public funds expenditure in preschool education, capital construction expenditure in preschool education	Number of preschool teachers and number of pre-school classes, number of teachers, education of teachers, average dormitory size.	Local differences in preschool education expenditure efficiency were observed. The efficiency on local preschool education spending in the eastern part is larger than the west and middle regions. Most of the loss of overall efficiency resulted from the scale efficiency.

Authors (year)	Scope	Method	Inputs	Output	Results
Solihin et al. (2005)	East Java	Data Envelopment Analysis	Number of teachers per student, number of classrooms per student, ratio or the number of schools per school-age population, level of government spending	Index of Education	Government spending in the education sector in most of the district and the city of East Java Province is not efficient.
Blackburn et al. (2014)	1650 primary and 400 secondary schools in New South Wales (Australia)	Data Envelopment Analysis	Total expenditure per pupil	Average test scores on reading, writing, spelling, grammar and numeracy	A moderate level of overall cost efficiency (approx. 82 %). The efficiency increases for the quintile of schools with the most favorable environment. Further, efficiency gains are realized with increasing enrollment.
Wanke et al. (2016)	New South Wales (Australia) primary and secondary schools	Two-stage network Data Envelopment Analysis	Multiple financial variables, including total cost, teacher salaries, maintenance, depreciation, utility, etc. costs, value of school land and building	Reading, writing, spelling, grammar and numeracy test scores	Australian public schools are heterogeneous. The collective efficiency of the educational units analyzed did not change during the period of study.

Source: Author's own work.