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Policy Research Working Paper 9077

Quality Education and the Efficiency of Public Expenditure

A Cross-Country Comparative Analysis

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WORLD BANK GROUP
Human Development Global Practice
December 2019

Policy Research Working Paper 9077

Abstract

Improving access to quality education has been the backbone of several development strategies around the world and considerable public resources have been dedicated to achieving this goal. However, one could wonder whether increasing public education expenditure would drive better access to quality education despite the inefficiencies plaguing public sectors in general. The purpose of this study is to investigate the efficiency with which public education spending is translated into increased access to quality education in the light of the learning-adjusted years of schooling. The results show that education expenditure per school-age individual is positively associated with an increased number of years of quality schooling. However, it is estimated that, on average, 16 percent of the public financial resources dedicated to education in developing countries are wasted because of inefficiencies. Although efficiency greatly varies across countries, low-income countries are overall facing a double issue of low levels of education expenditure and weak efficiency of public expenditure on education. Factors related to governance, labor market conditions, and the type of education aid seem to matter for efficiency.

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Produced by the Research Support Team

Quality Education and the Efficiency of Public Expenditure: A Cross-Country Comparative Analysis

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Keywords: Education, Public Expenditure, Efficiency

JEL Codes: O15, I25

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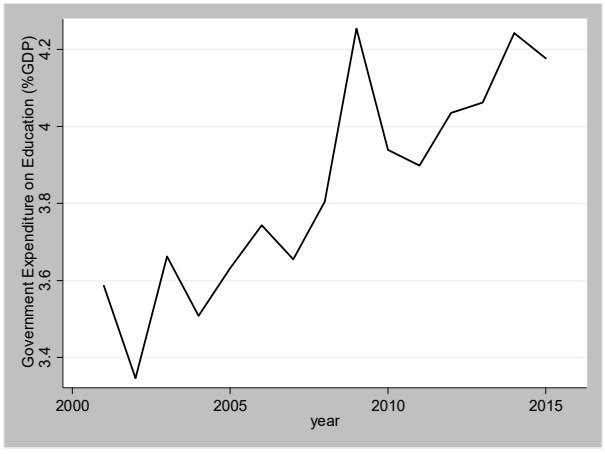
1. Introduction

Improving access to quality education is at the core of all development strategies. It has long been recognized that education is associated with tremendous effects on economic development (Nelson & Phelps, 1966; Lee & Barro, 2001; Hanushek, 2007; Hanushek & Woessmann, 2008; Pelinescu, 2015; Angrist, et al. 2019). Given the lack of necessary resources for proper investment in education, the Millennium Development Goals (MDGs), as well as the recent Sustainable Development Goals (SDG 4), called international partners for more assistance to developing countries to achieve universal basic education as well as quality education for all. As a result, the volume of aid to education has experienced a strong improvement since the 2000s, increasing from $4.8 billion to $12.7 billion in 2017.[1] Developing countries were also urged to allocate more resources to the education sector.

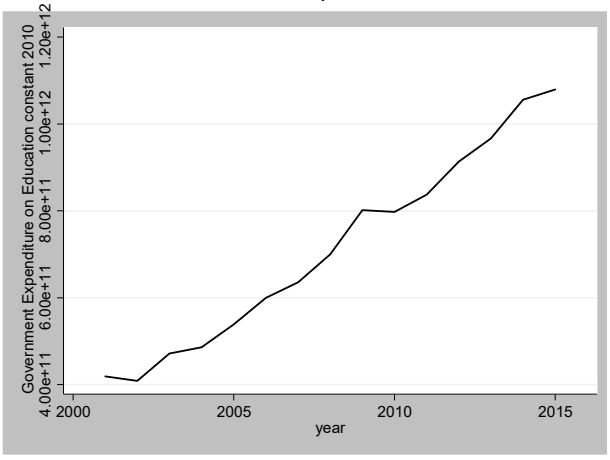
Government expenditure on education as a share of the GDP registered a significant increase in low- and middle-income countries from an average of below 3.6 % in the 2000s to above 4 % in 2015 (Figure 1). The volume of government expenditure on education also experienced a strong improvement, tripling from around $400 billion in the 2000s to nearly $1,200 billion in 2015. The school-age population (population of pre-primary, primary, secondary and higher education) grew from about 2.02 billion to 2.14 billion over the same period. Therefore, government expenditure per school-age individual experienced a strong improvement over the past 15 years, increasing from an average of US$457 to US$1,110 in low- and middle-income countries. Combined with the donors' contribution to education financing, this represents significant progress for education financing.

Figure 1: Government expenditure on education in Low- and Middle-Income countries

Education expenditure as a share of the GDP



Volume of education expenditure (constant, 2010)



Source: World Development Indicators

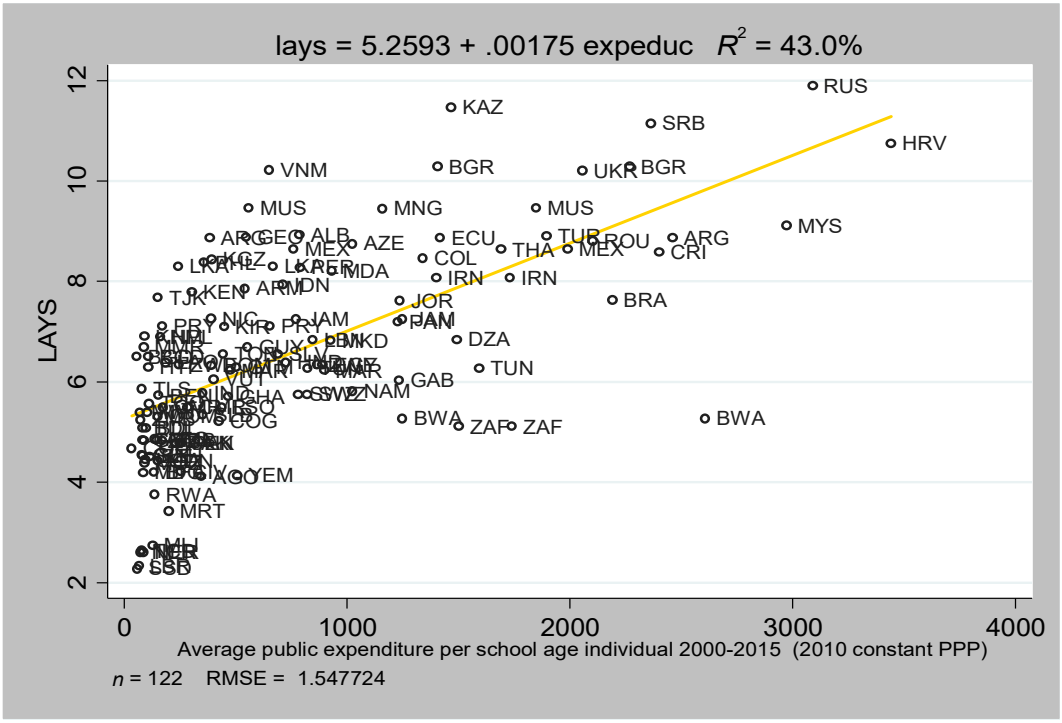
Despite the progress in terms of making financial resources available for education, educational outcomes did not experience similar trends. The average primary completion rate in low- and middle-income countries increased from 81 % in 2000 to 89% in 2017. Most developing countries have not yet achieved universal primary education although there is some progress in terms of access to education. More and

[1] Miningou (2019).

more children are being enrolled since 2000 but learning becomes a serious concern. It is estimated that more than 617 million children and adolescents are not achieving minimum proficiency levels in reading and mathematics and most of these individuals are living in developing countries (UIS, 2017). The World Bank's Human Capital Index (HCI) shows that the next generation of workers in low- and middle-income countries would only have 51 % of the productivity that they could have if they had complete education and full health.[2] A decomposition of the average HCI shows that the education component is associated with the lowest achievement and the average of the learning-adjusted years of schooling (LAYS) seems very low in most developing countries and far below the benchmarks.[3]

A simple visualization of the relationship between the total public education expenditure (government expenditure + donors' contribution) per school-age individual and the LAYS shows that there could be some correlation between public expenditure on education and access to quality education (Figure 2). This relationship has been reported in previous studies (Jung & Thorbecke, 2003; Dissou, Didic, & Yakautsava, 2016; Al-Samarrai, Cerdan-Infantes, & Lehe, 2019). More interestingly, Figure 2 shows that countries with similar levels of average public expenditure on education over the past two decades register different achievements in terms of access to quality education. This indicates that countries may face issues related to their ability to translate resources into quality education.

Figure 2 Average public expenditure per school-age individual and the LAYS



[2] A population weighted average of the HCI was calculated based data available in 133 low- and middle-income countries. The average value of the HCI is 0.5089977. A decomposition of the HCI into its component shows that the survival component value is 0.9665485 while the health and the schooling components' values are respectively 0.9039009 and 0.5777548.

[3] See Kraay (2018) for a discussion on the HCI benchmarks.

There is an increasing interest in the efficiency of public expenditure on education in the economic literature. Some studies tried to provide a cross-country comparison of education expenditure in OECD countries (Afonso & Aubyn, 2005; Verhoeven, Gunnarsson, & Lugaresi, 2007; Aristovnik, 2013; Agasisti, 2014; Ahec Šonje, Deskar-Škrbić, & Šonje, 2018). Most of these studies investigate how education expenditure translates into learning as demonstrated by the PISA test scores. Other studies attempt to make an international benchmark of the efficiency of public expenditure on social sectors including education (Herrera & Pang, 2005; Herrera Aguilera & Ouedraogo, 2018) but these studies exclude learning, probably because of the lack of data. A recent attempt by Miningou, Bernard, & Pierre-Louis, (2019) provides an evaluation of the efficiency in the use of resources to achieve learning outcomes in 10 francophone Africa countries, with no focus on public expenditure on education. To the best of our knowledge, no study has investigated how public resources from domestic and foreign sources are used to deliver quality education, with an international perspective. The World Bank's new learning-adjusted years of schooling (LAYS) offers an opportunity to benchmark countries and investigate how public resources are being utilized to achieve good quality education.

The purpose of the current study is to investigate the efficiency of public education expenditure around the world, with a focus on developing countries. It aims at providing an international benchmark for the efficient utilization of public resources dedicated to the education sector. How efficient are public expenditures on education in driving better quality education? What are the countries with the highest efficiency levels that could potentially serve as benchmarks for other countries? These are the questions that the current paper will try to answer. Section 2 discusses the empirical strategy for measuring the efficiency of public education spending while section 3 presents the data and section 4 discusses the results of the study. Section 5 elaborates on the possible implications of the findings from the current paper.

2. Empirical Strategy

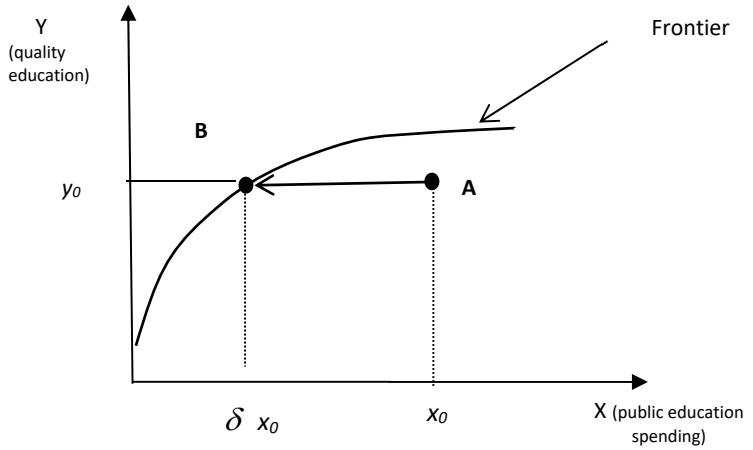
There are two main approaches to measuring efficiency in the economic literature. A first methodology can be qualified as an 'ad doc' method, as it is based on the calculation of unit costs of education products or the ratio of the input over the output. This approach is very useful in evaluating the cost-effectiveness of education interventions. The 'ad doc' methodology only works in the case of education activities that involve single input and output. Besides, the output needs to be countable for the analysis to be accurately interpreted. As an alternative to the 'ad doc' methodologies, frontier approaches offer an opportunity to measure efficiency using a wider range of variables.

The frontier approach is particularly suitable for multi-input and multi-output technologies. This approach is based on the construction of a production frontier that gives the maximum outputs (quality education in our case) that can be achieved given the quantity of the inputs used (public expenditure on education). The frontier approach allows benchmarking countries and finding out those with the best practice in terms of the efficient utilization of pubic financial resources in the education sector. Efficiency is then measured by looking at the distance between the countries on the frontier of best practice and the other countries below the frontier.

Figure 3 presents an illustration of the efficiency analysis using the frontier approach. Let's assume that countries use one input X (public education expenditure) to produce a single output Y (an indicator of

access to quality education). The frontier represents the maximum amount of output that can be produced given different levels of the input X. Countries below the frontier are considered relatively inefficient while countries on the frontier are considered relatively efficient. For instance, a given country uses x_0 to produce y_0 and is at point A in Figure 3. The point A being below the frontier, this country is considered inefficient. It would have been efficient if the same level of output (y_0) was achieved with fewer resources (δx_0 , with $0 \leq \delta \leq 1$), corresponding to point B on the frontier. This means that x_0 -δx_0 is the corresponding volume of financial resources wasted because of inefficiency in the use of public expenditure on education. The distance to the frontier, captured by δ, can be used to calculate an efficiency score that reflects the ability of each country to translate their input into output.

Figure 3 Illustration of the frontier approach



The literature on efficiency measurement in education shows that there are two classes of methods for the construction of the frontier: Parametric and nonparametric. The Data Envelopment Analysis (DEA) method appears to be one of the most commonly used nonparametric approaches for efficiency analysis. However, the main drawback facing the DEA method is related to the fact that it treats all deviations from the frontier as inefficiency, including those attributable to measurement errors (Sexton & et al., 1986; Simar & Wilson, 1998).[4] Parametric models, and more specifically, the stochastic frontier analysis (SFA) method, allow "noise" to be separated from the inefficiency measure under certain assumptions. This method also offers the opportunity to investigate the relationship between the input and the output when inefficiencies are controlled for. The SFA method is thus applied to construct a production frontier in this study. This production frontier gives the maximum access to quality education that can be achieved with the volume of financial resources dedicated to the education sector. However, it is important to highlight that the stochastic frontier method has also been criticized in the literature on aspects related to some of the assumptions on which it is built.[5]

Consider input $x \in R$, and the output $y \in R$. Following Battese & Coelli (1995), the frontier function is given by:

[4] Simar & Wilson (1998) suggest a bootstrapping technique allowing to estimate the "noise" and to build confidence intervals around efficiency estimates but this technique appears to face some criticisms related to assumptions underlying the proposed bootstrapping method (Simar & Wilson, 2007; Tziogkidis, 2012).

[5] For instance Ahmad & Bravo-Ureta (1996) highlight the fact that efficiency estimates are sensitive to different assumptions of model specification, while Kutlu (2010) points out the endogeneity issue in the stochastic frontier model.

$$Log(y)_n = Log[f(x)_n] + u_n - \lambda_n \quad (1)$$

with *n* an indicator for countries.

The function *f(.)* approximates the maximum educational outcomes that can be achieved given different levels of expenditure on education. Deviations from the estimated production frontier are attributable to inefficiency (λ_n), as well as "noise" (u_n). λ_n captures the *inefficiency* with which education expenditure is translated into educational outcomes in country n. u_n is normally distributed while λ_n follows a half-normal distribution.[6]

The efficiency in the use of public financial resources allocated to the education sector may be influenced by some environmental factors (countries' income level, institutional capacity, etc.). Derivation of the efficiency indicator should take into consideration these environmental factors. Following Battese & Coelli (1995), Equation 2 allows an estimation of the explanatory factors for λ_n while Equation 3 gives a final *efficiency* score that is corrected for factors that could have undermined the accuracy in the estimation of the inefficiency measure λ_n.

$$\lambda_n = Z_n\eta + w_n \quad (2)$$

$$TE_n = exp(-\lambda_n) = exp(-Z_n\eta - w_n) \quad (3)$$

where w_n is an error term that is normally distributed and is truncated at the point $Z_n\eta$, with mean 0 and variance σ_w^2. Z_n is the matrix of explanatory variables that include some explanatory factors of the inefficiency parameter λ_n, η is a vector of parameters to be estimated and TE_n is the technical efficiency.

Equations 1 and 2 are estimated simultaneously with the maximum likelihood method, using the likelihood function suggested by Battese & Coelli (1995) and the efficiency score is calculated using Equation 3. Two main functional forms are used in the literature for *f(.)*: The translog function and the Cobb Douglas function. The translog function is more flexible as it allows the frontier to be quasi-concave. *f(.)* is then approximated by a translog function. The translog function is suitable for capturing the concave relationship between public expenditure and educational outcomes. It is assumed that an additional unit of expenditure has a lower impact compared to the previous unit. The variables included in the matrix *Z,* as well as those related to *x* and *y* are discussed in the following section.

3. Data

Based on the educational production function theory (Bowles, 1970; Polachek, Kniesner, & Harwood, 1978; Hanushek, 1987; Monk, 1989) , we assume that the education systems in countries use inputs and translate them into educational outcomes. Measuring the efficiency of public expenditure on education thus requires input and output variables to be defined. Input should reflect total public expenditure on education while the output would need to gauge achievements in terms of quality education.

Input variable (x)

In the literature on cross-country analysis of the efficiency of public expenditure, two main sets of variables are commonly used as input indicators: Public education expenditure as a share of GDP or as a

[6] There are three distributions commonly used to approximate the inefficiency parameter: truncated normal, half-normal and exponential distributions. Section 4 provides a discussion on alternative distributions.

share of total public expenditure and the expenditure per student or per school-age child. While public education spending as a share of GDP or as a share of total government expenditure reflects government efforts towards education financing given the available resources, it does not perfectly capture the actual flows of public financial resources into the education sector. These variables do not account for the demand for education in countries as reflected by the size of the school-age population. Given the differences in the demographic structures, the demand for education as well as the resources needed may differ across countries. In the current paper, total public expenditure (government expenditure + education aid received) per school-age individual (population of pre-primary, primary, secondary and higher education age) is used as an input variable. To control for differences in purchasing power across countries as well as the inflation, public expenditure is expressed in constant PPP terms.

Output variable (y)

The ideal output variable should capture both access to education and learning. The World Bank's Human Capital Project introduced a Human Capital Index (HCI) that measures the productivity of the labor force in countries, taking into consideration three key dimensions of human capital: Survival, health and quality education (Kraay, 2018; 2019). The learning-adjusted years of schooling (LAYS) is the indicator used for the education component. The LAYS captures the number of years of quality schooling a child can expect to obtain by age 18. It includes two components: Expected years of schooling and a harmonized test score. Learning is measured by a relative learning score calculated from global and regional learning assessments (Altinok, Angrist, & Patrinos, 2018; Patrinos & Angrist, 2018). The harmonized learning score is currently the only comparable measure of learning that covers a large number of countries.[7] Without ignoring the limitations surrounding the LAYS, this appears to be one of the most reliable indicators of quality education that is available and covers a large number of countries including developing countries.

Control variables (z)

The education production function theory shows that inputs can be grouped into two main categories: financial and non-financial resources. Financial resources come from three main sources: aid to the education sector (*aid*), government expenditure (*govspend*) and households' spending (*hhspend*).[8] Non-financial resources are related to supply-side factors (availability of teachers for instance) and demand-side factors (population's demand for education for instance). This implies that public expenditure may not be the only input for educational outcomes and the efficiency measurement may be adjusted accordingly. From the financial inputs side, *aid* and *govspend* are already captured by the input variable *x.* Countries' income level dummies are included in *z* to control for the population income, and to some extent, *hhspend*. Regarding the non-financial resources used by the education sector, the primary completion rate (*pcr*) is included as a measure of the households' demand for education and the capacity of the education system to deliver basic education, while the students-to-trained teachers ratio (*sttr*) is a supply-side indicator capturing the availability of trained teachers. Availability of qualified teachers has been recognized as one of the key ingredients for quality education (World Development Report, 2018). The unemployment rate (*unemploy*) is introduced as an additional control variable capturing the economic environment and, to some extent, the demand for labor in the economy. The share of official development assistance (*odashare*) is also included as a control variable for aid dependency.

[7] See Patrinos & Angrist (2018) for a discussion on the harmonized test score as well as its imitations.

[8] Education aid include sector allocable ODA to the education sector received by countries included in the sample.

The output variable is only available for the year 2017. All input and control variables (except dummies) are averaged for the period 2000 to 2015. This seems to make sense because the output variable reflects the effects of past investments in the education sector. In addition, it may take some time for the input to impact on the output, so the input variable is delayed with respect to the output. Since resources necessary to improve access and quality require sustained investments over a relatively long period, considering the average expenditure over the last 15 years allows past investments into the education system to be taken into consideration. The data set used is then a cross-section covering the period 2000-2015 for the input and control variables and the year 2017 for the output variable. Data are collected from three main sources: The World Development Indicators, the UNESCO Institute of Statistics (UIS), and the OECD Creditor Reporting System (OECD-CRS). Table 1 presents descriptive statistics of the data.

Table 1 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Coef. of Variation
Output (y)						
Learning-Adjusted Years of Schooling (lays)	157	7.895	2.683	2.275	12.905	2.942
Input (x)						
Total public expenditure per school-age individual PPP (expeduc)	175	2862.225	3852.216	29.981	22448.080	0.743
Control variables (z)						
Share of aid in public education expenditure (odashare)	178	0.047	0.094	0	0.648	0.500
Unemployment rate (unemploy)	186	9.008	6.151	0.650	31.994	1.464
Primary Completion Rate (pcr)	180	87.370	18.761	25.734	138.222	4.657
Student to Trained Teacher Ratio (sttrm)	217	40.546	23.586	8.730	221.937	1.719
High-Income country	217	0.355	0.480	0	1	0.740
Upper Middle-Income country	217	0.143	0.351	0	1	0.407
Lower Middle-Income country	217	0.244	0.431	0	1	0.567
Low-Income country	217	0.258	0.439	0	1	0.588

To increase the size of the sample and improve the reliability of the econometric regressions, all countries with data available will be considered, including high-income countries. In addition to increasing the sample size, including high-income countries allows to benchmark all countries and to compare developed and developing countries in terms of efficiency.

Data presented in Table 1 show large heterogeneity in terms of public education spending. The spending per school-age individual varies from $US 30 in the Central African Republic to $US 22,448 in Qatar. The LAYS also varies from a lowest of 2.27 years in South Sudan to a highest of 12.90 years in Singapore. The coefficient of variation, which is a measure of the inequality in the distribution of a variable shows that there is higher inequality with respect to the LAYS compared to the public expenditure per school-age individual. This may imply that certain countries may not necessarily be translating their spending into quality education properly, when compared to others. Table 2 shows that low-income countries have the lowest spending per individual and the lowest LAYS. The spending per school-age individual and the LAYS both increase with respect to income (as shown by the income groups).

Table 2 Input and output data disaggregated by Income group

	Obs	Mean	Std. Dev.	Min	Max	Coef. Variation
LAYS						
High- Income	48	10.818	1.176	7.630	12.905	9.199
Upper Middle-Income	38	8.094	1.771	4.004	11.900	4.570
Lower Middle-Income	45	6.556	1.635	3.424	10.214	4.010
Low-Income	26	4.528	1.228	2.275	6.890	3.688
Expenditure per school-age individual						
High-Income	53	7488.619	4104.003	1238.602	22448.080	1.825
Upper Middle-Income	45	1612.518	768.749	395.142	3449.911	2.098
Lower Middle-Income	48	581.917	410.910	84.865	2062.425	1.416
Low-Income	29	120.597	54.282	29.981	266.736	2.222

4. Results

The stochastic frontier model discussed in section 2 is estimated using the data presented in section 3. Equations 1 and 2 are simultaneously estimated using the maximum likelihood method discussed by Battese & Coelli (1995). The results allow an assessment of the relationship between public education expenditure and access to quality education, to gauge the efficiency in the use of public education spending and to explore the correlates of the inefficiency.

4.1 Public education expenditure and the learning-adjusted years of schooling

Model 1 in Table 3 provides an estimation of Equation 1 only, while Model 2 gives the results of the simultaneous estimation of Equations 1 and 2. After controlling for country-level inefficiencies related to public expenditure on education, there seems to be a positive correlation between public education spending and the learning-adjusted years of schooling. A higher expenditure per school-age individual is associated with increased access to quality education. However, these results must be interpreted with caution as there might be some endogeneity surrounding this relationship. In fact, the decision made by the government and the international partners to invest in education may be linked to the performance of the education sector. For instance, in countries with poor access to education, there might be a rationale for increased expenditure on education with the hope that this could drive better educational outcomes. Increased expenditure could also contribute to improving the access to quality education. These results should then be understood as a correlational relationship rather than a causality relation.

Although public expenditure on education seems to be correlated with increased years of quality education overall, the relationship appears to be concave and decreases with the level of spending. One additional unit of spending is less associated with increased access to quality education, compared to the previous unit. In other terms, countries that seem to already spend too much on education may not expect to significantly increase the access to quality education by spending more. However, countries that initially spend relatively less on education could expect a stronger correlation between increased spending and educational outcomes, all things being equal. Al-Samarrai, Cerdan-Infantes, & Lehe (2019) also suggest that there is a clear relationship between spending on education and educational outcomes, which decreases with the level of spending. On average, they find that a 10 % increase in spending per child leads to a 0.8 % improvement in the LAYS. Our estimations show that when inefficiencies are controlled for, and when the measurement of public expenditure includes education aid, the relationship between

the spending per school-age individual and the LAYS is much stronger, with a 10 % increase in public spending per school-age individual being associated with 2.28 % improvement in the LAYS.[9] On average, an increase of the LAYS by one additional year requires 55.5 % increase in the spending per school-age individual. For developing countries in particular, it can be approximated that one additional year of quality education costs an additional $US 458 per school-age individual, on average. Given the fiscal constraints in most developing countries, strategies to improve access to quality education should not rely only on the volume of public education spending but could also consider improving the efficiency of spending.

Table 3: Results of the stochastic frontier estimations

	Model 1 (Equation 1 only)	Model 2 (Equation 1 & 2)
Frontier (Equation 1)		
Total public expenditure per school-age individual PPP (expeduc)	0.353***	0.321***
	(0.001)	(0.096)
Total public expenditure per school-age individual PPP (expeduc) squared	-0.013***	-0.013**
	(0.006)	(0.007)
Intercept	0.484***	0.597*
	(0.083)	(0.321)
Inefficiency factors (Equation 2)		
Share of aid in public expenditure (odashare)		4.928
		(3.134)
Unemployment (unemploy)		0.068**
		(0.034)
Primary Completion Rate (pcr)		-0.101***
		(0.023)
Student to Trained Teacher Ratio (sttrm)		-0.001
		(0.009)
Lower Middle-Income country		2.280**
		(1.087)
Upper Middle-Income country		0.970
		(0.708)
Intercept		2.812*
		(1.483)
Number of observations	144	130
	Wald chi2 (2) = 199.2 Prob > chi2 = 0.0000 Average efficiency score: 0.793	Wald chi2(2) = 158.67 Prob > chi2 = 0.0000 Average efficiency score: 0.871

*Significant at 10%; **significant at 5%; ***significant at 1%

The input and output variables are logged, and the marginal effects capture elasticities

[9] It is worth mentioning that endogeneity seems to have little impact on the estimated parameters. Endogeneity will be discussed in section 4.4. Also, the explanatory variables are different in this paper compared to Al-Samarrai, Cerdan-Infantes, & Lehe (2019) as they consider public expenditure from domestic sources per basic and secondary school-age child.

4.2 Efficiency of public education spending

An efficiency score is derived for each country, using the estimations presented in Table 3 (Model 2) along with Equation 3. The efficiency score varies between 0 and 1 and captures the relative capacity of countries to make proper use of the financial resources provided to the education sector. It is important to notice that this is a relative measurement of efficiency and the results may vary if there are changes in the sample of countries considered or in the variables included in the analysis. Table 4 shows that the average efficiency is about 87 %. On average, the LAYS would have been achieved with 13 % less spending if all countries were efficient. In other terms, making all countries as efficient as the most efficient countries in the sample could have saved, on average, 13 % of the public expenditure on education. There are some important cross-country heterogeneities in terms of efficiency of public education expenditure.

The overall efficiency score may hide some important differences between developing and developed countries. Table 4 shows that efficiency is the highest in the category of high-income countries with an average efficiency score of 97 %. In other terms, developed countries seem to be close to the frontier. However, developing countries (low- and middle-income countries) seem to experience a lower efficiency level on average (84 %). The average efficiency is particularly low in low-income countries (75 %) and in Sub-Saharan Africa (74 %). Developing countries in general and low-income countries, in particular, are facing a double challenge: very low expenditure and low efficiency of public expenditure on education. This means that policies aiming to improve access to quality education might consider providing incentives for increased education expenditure but might also address the efficiency issues to make sure that the resources allocated to the education sector are efficiently utilized.

Table 4 Descriptive statistics of the efficiency scores[10]

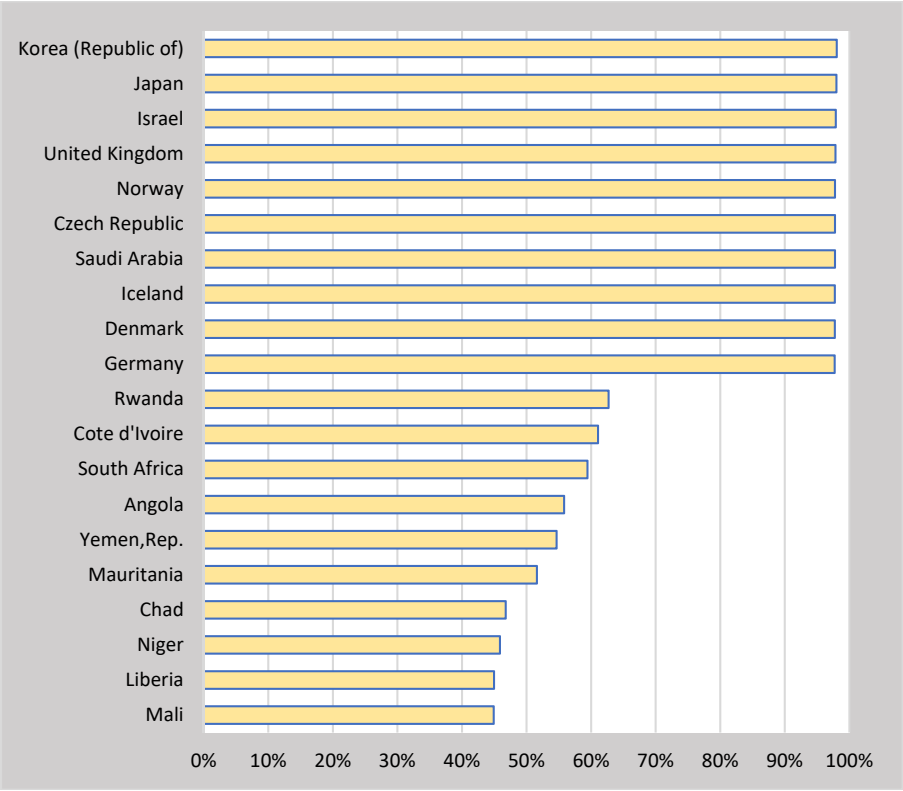
	Obs	Mean	Std.Dev.	Min	Max	Coef. of Variation
	Average efficiency by income group					
Overall	130	0.872	0.131	0.449	0.981	0.150
High-Income	34	0.973	0.008	0.936	0.981	0.009
Upper Middle-Income	33	0.876	0.094	0.594	0.964	0.107
Lower Middle-Income	40	0.852	0.130	0.516	0.975	0.152
Low-Income	23	0.752	0.163	0.449	0.964	0.216
	Average efficiency by region					
East Asia & Pacific	16	0.921	0.071	0.725	0.981	0.077
Europe & Central Asia	38	0.957	0.032	0.802	0.978	0.033
Latin America & Caribbean	19	0.911	0.042	0.827	0.971	0.046
Middle East & North Africa	14	0.890	0.115	0.547	0.979	0.130
South Asia	5	0.900	0.100	0.726	0.964	0.111
Sub-Saharan Africa	38	0.735	0.147	0.449	0.955	0.200

There could be a great potential for cross-country cooperation in terms of efficiency. Figure 4 shows that the Republic of Korea, Japan, Israel, the United Kingdom, and Norway seem to be the most efficient countries in the sample, while Mali, Liberia, Niger, Chad, and Mauritania appear to be the countries with

[10] Data on all variables included in the stochastic frontier model are only available for 130 countries. None of the countries in the North America region is included in the econometric regressions.

the lowest efficiency levels. It can be assumed that countries with the highest efficiency levels have better practices in terms of public education financing and a "transfer of technology" between the most and least efficient countries can be one of the ways to improve efficiency. In other terms, the least efficient countries could learn from the most efficient ones, practices that could potentially drive better use of education expenditure.

Figure 4: Efficiency score by country (top and bottom 10)



Although the countries with the lowest efficiency levels are more likely to be in Sub-Saharan Africa, some countries in this region are performing relatively well. For instance, Table 8 in the annex section shows that countries such as Kenya, Zimbabwe, and Mauritius have an efficiency score above 90 %. This shows that within the same regions or within the same income groups, some countries can be considered as reference countries in terms of efficiency. South-South cooperation between developing countries could then lead to knowledge sharing on how to improve the efficiency of public expenditure on education.

One important policy question that could emerge from the analysis could be to understand how much the best performing developing countries (countries with the highest LAYS and the highest efficiency levels) spend per school-age individual. In other terms, given the experience of other developing countries, how much is reasonable to spend on education, assuring that spending is not too low to produce results, but also, it is not too high to drive inefficiencies, all things being equal. An analysis of clusters is then applied using the efficiency score and the LAYS as variables and applying Ward's (1963) hierarchical clustering

method. The idea of this analysis is to group countries in the way that the variance of the selected variables is maximized across groups but minimized within each group.

On the one hand, a group of 35 countries (group 1 in Table 9 in the annex section) with very low spending (US$ 139 on average), achieve low LAYS (4.9 years on average) and low average efficiency score (77 %). On the other hand, a group of 9 countries (group 2 in Table 9) with a moderately high level of spending (US$ 1,334 on average or between US$ 1,198 and US$ 1,503) registers an average efficiency score (88%) and a level of LAYS (8 years on average) among the highest in the sample. This group of countries could be considered as a reference group in terms of efficiency of public expenditure on education in developing countries. It may be important to take a closer look at the qualitative and quantitative factors behind efficiency in these countries and draw some lessons that could be shared with the other countries.[11]

4.3 Efficiency correlates

Table 3 (Model 2) shows that households' demand for education and the capacity of the education system to deliver basic education as reflected by the primary completion rate as well as the situation of the labor market (unemployment rate) are both negatively correlated with inefficiency. In other terms, when the labor market provides a signal for higher employment (low unemployment rate) there seems to be a greater incentive for the education system to efficiently deliver higher quality education using the available resources. This implies that improving the efficiency of public expenditure on education requires coordinated policies involving households, the education system, the labor market and the economy as a whole. The labor market may need to signal a need for increased quality education, households should be willing to enroll their kids into the education system and finally the education system needs to react to these incentives provided by the households and the labor market. There is an increasing literature on the coordination between the education system and the labor market highlighting this issue in many developing and developed countries (Psacharopoulos, 1986; Dumartin, 1997; Vincens, 2005). The current study stresses that this lack of coordination could be associated with increased inefficiency of public education spending.

Other factors could be correlated with the efficiency of education expenditure (Table 5). The composition of education aid seems to matter for efficiency. There is a positive correlation between the share of technical assistance in the overall ODA received by low- and lower middle-income countries and the efficiency score. Countries that mostly receive education aid through the channel of technical assistance have a higher efficiency level. This finding could have some implications for education aid providers, although the relationship between technical assistance and efficiency needs to be further investigated. The quality of the countries' institutions also matters for efficiency. There is a positive correlation between the efficiency score and two the World Bank's Country Policy and Institutional Assessment (CPIA) scores: The quality of policies for social inclusion and equity and the quality of structural policies.

[11] These 9 countries are: Mongolia, Kazakhstan, Colombia, Ecuador, Jamaica, Panama, Algeria, Jordan and Gabon. The scope of the current study is not to focus on a particular country but to provide an overall benchmarking exercise that could be useful to identify the most efficient countries. This offers the opportunity for future studies to perform a deeper dive on the causes of efficiency in particular countries or groups of countries.

Table 5: Other correlates of the efficiency score

	Coefficient of Correlation
CPIA-Public sector management and institutions	0.1547
CPIA- Economic management	0.1547
CPIA-Policies for social inclusion/equity	0.3517*
CPIA- Structural policies	0.2448*
CPIA- Transparency, accountability, and corruption in the public sector	-0.0716
Education aid/Non-technical assistance	-0.0347
Education aid/Technical assistance	0.2968*
Share of aid for technical assistance	0.2584*
Corruption Perception Index	0.0448

*Significant at 10% level

4.4 Robustness check

There are two main assumptions that could have significant impacts on the results discussed so far: Potential endogeneity issues in Equation 1 and the assumption regarding the distribution of the efficiency parameter (λ). The purpose of this section is to better understand the extent to which the results hold given alternative assumptions.

Controlling for potential endogeneity issues

As discussed above, the relationship between education expenditure and access to quality education could face some endogeneity issues for several reasons. For instance, countries with low achievements in learning might be encouraged to spend more on education, expecting an improvement of educational outcomes. Higher spending can also have an influence on access to quality education. There may be a reverse causality relationship between public education expenditure and the LAYS. There is a promising literature on the estimation of scholastic frontier models with instrumental variables, but applications are very limited in the literature (Amsler, Prokhorov, & Schmidt, 2016; Kutlu, 2018). Amsler, Prokhorov, & Schmidt (2016) provide a review of literature on existing techniques to deal with endogeneity in stochastic frontier models. The most important difficulty related to the application of an IV technique is related to finding a strong and valid instrument for public expenditure.

A good instrument should be strongly correlated with education expenditure and not directly to the LAYS. The government's level of debt seems to have a strong correlation with government expenditure on social sectors, including education. However, it could be difficult to imagine a direct relationship between public debt and the LAYS. The government's debt service as a percentage of total expenditure as well as the debt stock as a percentage of the GNI are used as instruments. The 2SLS method for stochastic frontier models suggested by Amsler, Prokhorov, & Schmidt (2016) is applied to Equation 1 and results are presented in Table 6.

Table 6 IV-Stochastic Frontier model

	Model 1 SFA	Model 2 IV-SFA
expeduc	0.353***	0.309***
	(0.001)	(0.058)
expeduc squared	-0.013***	-0.018***
	(0.006)	(0.004)
Intercept	0.484*	0.831***
	(0.252)	(0.252)
Observations	144	99
	Wald chi2(2) = 199.2 Prob > chi2 = 0.0000 Average efficiency score: 0.793	Wald chi2(2) = 28.99 Prob > chi2 = 0.0000 Average efficiency score: 0.797

*Significant at 10%; **significant at 5%; ***significant at 1%
The input and output variables are logged, and the marginal effects are elasticities

Model 1 in Table 6 estimates Equation 1 applying a basic stochastic frontier model (similarly to model 1 in table 3) and model 2 provides an IV estimation of the same equation.[12] The estimated marginal effects decrease when endogeneity is controlled for. This means that the effects of public education expenditure on the access to quality education may be over-estimated in Table 3 as a result of endogeneity but remains positive and significant when endogeneity is controlled for. Therefore, the average efficiency seems to slightly increase by less than 1 percentage point in the IV model, but the overall empirical distribution of the efficiency scores changes only slightly. This implies that even though endogeneity is ignored in this analysis, the effect of endogeneity on the estimated efficiency scores remains small. It is important to mention that given the missing data related to the instrumental variables, estimating an IV-SFA model along with the control variable would have decreased the sample size to less than 80 countries. This is the reason why the basic SFA model is preferred because it offers better country coverage as well as a higher degree of freedom in the econometric estimations.

Distribution of the efficiency scores

The model discussed in section 2 assumes that the inefficiency parameter (λ) follows a half-normal distribution. There are two alternative distributions commonly used in the literature: The truncated-normal distribution and the exponential distribution. Table 7 shows that the half-normal and the exponential distributions provide very similar average efficiency while the efficiency estimated applying the truncated normal distribution seems lower. This could imply that the efficiency of public education expenditure estimated in this paper using a half-normal distribution provides average efficiency levels.

[12] The two instruments are strongly correlated to LAYS in the first stage regression with an F statistic of 11. However, a test of over-identification could not be performed because of the lack of proper methodology.

Table 7 Different distributions for the inefficiency parameter (λ)

Variable	Obs	Mean	Std.Dev.	Min	Max	Coef. Variation
Half-Normal	130	0.872	0.131	0.449	0.981	0.150
Truncated-Normal	130	0.835	0.142	0.420	0.992	0.170
Exponential	130	0.876	0.125	0.443	0.976	0.143

5. Conclusion and Discussion

The purpose of this paper is to assess the efficiency of public education expenditure to deliver good quality education, in the light of the learning-adjusted years of schooling (LAYS). A stochastic frontier model is applied to data from 130 countries including 96 developing countries and 34 high-income countries. Overall, the results show a positive and significant relationship between expenditure per school-age individual and the LAYS, when countries' contextual factors (including inefficiencies in use of public financial resources dedicated to the education sector) are controlled for. This relationship seems to hold after controlling for potential endogeneity issues.

The average efficiency is about 87 % overall and 84 % in developing countries. This illustrates that approximately 16 % of public resources (including education aid) dedicated to education in developing countries are wasted because of some inefficiencies in these countries. The efficiency level seems to be particularly low in low-income countries (74%). Countries with the lowest spending levels seem to register the lowest LAYS and the lowest efficiency levels. This means that most developing countries are facing a double issue related to the "quantity" and the "quality" of public expenditure on education. Improving access to quality education requires these two issues to be solved simultaneously.[13] In other terms, education expenditure needs to improve along with the efficiency in the use of public resources dedicated to the education sector in order to drive better educational outcomes.

Even though efficiency factors could vary by country, there are two main correlates for the efficiency of public education expenditure: Governance-related factors and countries' labor market conditions. On the one hand, better institutional capacity and especially better quality of policies for social inclusion and equity seem to be correlated with higher efficiency of public education expenditure. On the other hand, low unemployment rates are also associated with higher efficiency. This latter result is particularly interesting in the sense that this could imply that the labor market's signals for increased labor demand seem to be correlated with higher incentive to efficiently use the available resources to deliver better access to good quality education. In other terms, the coordination between the labor market and the education system seems to matter for the efficiency of public expenditure on education. The composition

[13] Al-Samarrai, Cerdan-Infantes, & Lehe (2019) conclude that countries with fiscal flexibility, low spending, and poor outcomes are the best candidates for increasing education funding, especially if they start from a very inefficient point. The current paper rather suggests that improving spending in an inefficient context will not necessarily bear the expected results unless the sources of the inefficiencies are addressed. Countries with lower spending offer a greater opportunity for increased educational outcomes through improved expenditure on education, but this requires inefficiency drivers to be identified and addressed.

of education aid also matters for efficiency, a higher share of technical assistance in education aid appearing to be associated to better efficiency. Although the current study allows benchmarking countries and finding out countries with the best practices in terms of the efficiency of education expenditure, there is still a need to better understand the efficiency drivers in the context of certain countries.

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Annex

Table 8 Efficiency score by Country

Rank	Country Name	Efficiency	Rank	Country Name	Efficiency
1	Mali	0.449	66	Lao PDR	0.929
2	Liberia	0.450	67	Azerbaijan	0.931
3	Niger	0.459	68	El Salvador	0.932
4	Chad	0.468	69	Albania	0.932
5	Mauritania	0.516	70	Mauritius	0.932
6	Yemen, Rep.	0.547	71	Malaysia	0.932
7	Angola	0.558	72	Bangladesh	0.933
8	South Africa	0.594	73	Armenia	0.934
9	Côte d'Ivoire	0.611	74	Luxembourg	0.936
10	Rwanda	0.627	75	Croatia	0.937
11	Botswana	0.654	76	Peru	0.938
12	Burkina Faso	0.671	77	Colombia	0.943
13	Gabon	0.682	78	Ecuador	0.943
14	Namibia	0.694	79	Bulgaria	0.944
15	Senegal	0.695	80	Moldova	0.946
16	Eswatini	0.699	81	Serbia	0.947
17	Sudan	0.701	82	Cambodia	0.952
18	Congo, Rep.	0.718	83	Zimbabwe	0.953
19	Lesotho	0.724	84	Indonesia	0.955
20	Solomon Islands	0.725	85	Kenya	0.955
21	Pakistan	0.726	86	Russian Federation	0.955
22	Mozambique	0.732	87	Greece	0.955
23	Ethiopia	0.744	88	Myanmar	0.955
24	Madagascar	0.775	89	Georgia	0.956
25	Uganda	0.783	90	Mongolia	0.958
26	Guinea	0.795	91	Philippines	0.961
27	Comoros	0.800	92	Tajikistan	0.962
28	Macedonia, FYR	0.802	93	Sri Lanka	0.963
29	Vanuatu	0.811	94	Kyrgyzstan	0.964
30	Sierra Leone	0.816	95	Kazakhstan	0.964
31	Lebanon	0.817	96	Nepal	0.964
32	Jamaica	0.827	97	Trinidad and Tobago	0.964
33	Morocco	0.829	98	Slovak Republic	0.965
34	Algeria	0.836	99	Ukraine	0.965
35	Cameroon	0.837	100	Chile	0.967
36	Tanzania	0.840	101	Spain	0.968
37	Gambia, The	0.841	102	Kuwait	0.969
38	Ghana	0.846	103	Qatar	0.969
39	Dominican Republic	0.855	104	Poland	0.970

40	Tonga	0.857	105	Uruguay	0.971
41	Burundi	0.858	106	Macao SAR, China	0.972
42	Guyana	0.862	107	Hungary	0.972
43	Guatemala	0.862	108	Switzerland	0.973
44	Malawi	0.876	109	Malta	0.973
45	Panama	0.877	110	Cyprus	0.974
46	Honduras	0.880	111	Latvia	0.975
47	Benin	0.884	112	Vietnam	0.975
48	Tunisia	0.885	113	Finland	0.976
49	Timor-Leste	0.885	114	Bahrain	0.976
50	Zambia	0.886	115	Estonia	0.976
51	Paraguay	0.892	116	Lithuania	0.976
52	Egypt, Arab Rep.	0.893	117	Italy	0.976
53	Iran, Islamic Rep.	0.904	118	Slovenia	0.976
54	Jordan	0.906	119	Austria	0.976
55	Nicaragua	0.909	120	Sweden	0.977
56	Costa Rica	0.910	121	Germany	0.977
57	Congo, Dem. Rep.	0.911	122	Denmark	0.977
58	Togo	0.913	123	Iceland	0.978
59	Thailand	0.914	124	Saudi Arabia	0.978
60	Romania	0.915	125	Czech Republic	0.978
61	India	0.917	126	Norway	0.978
62	Turkey	0.922	127	United Kingdom	0.978
63	Argentina	0.924	128	Israel	0.979
64	Mexico	0.926	129	Japan	0.980
65	Brazil	0.929	130	Korea, Rep.	0.981

Table 9 Grouping developing countries based on efficiency and the LAYS levels

		Efficiency score	LAYS	Expenditure per school-age individual
Group 1 (34 countries)	Mean	0.854	6.903	632.418
	Std.Dev	0.113	1.415	218.417
	Min	0.547	4.113	306.686
	Max	0.975	10.214	1051.486
Group 2 (9 countries)	Mean	0.882	8.128	1334.451
	Std.Dev	0.091	1.641	108.553
	Min	0.682	6.027	1197.642
	Max	0.964	11.469	1502.583
Group 3 (35 countries)	Mean	0.777	4.911	139.063
	Std.Dev	0.160	1.289	58.922
	Min	0.449	2.339	35.456
	Max	0.964	7.675	266.736
Group 4 (18 countries)	Mean	0.894	8.758	2256.409
	Std.Dev	0.100	1.849	514.649
	Min	0.594	5.107	1624.750
	Max	0.965	11.900	3449.911
Overall (96 countries)	Mean	0.836	6.639	822.863
	Std.Dev	0.135	2.077	815.858
	Min	0.449	2.339	35.456
	Max	0.975	11.900	3449.911