# METHODOLOGY FOR THE REPLENISHMENT INDICATORS

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GPE Transforming Education

# 1. Number of individuals with three additional years of quality education and number of children achieving minimum proficiency in primary reading

***Enable 175 million girls and boys to learn.***

The methodology applied to estimate the number of children who will be learning by 2025 is threefold: (i) Estimate the amount of spending necessary to increase the learning-adjusted years of schooling (LAYS) by one additional year, (ii) link the LAYS with the proportion of children achieving minimum proficiency levels in reading, and (iii) estimate the number of children that the Global Partnership for Education's contribution could help achieve minimum proficiency levels.

## 1.1. Cost of one additional year of LAYS

The relationship between the LAYS and education financing was previously investigated by Al-Samarrai, Cerdan-Infantes and Lehe in 2019.[1] On average, they find that a 10 percent increase in the spending per child leads to a 0.8 percent improvement in the LAYS. There are two main drawbacks associated with this estimation: (i) inefficiencies of public education spending are not controlled for, and (ii) education expenditure does not include official development assistance (ODA). Miningou addressed these issues in 2019 by estimating a stochastic frontier model in which spending inefficiencies are accounted for and education aid is included as a component of public education spending.[2]

Miningou (2019) shows that when inefficiencies are taken into consideration, 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 than

[1] S. Al-Samarrai, P. Cerdan-Infantes, and J. Lehe, "Mobilizing Resources for Education and Improving Spending Effectiveness: Establishing Realistic Benchmarks Based on Past Trends" (Policy Research Working Paper 8773, World Bank, Washington, DC, 2019). https://ideas.repec.org/p/wbk/wbrwps/8773.html.

[2] See E. W. Miningou, "Quality Education and the Efficiency of Public Expenditure: A Cross-Country Comparative Analysis" (Policy Research Working Paper 9077, World Bank, Washington, DC, 2019), http://documents1.worldbank.org/curated/en/751241575986941436/pdf/Quality-Education-and-the-Efficiency-of-Public-Expenditure-A-Cross-Country-Comparative-Analysis.pdf, for technical details on the stochastic frontier model as well as the data used. Controlling for inefficiencies does not mean that assumptions are being made regarding the efficiency of the spending. A parameter is added to the econometric model to capture cross-country heterogeneity in the efficiency of education expenditure. These heterogeneities could lead to a bias in the estimation of the effect of spending on the LAYS. Controlling for these heterogeneities improves the quality of the estimations. For most GPE countries, it is likely that inefficiencies are a concern—and adjustment is therefore made in our calculations.

what is previously estimated.[3] A 10 percent increase in public spending per school-age individual is associated with a 2.28 percent improvement in the LAYS. For developing countries, it can be approximated that one additional year of quality education costs an additional US$458 per school-age individual (all levels of education), on average. The equivalent figure for low-income and lower-middle-income countries (GPE focus countries) is given in Table 1.

**TABLE 1: COST OF ONE ADDITIONAL YEAR OF QUALITY EDUCATION (LAYS)**

| | Low- income countries | Lower-middle-income countries |
|---|---|---|
| Average LAYS | 4.5 | 5.8 |
| Actual average annual public spending per school-age child (government expenditure + ODA) | 106 | 373 |
| Miningou (2019)* | | |
| Average public cost of one additional year of quality education | 118 | 398 |
| Minimum public cost of one additional year of quality education (lower conf. interval) | 49 | 165 |
| Maximum public cost of one additional year of quality education (upper conf. interval) | 188 | 631 |
| Al-Samarrai, Cerdan-Infantes and Lehe (2019)** | | |
| Cost of one additional year of quality education in low and middle-income | 290 | 805 |

Note: A 95 percent confidence level is used to build confidence intervals. Given the small sample size used by Miningou (2019) to estimate the effect of public education spending on the LAYS (130 observations), the level of precision in the estimations is limited and this leads to large confidence intervals. ODA = official development assistance.

* The annex presents the stochastic frontier model used by Elise Miningou, "Quality Education and the Efficiency of Public Expenditure."

** Al-Samarrai, Cerdan-Infantes and Lehe, "Mobilizing Resources for Education and Improving Spending Effectiveness."

It is important to note that the 2019 studies by both Miningou and Al-Samarrai, Cerdan-Infantes and Lehe found a concave relationship between education spending and the LAYS. One additional unit of spending is associated with a stronger increase of the LAYS in countries with a low level of spending and low LAYS, compared with the countries with a high level of spending and high LAYS. In other words, for countries with very low spending per school-age child, increasing the LAYS by one additional unit would

[3] The population of pre-primary, primary, secondary and higher education age is considered. Education expenditure covers all subsectors. Controlling for inefficiency does not mean that assumptions are being made on whether countries are efficient or not. A stochastic parameter is being added to the econometric model (see appendix A) to "isolate" the effect of inefficiency on the relationship between the LAYS and the education spending.

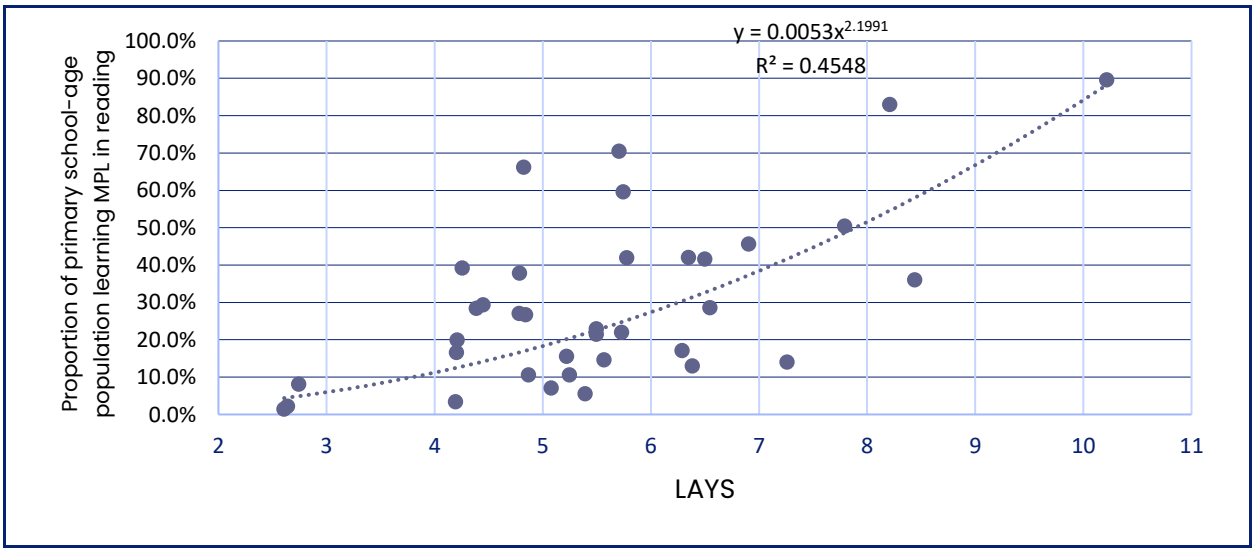
require much less additional spending, compared with the averages estimated above. One additional unit of LAYS costs less in low-income countries (LICs), compared to lower-middle-income countries (LMICs) because of the lower levels of spending and the low level of the LAYS in LICs.

It seems important to note that the figures presented in Table 1 are related to the additional spending per child required to move the LAYS by one additional year (all things being equal), in addition to what is already spent. These do not refer to annual spending but are related to the overall increase that is necessary to "buy" one additional LAYS, all things being equal. In other terms, spending could be spread over years.

## 1.2. Linking the LAYS to the proportion of children achieving minimum proficiency levels

Given the lack of data on the proportion of children achieving minimum proficiency levels (MPL),[4] it is difficult to establish a direct relationship between education expenditure and the MPL. There are many ways to deal with the lack of data, one of them being to explore this relationship using a scatter plot (Figure 1).

**FIGURE 1: PROPORTION OF PRIMARY SCHOOL-AGE CHILDREN ACHIEVING A MINIMUM PROFICIENCY LEVEL IN READING AND LAYS**




[4] Only 37 countries have at least one data point available between 2005 and 2018.

The relationship between the proportion of children achieving MPL and the LAYS seems to be best approximated by the following equation:[5]

$$Proportion\ meeting\ MPL = 0.0053 * LAYS^{2.1991} \quad (1)$$

Equation (1) shows that 45 percent of the cross-country variations of the proportion of children meeting the minimum proficiency levels are explained by differences in the LAYS.[6] Each level of the proportion of children achieving minimum proficiency levels in primary education can be determined using the average LAYS. For instance, this equation predicts that an average of nine years of LAYS corresponds to 66.5 percent of primary school-age children reaching minimum proficiency levels. Data show that countries with a LAYS between 8 and 10 register on average, 64.8 percent of primary school-age children reaching minimum proficiency level, showing that this equation seems to well capture the relationship between the two variables.

One main drawback associated with this approach is that factors other than the LAYS that could potentially influence the proportion of primary school-age children achieving minimum proficiency level are ignored.

### 1.3. Estimating the number of individuals with three additional years of quality education and the number of children achieving minimum proficiency levels

To determine the number of additional children that the partnership would support in 2020-2025, some key assumptions are made:

- **Assumption 1:** Public funding for improved learning comes from four main sources: GPE Fund, increased domestic public financing, savings from better use of government expenditure and increased ODA.
- **Assumption 2:** The additional funds available in the period 2020-2025 are used to increase the LAYS to nine years (basic education in most GPE countries) among a given group of children who are not learning the basics. The equivalent number of children supported to reach nine LAYS depends on the cost of one additional LAYS and the financial resources available.
- **Assumption 3:** To measure the potential impact of the additional financing, it is assumed that the partnership would focus on the children who are learning below minimum proficiency levels.

[5] A linear trend line provides an R2 value of 39 percent. This functional form provides the highest R2 value.
[6] Removing outliers from the sample generates a model that predicts similar outcomes for the proportion of children meeting MPL.

- **Assumption 4:** An equivalent of the actual government expenditure and ODA is necessary to maintain the current level of learning. Any additional spending from the government and the donors (any future spending on top of the current level) is translated into additional children achieving minimum proficiency levels.
- **Assumption 5:** The partnership's efforts to improve the efficiency of education expenditure would result in savings that would be used to improve learning.
- **Assumption 6:** The allocation of the GPE Fund among LICs and LMICs remains the same as the current allocation (70 percent for LICs and 30 percent for LMICs).
- **Assumption 7:** The average cost of one additional LAYS is $118 for LICs and $398 for LMICs as estimated by Miningou.[7]
- **Assumption 8:** GPE would advocate for education aid not to decline given the pandemic. ODA would be maintained at its current level.
- **Assumption 9:** Because of the pandemic, domestic financing for education would decline in 2020, following the projections of the economic growth performed by the IMF's World Economic Outlook published in April 2020. Domestic financing for education would start increasing from 2021 going forward and will reach the long-term growth rates by 2030. In other words, the recovery of domestic education financing would happen from 2030 going forward. This appears to be a very conservative assumption because the impact of the pandemic on government finance is not expected to last until 2030.
- **Assumption 10:** GPE would incentivize efficiency improvements in partner countries. Currently, efficiency increases by 1 percentage every year and the partnership's effort would result in a 1.3 percentage point improvement of the efficiency annually.
- **Assumption 11:** GPE would raise $8 billion for the period 2020-2025 ($5 billion direct contributions to the GPE Fund and $3 billion through the GPE Multiplier funding mechanism).

[7] Miningou, "Quality Education and the Efficiency of Public Expenditure."

Given these assumptions, the total amount of available resources is given in Table 2. The total additional funding from the partnership in 2020-2025 is estimated at $53.3 billion.[8]

**TABLE 2: RESOURCES AVAILABLE IN 2020-2025 BY SOURCE (US$, BILLIONS)**

| | | LICs | LMICs-UMICs | Total |
|---|---|---|---|---|
| Direct contribution from the GPE Fund ($5 billion) and the Multiplier ($3 billion) | | 5.6 | 2.4 | 8.0 |
| Savings from efficiency (2020-2025) | | 1.1 | 14.6 | 15.7 |
| Domestic financing | Baseline | 16.9 | 224.1 | 241.0 |
| | Additional (2020-2025) | 1.0 | 28.6 | 29.6 |
| Official development assistance | Baseline | 3.4 | 5.7 | 9.1 |
| | Additional (2020-2025) | - | - | - |
| Total | | 7.7 | 45.6 | 53.3 |

Note: LICs = low-income countries, LMICs = lower-middle-income countries, UMICs = upper-middle-income countries.

Based on the total financial resources available in 2020-2025 and the unit cost of quality education, it is estimated that the additional financial resources for education would be used to "buy" 3.3 years of quality schooling for 50.3 million individuals. The current average LAYS in GPE countries is 5.7 years and the partnership's intervention would allow 50.3 million additional individuals to reach nine LAYS.[9]

Using the established relationship between the LAYS and the proportion of children learning the basics in primary education, it is estimated that 50.3 million individuals achieving nine LAYS would translate to 33.5 million additional children achieving minimum proficiency level in primary reading (Table 3). Currently, 141.8 million children are learning the basics of primary reading in the 88 GPE countries. The proportion of children learning the primary education basics is 34.3 percent. With the 33.5 million additional children learning, a total of 175.3 million (rounded to 175 million) children would be achieving minimum proficiency levels by 2025, which corresponds to 39.1

[8] It is important to note that a group of three experts from the United Nations Children's Fund (UNICEF), the Global Education Monitoring (GEM) Report and RTI International reviewed our approach to estimate the financial resources available in 2020-2025. They have also provided useful recommendations on how best to estimate the number of children with access to quality education given the partnership's intervention.

[9] Nine years of schooling is equivalent to basic education in most GPE partner countries.

percent of the primary school-age population in the 88 GPE partner countries (Figure 2).

**FIGURE 2. PROPORTION AND NUMBER OF CHILDREN ACHIEVING THE MINIMUM PROFICIENCY LEVEL IN PRIMARY READING**

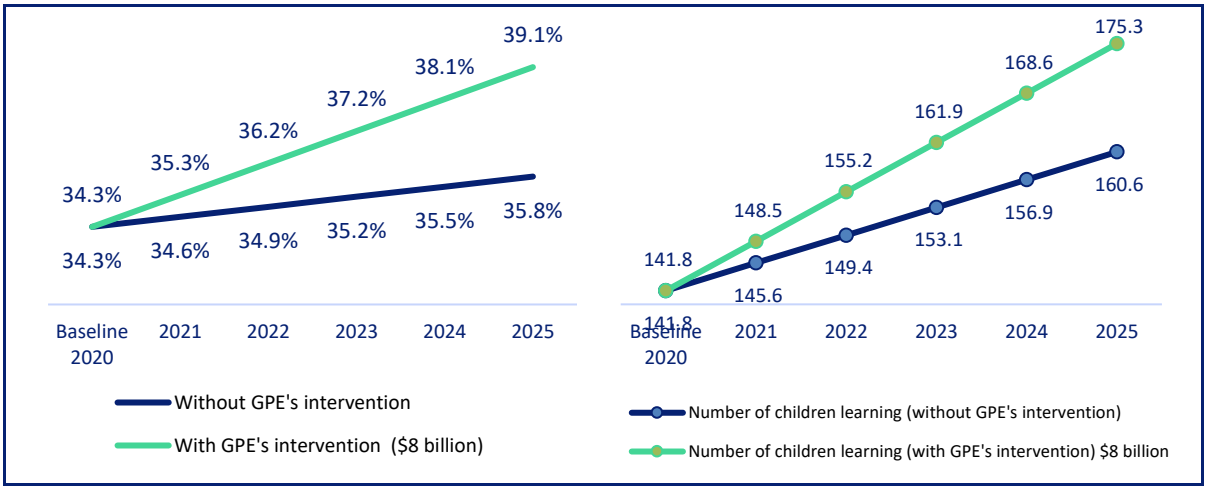



**TABLE 3: ESTIMATED ADDITIONAL NUMBER OF CHILDREN ACHIEVING THE MINIMUM PROFICIENCY LEVEL IN PRIMARY READING (MILLIONS)**

| | GPE Fund | Savings from efficiency | Domestic financing | Official development assistance | Total |
|---|---|---|---|---|---|
| Additional number of children achieving the minimum proficiency | 8.3 | 9.0 | 16.2 | - | 33.5 |

## 2. Number of school-age children enrolled

***Get 88 million more children, including 46 million more girls, in school.***

To estimate the total number of children (including girls) who could be potentially enrolled in pre-primary, primary and secondary education thanks to the partnership's overall contribution, projections of the gross enrollment rates (GERs) are performed. These projections make use of the estimations of the amount of money that the partnership is expecting to invest in education in 2020-2025 (section 1 above).

There is a correlation between education spending and school enrollments. For each additional unit of spending spent, the GER increases by a certain percentage. This correlation is explored using an econometric regression (a fixed-effects econometric

model). The fixed-effects model allows us to take into consideration country individual characteristics (any factors that are specific to each country).

$$LogGER_{it} = \beta_0 + \beta_1 logEduExpchild_{it} + \beta_2 logEduExp_{per_{it}}{}^2 + u_{it} + \varepsilon_i \quad (2)$$

with $LogGER_{it}$, the natural logarithm of the gross enrollment rate of country *i* at time *t*, $logEduExpchild_{it}$, the log of the education expenditure per school-age child, $\beta$ a series of parameters to be estimated, $u_{it}$ the residuals of the regression, and $\varepsilon_i$ individual fixed effects that capture specific factors affecting each country *i*.[10]

Equation (2) is estimated using various dependent variables: pre-primary GER, primary GER, lower secondary GER and upper secondary GER. The data are collected from four main sources: The World Development Indicators, UNESCO Institute for Statistics (UIS), UN Population and EdStats. These data cover the period 1970-2016. Table 4 presents the effects of a 1 percent increase in the spending per child on the GER.

**TABLE 4: RESULTS OF THE FIXED-EFFECTS ECONOMETRIC REGRESSION ON THE GER**

| | Marginal effects associated with 1% increase in the spending per child | Standard errors |
|---|---|---|
| Pre-primary GER | 0.75% | (0.237) |
| Primary GER | 0.11% | (0.080 |
| Lower secondary GER | 0.31% | (0.137) |
| Upper secondary GER | 0.45% | (0.141) |

Note: All marginal effects are statistically significant at 1% level. GER = gross enrollment rate.

The average spending per child in the 88 GPE countries is $206. Given the partnership's expected investment in the period 2020-2025 (direct investment through the GPE Fund, additional domestic financing for education, savings from efficiency improvements and additional investment from other partners), the average spending per school-age child is expected to increase to $224 on average for the period 2020-2025. Using the results of the econometric regression (Table 4), the marginal impact of the partnership's investment on the GER is calculated and converted into the

[10] Using the logs of the variables allows a direct estimation of the elasticities: the impact on the dependent variable (in percent), given a 1 percent increase in the regressor. Also, the log-linear functional form and the fixed-effects model are preferred when some specification tests are performed, comparing these specifications with some alternative models (random effects model and different functional forms).

number of additional children with access to education, using UIS school-age population data and UN Population projections.

The results show that the additional spending over the period 2020-2025 would allow 88.1 million additional children of pre-primary, primary and secondary education age to be enrolled. Currently, around 48.4 percent of the children enrolled in pre-primary, primary and secondary education are girls. Given the partnership's focus on girls in 2020-2025, it is assumed that the proportion of girls enrolled would improve by 0.5 percentage points every year.[11] In other terms, 50.8 percent of the 88.1 million additional children who would be enrolled between 2020 and 2025 would be girls (45.7 million, of which about 40 million in primary and secondary education and 6 million in pre-primary education). [12]

## 3. Number of teachers trained and number of students benefiting from trained teachers

***Reach at least 140 million students with better education through 3.5 million newly trained teachers.***

Using data from GPE's grant documents, it is estimated that the average unit cost of teacher training in GPE countries is $371. Currently, 16.2 percent of the GPE grants' volume is supporting teacher training and teacher development activities in general. With an $8 billion replenishment, it is assumed that $1.3 billion (16.2 percent of the replenishment) would support teacher training, leading to 3.5 million teachers trained. Assuming the recommended 40:1 student to teacher ratio, it is estimated that 139 million (rounded to 140 million) additional students would benefit from trained teachers.

## 4. Saving from the efficient utilization of resources

***Save $16 billion through more efficient education systems, enabling these funds to be reinvested in education for the most marginalized children.***

As already discussed in section 1, assessing the efficiency of public spending on education shows that since 1990, on average, GPE countries have been achieving the same results (lower secondary completion) with approximately 1 percent fewer

[11] The 0.5 percentage point is somehow arbitrary and should be seen as the partnership's aspiration regarding gender equality.
[12] These estimations were done separately for LICs and LMICs and aggregated to obtain the figures presented.

resources.[13] Equivalently, countries have been achieving 1 percent more results with the same resources from one year to another. It is assumed that GPE would contribute to increasing the efficiency level to 1.3 percent annually. Spending 1.3 percent less for the same outcomes every year would lead to a total of $15.7 billion (rounded to $16 billion) in savings in the 88 GPE partner countries. It is assumed that the $16 billion is reinvested in the sector, which would contribute to the total 175 million children achieving minimum proficiency level estimated in section 1.

## 5. Impact of the partnership's investment on the economy

***Add $164 billion to the global economy.***

By allowing more children to have access to quality education, GPE's intervention could have a long-term impact on the gross domestic product (GDP), assuming that the additional children that GPE would help acquire quality education would be actively involved in the economy.

Many studies in the literature attempted to establish a causal relationship between years of schooling and GDP.[14] Hanushek and Woessmann show that each year of schooling is statistically significantly associated with a long-run growth rate that is 0.58 percentage points higher.[15] Hanushek and Woessmann also show that learning matters for economic growth.[16]

In Table 5, Hanushek and Woessmann econometric specification was applied on more recent data, but the mean years of schooling is replaced by the learning-adjusted years of schooling.[17] The results show that one additional unit of LAYS is associated with

[13] A stochastic frontier model is estimated using the spending per school-age child as an input and the lower-secondary completion rate as an output.
[14] R. Barro, "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, 106, no. 2 (May 1991): 407-443, http://piketty.pse.ens.fr/files/Barro91.pdf; R. Barro, *Determinants of Economic Growth: A Cross-Country Empirical Study* (Cambridge, MA: The MIT Press, 1997), https://mitpress.mit.edu/books/determinants-economic-growth; G. Mankiw, D. Romer, and D. N. Weil, "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics* 107, no. 2 (1992): 407-437, https://eml.berkeley.edu/~dromer/papers/MRW_QJE1992.pdf; E. A. Hanushek and L. Woessman, "The Role of Education Quality in Economic Growth" (Policy Research Working Paper 4122, World Bank, Washington, DC, 2007), https://openknowledge.worldbank.org/handle/10986/7154; E. A. Hanushek and L. Woessman, "Do Better Schools Lead to More Growth? Cognitive Skills, Economic Outcomes, and Causation," *Journal of Economic Growth* 17, no. 4 (2012): 267-321.
[15] Hanushek and Woessman, "The Role of Education Quality in Economic Growth."
[16] Hanushek and Woessman, "The Role of Education Quality in Economic Growth"; Hanushek and Woessman, "Do Better Schools Lead to More Growth? Cognitive Skills, Economic Outcomes, and Causation."
[17] Hanushek and Woessman, "The Role of Education Quality in Economic Growth."

0.89 percentage points additional growth (about 30 percentage points above what is originally estimated by Hanushek and Woessmann).[18]

**TABLE 5: ECONOMETRIC RESULTS**

| | Model 1 (dep: GDP per capita 2017) | Model 2 (dep: GDP per capita 2017) |
|---|---|---|
| GDP 1990 | -0.00026*** | -0.00027*** |
| | (0.0001) | (0.0001) |
| Mean years of schooling | 0.381* | |
| | (0.214) | |
| LAYS | | 0.894*** |
| | | (0.218) |
| Constant | 4.087* | -1.454 |
| | (2.354) | (2.369) |
| F | 31.749 | 33.653 |
| R2 | 0.717 | 0.736 |
| *N* | 104 | 112 |
| *Regional dummies* | Yes | Yes |
| *Income group dummies* | Yes | Yes |

Note: F = F-statistics, GDP = gross domestic product, LAYS = learning-adjusted years of schooling, *N* = sample size, R2 = coefficient of determination.
* significant at 10% level, ** significant at 5% level, *** significant at 1%. Robust standard errors are given in parenthesis.

Using these results, it is possible to estimate the impact of the partnership's intervention on GDP in three steps:

- **Step 1**: **Estimate the total number of individuals reached**. Given the unit cost of one additional year of LAYS and the expected additional investment in the education sector (as described in section 1), the total number of children who the partnership would reach is estimated.
- **Step 2**: **Estimate the potential increase in the GDP associated with some additional individuals acquiring quality education**. It is assumed that the partnership would increase the average LAYS from 5.7 to nine years among a specific group of individuals. According to the estimations presented in Table 5, the GDP growth is 0.89 points higher given an increase of one LAYS among the entire population (or 2.9 points for an increase of the LAYS by 3.3 points: 0.86 x

[18] Ibid.

3.3). GPE's intervention is not targeting the entire population. The impact on GDP is then weighed by the size of the population that would directly benefit from GPE's intervention.

- **Step 3**: **Estimate the present value of the additional income generated in the economy for the next 47 years**. It is assumed that the average individual would work from age 18 to 65 (47 years). The overall income generated during this period is discounted using the average inflation rate of 1.69 percent to derive the present value of the impact of GPE's intervention on income.

The results presented in Table 6 show that $1 invested in the GPE Fund would generate $5.1 ($40.8 billion/$8 billion, including the Multiplier). These results are consistent with the literature. For instance, the Education Commission shows that $1 invested in a one-year increase in the mean years of schooling generates more than $5 in additional gross earnings in low-income countries and $2.5 in lower-middle income countries. Heckman et al. found that high-quality early childhood programs can yield a $4-$9 dollar return per $1 invested.[19]

**TABLE 6: ESTIMATED IMPACT OF THE PARTNERSHIP'S INTERVENTION ON GDP (US$, BILLIONS)**

| | GPE Fund | Savings from efficiency | Domestic financing | Official development assistance | Total |
|---|---|---|---|---|---|
| Additional GDP due to 3.3 additional years of LAYS | 40.8 | 44.0 | 79.2 | - | 164.0 |

Note: GDP = gross domestic product, LAYS = learning-adjusted years of schooling.

## 6. Number of people lifted out of poverty

***Lift 18 million people out of poverty.***

A portion of the $164 billion generated (as discussed in section 5) would contribute to increasing households' consumption.[20] The poverty gap is the average amount of money necessary to compensate the average poor so that they can reach the extreme poverty line ($1.90 a day) and become non-poor. In other terms, the poverty gap illustrates the difference between the income of the average poor and the poverty

[19] J. J. Heckman et al., "The Rate of Return to the High/Scope Perry Preschool Program," *Journal of Public Economics* 94, no. 1-2 (2010): 114-128.

[20] The World Bank's World Development Indicators show that households' final consumption as a share of the GDP is about 75 percent in GPE countries.

line. It is assumed that 75 percent of the $164 billion generated in the economy would support households' consumption, allowing some people to reach the extreme poverty line. Given the average poverty gap in GPE countries, it is estimated that the partnership's intervention could potentially allow 17.7 million poor (rounded to 18 million) to reach the extreme poverty line and become non-poor (Table 7).

**TABLE 7: ESTIMATED NUMBER OF INDIVIDUALS LIFTED FROM INCOME POVERTY (MILLIONS)**

| | GPE Fund* | Savings from efficiency | Domestic financing | Official development assistance | Total |
|---|---|---|---|---|---|
| Estimated number of individuals lifted from income poverty | 4.73 | 4.72 | 8.28 | - | 17.73 |

* The impact of the GPE Fund is higher than that of the efficiency savings because GPE would allocate a large share of its funding to low-income countries (70 percent) where the poverty incidence is the highest. By channeling resources to the countries facing poverty, the GPE Fund is expected to make a substantial contribution to poverty reduction.

## 7. Number of lives saved

***Save 3 million lives.***

The Education Commission's report estimates that one additional year of schooling is associated with a 3 percentage point reduction in the mortality rate.[21] Revisiting this relationship using more updated data (Table 8) and accounting for learning allows us to estimate that one additional year of LAYS is associated with a 5.13 percentage point decrease in the mortality rate (-15.556 x 3.3/1,000).[22] The number of lives saved (2.8 million rounded to 3 million) is then derived using the population data and the 5.13 percentage point figure estimated (Table 9).

[21] M. Schäferhoff et al., "Estimating the Economic Returns of Education From a Health Perspective," Prepared by SEEK Development for the International Commission on Financing Global Education Opportunity as a background paper for *The Learning Generation*, Berlin, Germany, 2016, http://report.educationcommission.org/wp-content/uploads/2016/11/Estimating-the-Economic-Returns-of-Education-from-a-Health-Perspective.pdf.

[22] The mortality rate is expressed in terms of 1,000 people.

### TABLE 8: ECONOMETRIC RESULTS

| | Dependent variable: Mortality rate 2017 |
|---|---|
| Mortality rate 2000 | -0.069 |
| | (0.052) |
| LAYS | -15.556*** |
| | (2.801) |
| Intercept | 12.032*** |
| | (2.1) |
| R2 | 0.7041 |
| *N* | 140 |
| *Regional dummies* | Yes |
| *Income group dummies* | Yes |

Note: LAYS = learning-adjusted years of schooling, *N* = sample size, R2 = coefficient of determination. * significant at 10% level, ** significant at 5% level, *** significant at 1%. Robust standard errors are given in parenthesis.

### TABLE 9: ESTIMATED NUMBER OF LIVES SAVED (THOUSANDS)

| | GPE Fund | Savings from efficiency | Domestic financing | Official development assistance | Total |
|---|---|---|---|---|---|
| Estimated number of lives saved | 692.9 | 748.0 | 1,345.6 | - | 2,786.5 |

## 8. Number of girls prevented from early marriage

***Save 2 million girls from child marriage.***

According to a study conducted by the World Bank,[23] one additional year of education reduces the likelihood of child marriage by 7.5 percentage points. It is assumed that GPE's intervention would result in an increase in the average years of schooling among girls, according to the relationship between the LAYS and the education spending discussed earlier. Using the results of the World Bank's study and the equivalent number of girls, it can be approximated that GPE's intervention would prevent 1.86 million girls (rounded to 2 million) from early marriage (Table 10).

[23] Q. Wodon et al., *Educating Girls and Ending Child Marriage: A Priority for Africa*, The Cost of Not Educating Girls Note Series (Washington, DC: World Bank, 2018), http://documents1.worldbank.org/curated/en/268251542653259451/pdf/132200-WP-P168381-PUBLIC-11-20-18-Africa-GE-CM-Conference-Edition2.pdf.

**Table 10: ESTIMATED NUMBER OF GIRLS PREVENTED FROM BECOMING CHILD BRIDES (THOUSANDS)**

| | GPE Fund | Savings from efficiency | Domestic Financing | Official development assistance | Total |
|---|---|---|---|---|---|
| Estimated number of girls prevented from becoming child brides | 464 | 501 | 901 | - | 1,865 |

## References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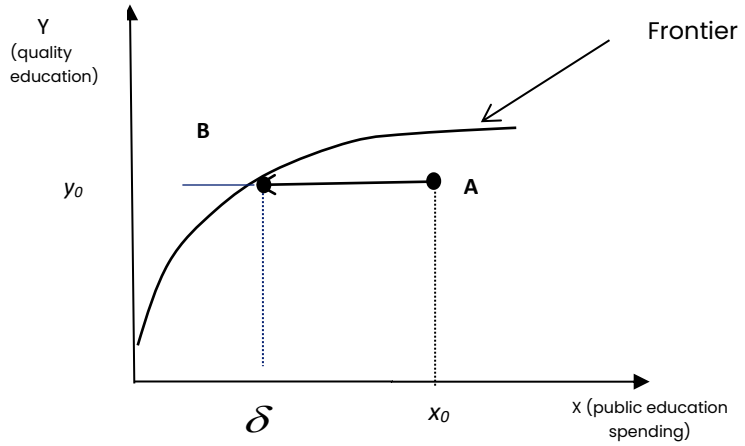
# APPENDIX A: MEASURING THE EFFICIENCY OF PUBLIC EDUCATION EXPENDITURE AND THE COST OF ONE ADDITIONAL UNIT OF LAYS

## Empirical strategy

There are two main approaches to measuring efficiency in the economic literature. A first methodology can be qualified as the "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 a 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.

Figure A.1 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 A.1. 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 ( $\delta x_0$ , with $0 \leq \delta \leq 1$ ), corresponding to point B on the frontier. This means that $x_0 - \delta x_0$ 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 $\delta$, can be used to calculate an efficiency score that reflects the ability of each country to translate their input into output.

**FIGURE A.1: ILLUSTRATION OF THE FRONTIER APPROACH**




The stochastic frontier model will be estimated using equations (1) and (2) below. Consider input $x \in R$, and the output $y \in R$. Following Battese and Coelli,[24] the frontier function is given by:

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

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 $(\lambda_n)$ as well as "noise" $(u_n)$. $\lambda_n$ captures the *inefficiency* with which education expenditure is translated into educational outcomes in country *n*. $u_n$ is normally distributed, while $\lambda_n$ follows a half-normal distribution.[25]

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 and Coelli,[26] equation (2) allows an estimation of the explanatory factors for $\lambda_n$, 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 $\lambda_n$.

[24] G. E. Battese and T. J. Coelli, "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data," *Empirical Economics* 20, no. 2 (1995): 325-32.
[25] There are three distributions commonly used to approximate the inefficiency parameter: truncated normal, half-normal and exponential distributions. Miningou ("Quality Education and the Efficiency of Public Expenditure: A Cross-Country Comparative Analysis") provides a discussion of alternative distributions.
[26] Battese and Coelli, "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data."

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

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

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 $\sigma_w^2$. $Z_n$ is the matrix of explanatory variables that include some explanatory factors of the inefficiency parameter $\lambda_n$, $\eta$ 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 and Coelli,[27] 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 that 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.

## Data

Based on the educational production function theory,[28] 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

[27] Ibid.

[28] S. Bowles, "Towards an Educational Production Function," in *Education, Income, and Human Capital,* ed. W. L. Hansen (Cambridge: National Bureau of Economic Research, 1970), 11-70; S. W. Polachek, T. J. Kniesner, and H. J. Harwood, "Educational Production Functions," *Journal of Educational Statistics* 3, no. 3 (1978): 209-231; E. A. Hanushek, "Educational Production Functions," in *Economics of Education,* ed. G. Psacharopoulos, (Cambridge: Elsevier Science, 1987): 33-42.; and D. H. Monk, "The Education Production Function: Its Evolving Role in Policy Analysis," *Educational Evaluation and Policy Analysis* 11, no. 1 (1989): 31-45.

expenditure as a share of GDP or as a 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 toward 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.[29] The learning-adjusted years of schooling 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 taking learning into consideration. 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.[30] The harmonized learning score is currently the only comparable measure of learning that covers a large number of countries.[31] Without ignoring the limitations surrounding the LAYS (the learning assessments not being from the same period and the linking method used to make learning assessment comparable having some weaknesses as reported by Patrinos and Angrist,[32] this appears to be one of the

[29] A. Kraay, "Methodology for a World Bank Human Capital Index" (Policy Research Working Paper 8593, World Bank, Washington, DC, 2018), https://openknowledge.worldbank.org/handle/10986/30466?locale-attribute=en; A. Kraay, "The World Bank Human Capital Index: A Guide," *World Bank Research Observer* 34, no 1 (2019): 1-33.

[30] N. Altinok, N. Angrist, and H. A. Patrinos, "Global Data Set on Education Quality (1965-2015)" (Policy Research Working Paper 8314, World Bank, Washington, DC, 2018); H. A. Patrinos and N. Angrist, "Global Dataset on Education Quality: A Review and Update (2000-2017)" (Policy Research Working Paper 8592, World Bank, Washington, DC, 2018), https://openknowledge.worldbank.org/handle/10986/30465.

[31] See Patrinos and Angrist, "Global Dataset on Education Quality: A Review and Update (2000-2017)," for a discussion on the harmonized test score as well as its imitations.

[32] Patrinos and Angrist, "Global Dataset on Education Quality: A Review and Update (2000-2017)."

most reliable indicators of quality education that is available and it 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 nonfinancial resources. Financial resources come from three main sources: aid to the education sector (*aid*), government expenditure (*govspend*) and households' spending (*hhspend*).[33] Nonfinancial 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 nonfinancial resources used by the education sector, the primary completion rate (*pcr*) is included a measure of the households' demand for education and the capacity of the education system to deliver basic education, while the student to trained teacher 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.[34] 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.

The output variable is only available for the year 2017. All input and control variables (except dummies) are averaged for the period 2000-2015. 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 considered. 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

[33] Education aid includes sector-allocable ODA to the education sector received by countries included in the sample.
[34] World Bank, *World Development Report 2018: Learning to Realize Education's Promise* (Washington, DC: World Bank, 2018).

World Development Indicators, the UNESCO Institute for Statistics (UIS) and the OECD Creditor Reporting System (OECD-CRS). Table A.1 presents descriptive statistics of the data.

**TABLE A.1: DESCRIPTIVE STATISTICS**

| Variable | Obs. | Mean | Std. dev. | Min. | Max. | Coeff. of variation |
|---|---|---|---|---|---|---|
| **Output (y)** | | | | | | |
| Learning-adjusted years of schooling (LAYS) | 157 | 7.895 | 2.683 | 2.275 | 12.905 | 0.340 |
| **Input (x)** | | | | | | |
| Total public expenditure per school-age individual PPP (expeduc) | 175 | 2862.225 | 3852.216 | 29.981 | 22448.080 | 1.346 |
| **Control variables (z)** | | | | | | |
| Share of aid in public education expenditure (odashare) | 178 | 0.047 | 0.094 | 0 | 0.648 | 1.999 |
| Unemployment rate (unemploy) | 186 | 9.008 | 6.151 | 0.650 | 31.994 | 0.683 |
| Primary completion rate (pcr) | 180 | 87.370 | 18.761 | 25.734 | 138.222 | 0.215 |
| Student to trained teacher ratio (sttr) | 217 | 40.546 | 23.586 | 8.730 | 221.937 | 0.582 |
| High-income country | 217 | 0.355 | 0.480 | 0 | 1 | 1.352 |
| Upper-middle-income country | 217 | 0.143 | 0.351 | 0 | 1 | 2.455 |
| Lower-middle-income country | 217 | 0.244 | 0.431 | 0 | 1 | 1.763 |
| Low-income country | 217 | 0.258 | 0.439 | 0 | 1 | 1.700 |

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

## Results

*Public education expenditure and the learning=adjusted years of schooling*

Model 1 in Table A.2 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 and Lehe (2019) also suggest that there is a clear relationship between spending on education and educational outcomes, which decreases with the level of spending.[35] On average, they find that a 10 percent increase in spending per child leads to a 0.8 percent 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 percent increase in public spending per school-age individual being associated with 2.28 percent improvement in the LAYS.[36] On average, an increase of the LAYS by one additional year requires a 55.5 percent 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 $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.

[35] Al-Samarrai, Cerdan-Infantes and Lehe, "Mobilizing Resources for Education and Improving Spending Effectiveness."

[36] It is worth mentioning that endogeneity seems to have a little impact on the estimated parameters. Endogeneity is discussed by Miningou ("Quality Education and the Efficiency of Public Expenditure: A Cross-Country Comparative Analysis"). Also, the explanatory variables are different in this paper compared to Al-Samarrai, Cerdan-Infantes and Lehe ("Mobilizing Resources for Education and Improving Spending Effectiveness") because they consider public expenditure from domestic sources per basic and secondary school-age child.

## TABLE A.2: RESULTS OF THE STOCHASTIC FRONTIER ESTIMATIONS

| | Model 1 (Equation 1 only) | Model 2 (Equations 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 (sttr) | | -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) = 158.67 |
| | Wald chi2 (2) = 199.2 | Prob > chi2 = 0.0000 |
| | Prob > chi2 = 0.0000 | Average efficiency score: 0.871 |
| | Average efficiency score: 0.793 | |

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

*Efficiency of public education spending*

An efficiency score is derived for each country, using the estimations presented in Table A.2 (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 A.3 shows that the average efficiency is about 87 percent. On average, the LAYS would have been achieved with 13 percent less spending if all countries were efficient. In other terms, making all countries as efficiency as the most efficient countries in the sample could have saved on average, 13 percent 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 A.3 shows that efficiency is the highest in the category of high-income countries, with an average efficiency score of 97 percent. 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 percent). The average efficiency is particularly low in low-income countries (75 percent) and in Sub-Saharan Africa (74 percent). 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 they might also address the efficiency issues to make sure that the resources allocated to the education sector are efficiently utilized.

## TABLE A.3: DESCRIPTIVE STATISTICS OF THE EFFICIENCY SCORES

| | Obs. | Mean | Std. dev. | Min. | Max. | Coeff. of variation |
|---|---|---|---|---|---|---|
| **Average efficiency by income group** | | | | | | |
| Overall | 130 | 0.872 | 0.131 | 0.449 | 0.981 | 0.150 |
| High-income countries | 34 | 0.973 | 0.008 | 0.936 | 0.981 | 0.009 |
| Upper-middle-Income countries | 33 | 0.876 | 0.094 | 0.594 | 0.964 | 0.107 |
| Lower-middle-income countries | 40 | 0.852 | 0.130 | 0.516 | 0.975 | 0.152 |
| Low-income countries | 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 |

Note: 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.

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