Public education spending and school outcomes: Insights from quantile regression

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Public education spending and school outcomes: Insights from quantile regression

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Abstract

The literature on the empirical link between public spending and school outcomes has yielded mixed and largely debated results. Given the current education landscape, where enrolment has improved considerably, it is crucial to reexamine how public spending impacts school performance across different quantiles. To this end, this study employed panel data from low- and lower-middle-income countries (LMICs) from 1990 to 2021 to investigate how public education spending impacts the relationship. It finds that public spending significantly affects enrolment at the median and higher quantiles at pre-primary schools but has an insignificant relationship in low-enrolling countries. The study also finds that spending positively and substantially influences primary school enrolment across all quantiles. Still, it negatively impacts dropout rates, with significant coefficients only in the 50th and higher quantiles. The relationship, however, was statistically insignificant in countries with the lowest dropout rates. While the ineffectiveness of public spending in further reducing school dropout rates in countries with the lowest out-of-school children is obvious, investigating why spending is ineffective during early childhood in low-enrolling countries is an important area for future research.

Keywords: Public spending, School performance, School enrolment, out of school children, Child mortality, Quantile regression

1. Introduction

The importance of providing adequate resources across educational systems to enable all children have equal opportunities to acquire basic education cannot be overstated (Fuller & Clarke, 1994; Kremer, 1995). Schools need a minimum level of financial resources to acquire basic inputs, such as textbooks, study materials, and buildings, and to pay teacher wages (Vegas & Coffin, 2013). To that end, government have often had to make difficult balancing acts between costs, access and quality when planning for education provision (Baker, 2024). Although the role of spending on school outcomes has ignited intense debates and remains a highly contentious issue in education finance literature (Hanushek & Woessmann, 2017; Hedges et al., 1994; Card & Krueger, 1992, 1994; Hanushek, 1981), many policymakers continue to advocate for allocating more budgetary resources to schools. While the main issue is not to spend more or less on schools, but how to get the most rewards out of marginal spending (Hanushek, 1996; Card & Krueger, 1992), attempts to lend empirical credence to these policy prescriptions have often yielded contradictory results in the same way that school outcomes are quantified differently by different researchers (Baker, 2024, Sequeira & Robalo, 2008; Barro & Lee, 2001; Card & Krueger, 1994; Hanushek, 1989).

The human capital theory (Becker, 1962), and the social production function theory (Coleman, 1968) offer useful insights into the importance of funding education. According to the human capital theory, investment in education enhances productivity and earnings potential of individuals, while the lack thereof can reduce the quality of education, enrolments, and also increase dropout rates as children fail to see the value in continuing education. The social production function argues that school outcomes are a function of individual, school and societal factors as it determines teacher training quality, infrastructure, extracurricular opportunities, and willingness to remain in school. Often, the assumption is that educational access and quality is low due to inadequate funding (BenDavid-Hadar, 2018) to which utilitarians suggest increasing funding as a way to maximise returns to education (access and quality) (Kelly & Elliott-Kelly, 2018).

While empirical studies so far have greatly elevated our understanding of the resource input–output nexus during the second half of the 20th century, substantial changes have occurred in the development of education—not only at the level of global commitments, but also the perceived high levels of public and private investments, and strategies of multilateral development agencies, which necessitate a reassessment of how spending interacts with school outcomes. Furthermore, extant studies are mostly limited to cross-sectional data, partly due to the absence of large and consistent

cross-country datasets (Rajkumar & Swaroop, 2008). With the increasing availability of large panel datasets and robust estimation techniques to facilitate long-term analysis amid considerable developments in education over the past 30 years, it is now possible to reassess the public spending-school outcome nexus across several nations to arrive at more reliable estimates with a higher degree of accuracy.

This study considers the performance of school enrolment and dropout rates in low- and lower-middle-income countries (LMICs) by investigating the role of public spending on these outcomes. Given that these outcomes are crucial indicators of access to and quality of education, most countries have developed education policies to achieve higher enrolment and reduce dropout rates. Therefore, it is important to understand the relationship between public education spending and these performance indicators so as to advance recommendations that can help governments and policymakers craft policies on future resource distribution. To that end, we employ the ordinary least squares and two-stage least squares in our baseline analysis, and quantile via moment regressions as the main econometric technique to investigate this relationship.

Section 2 provides the empirical background and motivation for the study. Section 3 presents econometric models, identification strategies, and data sources. In Section 4, we present the results and conclude the study with final remarks in Section 5.

2. Background and motivation

Although average school enrolment has improved over the last three decades, the recent increase in school dropout rates is deeply concerning for governments in developing countries (Chipenda & Cochrane, 2024; Frola et al., 2024). According to statistics from UNESCO (2020), approximately 258 million children, youth, and adolescents were out of school in 2018, representing 20% of the global school-age population, with primary schools alone accounting for 23% (59 million). While this has been attributed to demand-and supply side constraints, such as poverty, insufficient budget allocations to education, conflicts, inadequate infrastructure, and a lack of trained teachers (Hossain & Hickey, 2019), much of the debate has continued to focus on whether schools effectively transform allocated resources into higher performance (Hanushek & Woessmann, 2017; Rajkumar & Swaroop, 2008; Hanushek, Rivkin & Taylor, 1996; Hanushek, 1995; Schultz, 1988).

While the bulk of the literature finds that public spending positively impacts school outcomes (Ferber & Baten, 2024; Jackson et al., 2016; Gustafsson, 2003; Hanushek, 2003; Jacques &

Brorsen, 2002; Michaelowa, 2001; Lee & Barro, 2001; Gupta et al., 1999; Toma, 1996; Hedges at al., 1994; Velez et al., 1993), many influential studies document considerable evidence that expanding financial resources to the education sector does not always correlate with improved outcomes (Hanushek & Kimko, 2000; Filmer & Pritchett, 1999; Ablo & Reinikka, 1998; Mingat & Tan, 1998; Hanushek, 1994, 1995, 2003; Harbison & Hanushek, 1992; Hanushek, 1981). A review of empirical studies, including randomised control experiments by Hanushek and Woessmann (2017), McEwan (2015), Glewwe et al. (2011), and the famous analysis of 147 education production studies by Hanushek (1986) have all led to the common conclusion that money might not always matter for school outcomes. This conclusion generally runs counter to conventional wisdom in education policy that advocates the allocation of more budgetary resources to achieve higher outcomes (Hanushek, 1994; Eide & Showalter, 1998). As the saying goes, correlation is not correlation, and the lack thereof doesn't translate into a lack of causation.

Hedges et al. (1994) and Kremer (1995) challenged this pessimistic view when they found a robust nexus between financial resources and school performance after re-examining an earlier study by Hanushek (1981) using more advanced analytical methods. While Hanushek's (1986) analysis was criticised for lacking robustness owing to its vote-counting methodology, the magnitude of the relations in Hedges et al. (1994) was based on an analysis of regression coefficients. Although neither Hedges et al. (1994) nor Kremer (1995) recommend unrestricted education spending, the tradition of analysing school outcomes with sophisticated econometric techniques has continued to dominate and influence the education finance literature and policy decisions. The OLS and Instrumental Variables are typical methods employed to estimate the "mean effects" of inputs into education production on outputs (see Table 1 in the appendix for an overview of some studies).

However, there seems to be a thin line between sophisticated and correct econometric methods. The technical details of such approaches often overshadow the significance of education policy or the critical elements necessary for policy decisions (Hanushek, 1994), such as how public spending affects performance at different quantiles. For instance, while increasing government expenditure on education may not be of utmost importance for "average" school enrolment in the current global education landscape where enrolment has improved, it would be interesting to discover how such spending affects enrolment in countries at extreme ends of the conditional distribution (Eide & Showalter, 1998). Additionally, it can be confusing for policymakers when studies arrive at different estimation results on public spending without suitable explanations,

especially when there are reasons to believe that the effect should vary across the distribution. On-going studies are also valuable as data availability as well as the context change over time, requiring continuous revisiting of questions and validating findings.

The main research question that motivates this study is: How does public expenditure on education impact school enrolment and dropout rates across different quantiles? In this regard, we do not only examine the critical issue of whether higher public expenditures matter for "average" enrolment and dropout rates but for whom it matters most. Numerous reasons can explain why the effects of public expenditure would vary across different quantiles. First, the level of infrastructure and quality of teachers varies across countries and may affect the effectiveness of public spending differently for countries at different quantiles. Second, some countries offer cash transfers and feeding programmes in schools. While many poor countries might not be able to offer such programs, such policies can influence the effect of public spending on school performance differently for countries at different quantiles. Finally, public spending may affect school outcomes differently across sub-regions, based on how they value education. For instance, education is still scarce in many low-income countries, which can motivate parents to enrol their children when schools are accessible.

In this regard, understanding the effect of public education spending on school outcomes at different points in the conditional distribution can help policymakers forecast future needs and set priorities for their educational investments. For instance, if countries with a higher number of out-of-school children exhibit more benefits from public expenditure, governments can plan to reallocate resources more effectively to support such countries. Additionally, knowing which quantiles are most responsive to public spending allows for a more efficient use of limited resources, which can ensure that funds are directed where they are likely to have the most impact.

We disentangle these effects and contribute to the ongoing debate and call for the allocation of more budgetary resources to education, especially with evidence from pre-primary and primary schools in low and lower-middle-income countries. While Eide and Showalter (1998) previously studied the school quality-pupil performance nexus with a similar approach, we focus more on the question of access to education in pre-primary and primary schools, employing a large panel dataset with improved versions of the panel quantile regression. Our paper is closely related to those in previous studies by Amin and Ntembe (2021), Oseni et al. (2020), Rajkumar and Swaroop (2008), Gupta et al. (1999), Ablo & Reinikka (1998), and Schultz (1988). While Rajkumar and Swaroop

(2008) extended the analysis to uncover the mediating role of governance on school performance, employing the quantile via moments (QvM) approach in this study to explain the dynamics of school outcomes with respect to changes in public spending brings a unique innovation to the literature.

3. Econometric model, data, and estimation procedures

3.1 Econometric model

Our empirical strategy for the baseline model was straightforward. Our first strategy is to follow previous studies by estimating the moment conditions model before introducing the quantile via moment regression into the system. We developed and estimated a multivariate education production model in which school performance is a linear function of government education expenditure as a share of GDP and a host of other socioeconomic variables. Our model in Eq. (1) was derived from previous studies by Dolton and Marcenaro-Gutierrez (2011), Rajkumar and Swaroop (2008), Sequeira and Robalo (2008), Lee and Barro (2000), and Gupta et al. (1999).

$$lnQ_{it} = \delta_0 + \delta_1 \ln PSE_{it} + \delta_2 \ln X_{it} + \epsilon_{it} \quad (1)$$

Eq. (1) relates the natural log of school enrolment or dropout rates (Q_{it}) in LMICs to the log share of public spending in GNI, a set of control variables (X_{it}), and white noise (ϵ_{it}). We describe all the variables in the following section.

3.1 Quantile via Moments

This study employs the Quantile via Moments (QvM) model technique to estimate the effects of government expenditure on education on school enrolment and dropout rates and to further probe whether they vary across different quantiles of their conditional distribution at pre-primary and primary schools. Koenker and Bassett (1978) introduced quantile regression in the econometric literature as a robust alternative to determining how covariates affect outcome variables at various quantiles, especially when assumptions of normality, typical of moments procedures, are not satisfied. This method has been employed to regress censored models, individual effects models, and those with endogenous covariates (Machado & Silva, 2019; Buchinsky, 1995; Powell, 1986). It is often applied when the objective is to derive the parameters of the explained variable at quantiles beyond the mean (Asongu et al., 2024; Eide & Showalter, 1997). According to Koengkan and Fuinhas (2021), it relies on moment conditions to produce conditional means under exogeneity, and can provide correct estimates when outliers are accounted for (Zhu et al., 2018).

Our proposed estimator can be introduced into a simple model using the normal education production function that relates school outcomes to a set of inputs and other control variables (Hanushek, 2020). Our dependent variables are school enrolment and the number of out-of-school children, while the independent variables include government education spending, GDP per capita, percentage of urban population, population growth, and child mortality rates. Quantile via Moments (QvM) is an extension of traditional quantile regression (Machado & Silva, 2019). We are primarily interested in estimating the conditional quantiles of enrolment and dropout rates (Y_{it}) whose distributions are conditional on a vector of explanatory variables (X_{it}) (Asongu et al., 2024). The distribution can be expressed using the following equation:

$$Y_{it} = \alpha_i + X'_{it}\beta + \sigma(\delta_i + Z'_{it}\gamma)U_{it} \quad (2)$$

Where Y_{it} is from a cross-section of N countries $i, \dots, N$ observed over T years (1990 to 2021), α_i are specific intercepts that capture heterogeneities across countries, $(\beta, \delta, \gamma)'$ are unknown parameters, Z encapsulates a set of k components of X. Its differential transformation is given by $Z_l = Z_l(X), l = 1, \dots k$; and σ is a known function such that $\Pr\{\sigma(\delta_i + Z'_{it}\gamma) > 0\} = 1$; X_{it} and U_{it} are idiosyncratic and $i.i.d$. Furthermore, the idiosyncratic error term is uncorrelated to X_{it} but not strictly exogenous (Machado & Silva, 2019). Based on Asongu et al. (2024), we specify the quantile of ($Q_{y_i}(\tau X|_{it})$) of school performance in Eq. (2).

$$Q_{y_i}(\tau X|_{it}) = (\alpha_i + \delta_i q(\tau) + \beta X_{it} + Z_{it}\gamma q(\tau)) \quad (3)$$

X_{it} encompasses all exogenous variables; $Q_{y_i}(\tau X|_{it})$, our outcome variables (enrolment and dropout rates) are contingent on the location of X_{it} (Machado & Silva, 2019); τ captures the fixed effects of the quantile for country i, which does not show intercept lag as in the least squares fixed effects. Prior to the analysis, we performed a series of preliminary tests, such as the Shapiro-Wilk test, Pesaran's cross-section dependence test (Pesaran, 2004), test for stationarity, and Westerlund panel cointegration (Westerlund, 2007). All econometric analyses were estimated using Stata 16.

3.2 Data, sources, and variable description

Our analysis uses annual data from 1990 to 2021 collated from the World Bank database (World Development Indicators). The years selected cover a longer period, more recent data, and more countries than in any other previous study. Many social indicators, such as school enrolment, out-of-school children, grade retention, class repetition, literacy, and completion rates, are commonly

employed to assess the performance of public expenditure on education. We employ two main criteria to facilitate the choice of instruments retained in our empirical analysis. First, we included variables for which data were available for most of the observations over the period considered, or for which generating missing observations did not lead to substantive qualitative or quantitative changes in the underlying characteristics (mean and variance differences were confirmed via t-test and variance comparison tests) of the data. Second, we selected indicators that were previously used in other studies to facilitate the comparison of the results.

To that end, we measure school outcomes with gross enrolment in pre-primary and primary schools (Schultz, 1988; Gupta et al., 1999; Oseni et al., 2020; Amin & Ntembe, 2021), and dropout rates (Hanushek, 1989; Lee & Barro, 2000; Sequeira & Robalo, 2008). Both variables were measured as the percentage of children of primary school age not enrolled at the respective levels. While school enrolment is generally considered an excellent indicator of access to schools, Lee and Barro (2001) considered dropout rates in their panel data as an indicator of school quality.

Regarding the independent variable, we measured public expenditure on education with education expenditure (% of GDP). Schultz (1988), Gupta et al. (1999), and Sequeira and Robalo (2008) employed this measure in their studies. While some studies use expenditure per pupil (Jackson et al., 2016; Vegas & Coffin, 2015; Lee & Barro, 2001; Hanushek, 1989), others measure it with specific allocations at the respective levels of education (Oseni et al., 2020; Rajkumar & Swaroop, 2008). However, there were missing observations in our dataset for public spending at primary schools and per-pupil expenditure in LMICs, which could have resulted in a significant loss of observations. In addition, there are no data on expenditures on pre-primary education. Although the limitation of measuring expenditure with the share of government education expenditure in GDP is that spending per pupil might differ between countries due to differences in GDP, we added GDP per capita as a control variable in our education production model to address this concern (Baker et al., 2002; Hanushek & Kimko, 2000; Heyneman & Loxley, 1982). It is important to note that the effect of per capita expenditure may also be estimated from the joint slopes of government expenditure share in GDP and GDP per capita (Gupta et al., 1999).

We also included a host of other control variables. First, we control for population size by including a variable that captures the share of the population aged 0-14. First, according to Mingat and Tan (1992), increasing school enrolment in low-enrolling countries with relatively younger populations can be challenging. It is expected that countries with a higher share of the population

aged 0-14 will be negatively associated with school enrolment if they have less than universal enrolment. Second, we expect households in urban areas to have better access to schools (urbanisation). Third, we controlled for child nutrition using the child mortality rate (Glewwe & Jacoby, 1995). We expect well-nourished school-aged children to enrol and continue with education, thereby enhancing enrolment rates. It is also expected that high rates of child mortality are associated with lower enrolment. Rajkumar and Swaroop (2008) used five mortality rates as measures of health status. We also expect a negative relationship with dropout rates for all variables that positively influence enrolment rates (see Lee & Barro, 2000).

3.3 Measurement errors, endogeneity issues, and estimation procedures

A typical problem that is often encountered when estimating the education production function in Eq. (1) is the endogeneity that arises from measurement errors, omitted variable bias, reverse causality, simultaneity, unobserved heterogeneity, and time-varying effects, among others. For instance, unaccounted country-specific variables may influence school inputs and outputs in the education sector. Although reverse causation may be less severe in our case because the responsiveness of enrolment to changes in government expenditure is easier within countries relative to between countries, this problem also arises in cross-country analysis (Lee & Barro. 2001; Kremer, 1995). Several studies attempt to control this problem by employing instrumental variable regression approaches such as the systems-GMM or 2SLS (Jackson et al., 2016; Rajkumar & Swaroop, 2008; Gupta et al., 1999; Filmer & Pritchett, 1999; Toma, 1996).

However, it can be challenging to find valid instruments that are orthogonal in the outcome equation, strongly related to the endogenous covariates (e.g., public spending in our case) and have no direct effect on the outcome variable (enrolment/dropout rate). To this end, we employed several measures to counter endogeneity. First, we follow Lee and Barro (2001) by accounting for country-fixed effects regression in one of our baseline models, since unexplained social and cultural factors (country-specific) enable societies to send children to schools, thereby simultaneously increasing school inputs and outputs (see Driscoll and Kraay fixed effects results in Table 3, appendix). Second, we used instruments for public spending in a 2SLS regression equation. In choosing our instruments, we make the following propositions: (i) Many LMICs consider education as a public good, which makes them rely on governments for its provision. At the pre-primary and primary school levels, the policy aligns with the UNSDGs' agenda to achieve universal access to education. Although the level of reliance varies across countries, state-oriented nations tend to rely more on governments for

education. (ii) The degree of state orientation across countries could depend on whether they have common law systems (the UK and its former colonies), civil law systems (France and its former colonies), or Islamic laws. French, English, and Islamic legal systems tend to influence the degree of state orientation (La Porta et al., 1999; Finer, 1997).

To address endogeneity, we created a dummy variable for each of these categories and used them as instruments in our regression equations (Rajkumar & Swaroop, 2008). Finally, poorer countries are more likely to rely on government for the education of children. Therefore, we also created and included dummy variables for low-income and sub-Saharan Africa as instruments for our models. These instruments did not perform well in our model on enrolment in pre-primary and primary schools, but passed all validation tests in models on the number of out-of-school children. We note that these factors do not perfectly describe the degree of state orientation. However, we can confirm that the results of our 2SLS are consistent with those of the pooled OLS regression. With respect to models on enrolment, we included the first two lags of government expenditure on education, GDP growth rate, unemployment, and governance quality (measured with the first Principal Component). The lag in public education spending may correlate with current education spending but not with the error term. In addition, countries with higher annual growth and unemployment rates may likely spend more on education because of the higher demand from the poorer segment of the population. Finally, good governance ensures efficiency in the management and distribution of education resources, and hence, outcomes (Rajkumar & Swaroop, 2008).

The study also used the Driscoll and Kraay procedure (D-K FE) to test for robustness. This technique addresses cross-sectional dependence, autocorrelation, unobserved heterogeneity, and heteroscedasticity, and its nonparametric approach does not restrict the number of panels (Driscoll & Kraay, 1998). The model also provides unbiased and consistent parameter estimates, adding an extra layer of reliability and robustness (Greene, 2018).

4. Results and deliberations

Table 1 presents the summary statistics. Based on the means, minimum, and maximum estimates, we can observe that there is wide variation in school performance (enrolment and dropout rates) in LMICs. All variables are moderately asymmetrical, based on skewness values, except for public education spending, which is highly asymmetric.

Table 1 Descriptive Statistics

	Mean	Std. Dev.	Min	Max	Skewness
Pre-primary school enrolment	28.02	27.53	.26	160.08	1.42
Primary school enrolment	94.58	23.17	22.08	151.73	-.58
Out-of-school children (primary)	20.61	18.13	0	80.4	.93
Education spending	3.99	3.66	.3	68.15	9.25
GDP per capita	1527.01	971.55	215.64	4920.87	.92
Urban population	38	17.21	7.62	91.63	.64
Population aged 0-14	40.44	5.92	22.55	51.12	-.88
Child Mortality rate	76.72	48.17	6.7	332.1	1.10

4.1 Pre-primary school enrolment

Figure 1 plots the scatter of the relationship between school enrolment and public spending in education with both linear and non-linear specifications at pre-primary level. Slopes of the predicted plots are upward linear, suggesting a positive association between enrolment and public education spending at pre-primary schools.

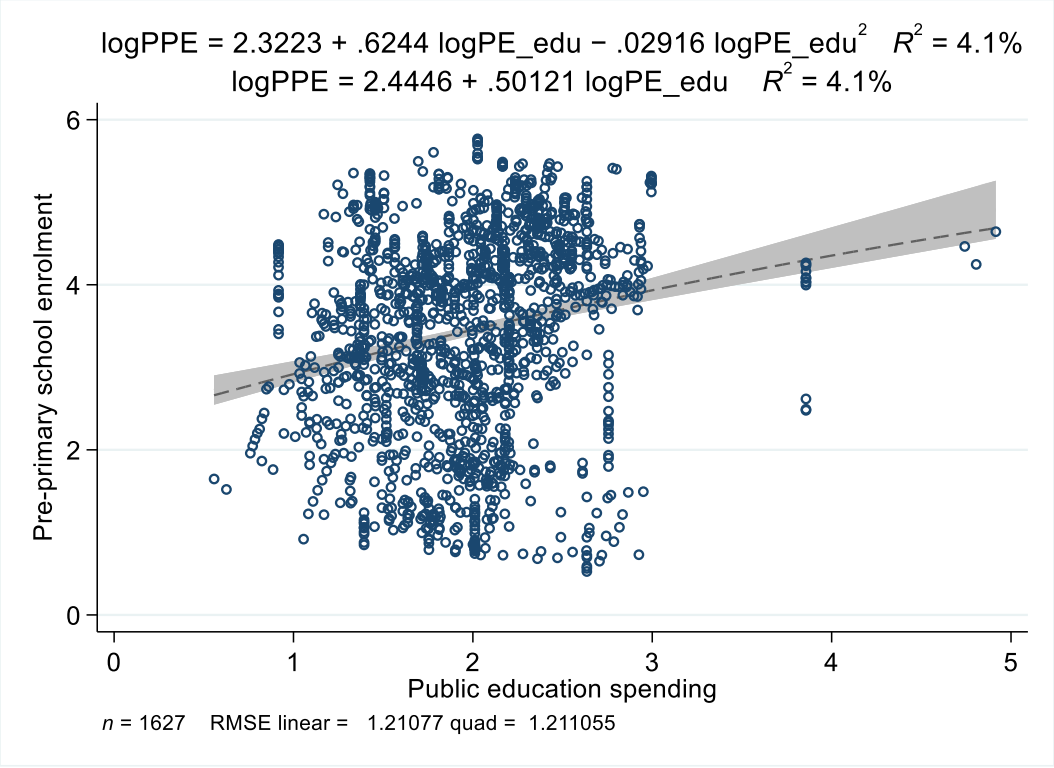

Figure 1 Enrolment and public education spending at pre-primary schools

Regression results for the methods of moments and quantiles via moments are shown in Table 2. Columns (1) and (2) presents OLS and 2SLS results for comparative purposes, respectively.

Based on Hausman's specification test, we estimate the 2SLS regression in column (2) with random effects. The coefficients from OLS and 2SLS show positive and highly significant government expenditure on pre-primary school enrolment.

The coefficients of quantile via moment estimates for all included variables are presented in columns (3) to (6). Regressions were run for the following quantiles: 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th}. We do not report the coefficients at the 10^{th}, 50^{th}, and 90^{th} quantiles[1]. Results from the quantile regression in columns (3), (5), and (6) also show positive coefficients, but the levels of statistical significance vary over the conditional distribution of enrolment. Unexpectedly, when enrolment is evaluated at the 25^{th} and lower quantiles, public spending has an insignificant influence on pre-primary school enrolment. For the 50^{th} and higher quantiles, government expenditure on education was significantly associated with higher school enrolment. Therefore, we conclude that government education expenditure has no significant relationship with school enrolment in the lowest-enrolling areas, for instance, in poor countries, at the pre-primary level. These findings also indicate that other factors, such as poverty, infrastructure, teacher availability, training facilities, and socio-cultural norms may be more important in explaining pre-primary school enrolment in low-enrolling areas. For instance, some countries might not consider pre-pre-primary school enrolment as an essential step towards subsequent learning needs.

Similarly, public spending is associated with pre-primary school enrolment, on average, in high-enrolling countries (e.g., urban or richer countries). These results uncover the crucial role of quantile regression in unmasking important results that would otherwise go unnoticed in the methods of moments procedures. Jackson et al. (2016), Dolton and Marcenaro-Gutierrez (2011), Rajkumar and Swaroop (2008), and Gupta et al. (1999) found supportive evidence of the public spending-enrolment nexus. Therefore, while focusing on education spending on average in high-enrolling countries can have a significant impact on performance, governments need to develop alternative strategies for low-enrolling countries, such as interventions to improve pre-primary school enrolment in disadvantaged countries. This can include programs to foster community engagement and social norms that support education in those countries and adjust policies to accommodate the different effects of public education spending across countries. The importance of

[1] Location coefficients were similar in direction, magnitude, and level of statistical significance with those in the 50^{th} quantile. Also, coefficients at lower (25^{th} & below) and at higher (75^{th} & higher) quantiles were similar in sign and level of statistical significance.

early childhood education has been well-documented in the literature (Glewwe & Jacoby, 1995). It is of crucial importance that governments take steps to address poor enrolment at this level in disadvantaged countries.

Table 2 further shows results from the list of control variables. GDP per capita, urban population, population of children aged 0-14, and child mortality rates are all significant determinants of pre-primary school enrolment, and the coefficients are consistent across OLS, 2SLS, and quantile regression. Results from the 2SLS also passed all validation tests.

Table 2 Results for enrolment at pre-primary schools

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS	Quantile via moments			
VARIABLES			Location	scale	qtile_25	qtile_75
Public edu. spending	0.148***	0.256***	0.148**	-0.00074	0.148	0.147**
	(0.0493)	(0.0693)	(0.0706)	(0.0589)	(0.108)	(0.0646)
GDP per capita	0.323***	0.166**	0.323**	0.194	0.148	0.513***
	(0.0865)	(0.0828)	(0.152)	(0.127)	(0.231)	(0.139)
Urban population	1.348***	1.309***	1.348***	0.224	1.146***	1.566***
	(0.148)	(0.140)	(0.234)	(0.195)	(0.356)	(0.213)
Population aged 0-14	0.771***	0.267	0.771*	0.284	0.515	1.048***
	(0.247)	(0.251)	(0.420)	(0.350)	(0.640)	(0.384)
Child mortality rate	-0.929***	-0.964***	-0.929***	0.124	-1.041***	-0.808***
	(0.0650)	(0.0622)	(0.100)	(0.0837)	(0.153)	(0.0917)
Constant	-3.078*	-0.332	-3.940	-3.992	-0.336	-7.835***
	(1.749)	(1.649)	(3.144)	(2.620)	(4.777)	(2.870)
$Adj.\ R^2$	0.8680	-	-	-	-	-
Observations	1,590	1,590	1,590	1,590	1,590	1,590

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2 Primary school enrolment

We now turn to the effect of public education spending on pre-primary school enrolment. Figure 2 presents a scatter plot of public expenditure on education and school enrolment at this level. The predicted trends also show a positive slope between the two variables, suggesting that spending potentially enhances enrolment at primary schools.

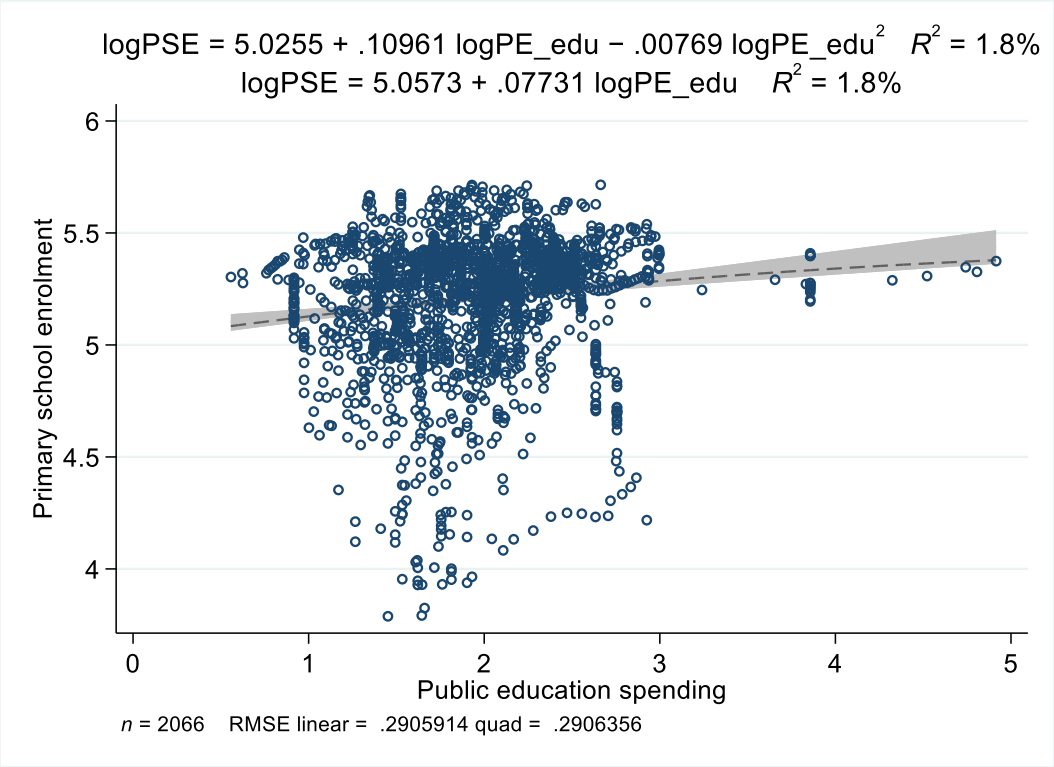

Figure 2 Scatter plots of public education spending and primary school enrolment

Table 3 lists the estimated coefficient of public education spending and all control variables for the OLS, 2SLS and quantile via moments models, an analogous procedure to the one in the preceding section. The education production function at primary schools was estimated with fixed effects as recommended by the Hausman's specification test. Again, the coefficients of public education spending are positive and highly statistically significant in the baseline regressions. Similarly, the coefficients of education spending based on the method of quantile via moments are positive and significant in columns (5) and (6). Therefore, government education spending is highly significant in both low-enrolling and in high-enrolling countries, consistent with most studies in the literature (Jackson et al., 2016; Vegas & Coffin, 2015; Gupta et al., 1999). Therefore, augmenting public spending on education impacts primary school enrolment significantly in low enrolling countries and in high-enrolling countries.

Table 3 Results of enrolment at primary school level

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS	Quantile via Moments			
VARIABLES			Location	scale	qtile_25	qtile_75
Public edu. spending	0.0801***	0.126***	0.0801***	0.0153*	0.0660***	0.0939***
	(0.0144)	(0.0207)	(0.0146)	(0.00866)	(0.0189)	(0.0139)
GDP per capita	0.115***	0.0234	0.115***	-0.00567	0.121***	0.110***
	(0.0223)	(0.0224)	(0.0230)	(0.0137)	(0.0299)	(0.0220)
Urban population	0.487***	0.174***	0.487***	-0.0418*	0.525***	0.449***
	(0.0376)	(0.0351)	(0.0376)	(0.0224)	(0.0488)	(0.0359)
Population aged 0-14	1.027***	0.524***	1.027***	-0.0960**	1.115***	0.940***
	(0.0672)	(0.0695)	(0.0660)	(0.0393)	(0.0856)	(0.0629)
Child mortality rate	-0.219***	-0.189***	-0.219***	0.0220**	-0.239***	-0.199***
	(0.0175)	(0.0168)	(0.0185)	(0.0110)	(0.0240)	(0.0176)
Constant	-1.176***	2.711***	-1.284***	0.607**	-1.841***	-0.735*
	(0.438)	(0.430)	(0.448)	(0.266)	(0.581)	(0.427)
$Adj.\ R^2$	0.7073	-	-	-	-	-
Observations	2,033	2,033	2,033	2,033	2,033	2,033

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3 Out-of-school children

This last sub-section presents the results of government education spending and dropout rates, with the number of out-of-school children as a proxy. The linear relationship between these variables is shown by the downward-sloping scatter plot in Figure 3.

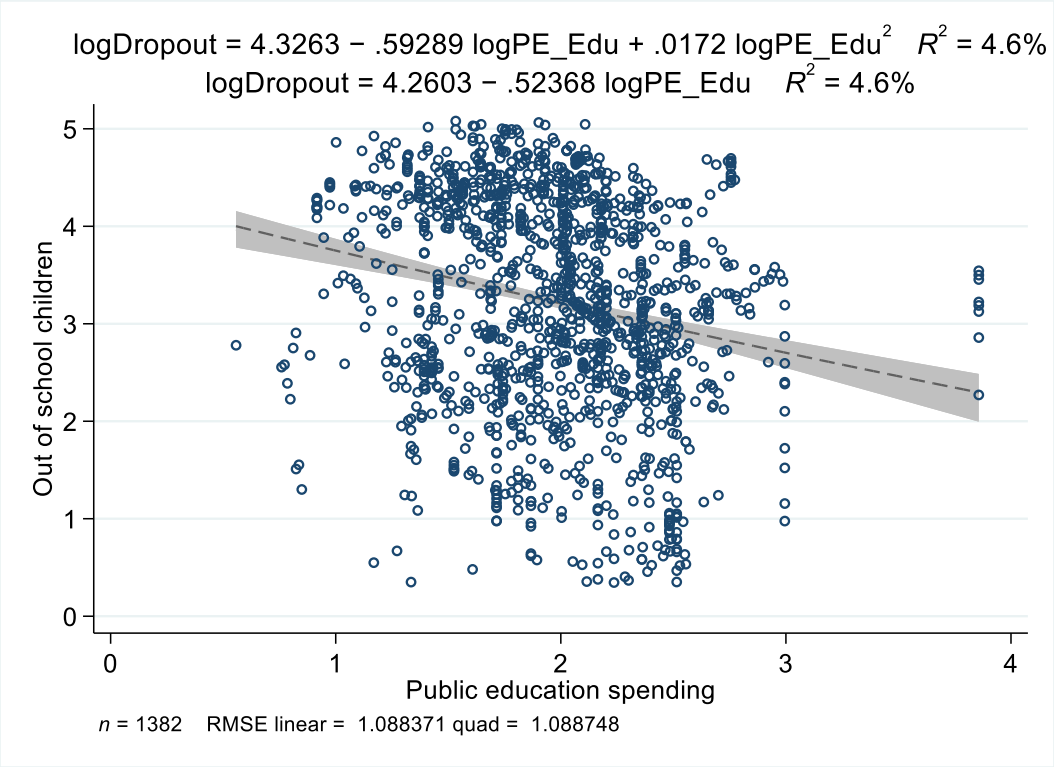

Figure 3 Scatter plot of public education spending and out-of-school children

Table 4 presents result from the OLS, 2SLS, and quantile via moments on the effect of government education expenditure on dropout rates. The coefficients from OLS and 2LS are negative and significant, implying that government expenditure on education is associated with a decrease in dropout rates at primary school level. Similarly, these coefficients are also negative in the quantile regression estimates, but the levels of statistical significance vary across different quantiles of the conditional distribution. At the 25th and lower quantiles, public spending have negative and insignificant effects at the 5% level, while the coefficients are significant at the 50th and higher quantiles.

These results imply that public education spending is more effective in reducing dropout rates in countries with more out-of-school children (higher quantiles). Similarly, public spending may also be less effective in addressing dropout rates in countries with fewer out-of-school children, perhaps because of diminishing returns. The results further imply that, to reduce inequalities in education, resource distribution should target more disadvantaged countries for effectiveness. Governments also need to reallocate resources from areas with fewer out-of-school children to those with higher needs.

Finally, the coefficients of all control variables align with our economic and statistical

expectations. The 2SLS also passed all validation tests. We tested for the consistency of the method of moments estimates using the Driscoll and Kraay fixed-effect model. The coefficients of all the included variables have the expected directions and statistical significance, as presented in Tables 3 to 5. Therefore, while we conclude that government education expenditure has a significant effect on enrolment and dropout rates, the findings align with our initial conjecture that the parameters might vary across the conditional distribution. Therefore, policymakers must consider country differences in education spending effectiveness when designing education policies and programs.

Table 4 Results for the number of out-of-school children

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	2SLS	Quantile via Moments				
VARIABLES			location	Scale	qtile_10	qtile_25	qtile_75
Public edu. spending	-0.205**	-0.371**	-0.205**	-0.0349	-0.149	-0.174*	-0.238***
	(0.0882)	(0.185)	(0.0839)	(0.0517)	(0.128)	(0.102)	(0.0897)
GDP per capita	-0.718***	-0.710***	-0.718***	-0.0674	-0.609***	-0.658***	-0.781***
	(0.117)	(0.153)	(0.128)	(0.0786)	(0.195)	(0.156)	(0.136)
Urban population	-0.953***	-1.095***	-0.953***	0.0974	-1.110***	-1.040***	-0.862***
	(0.204)	(0.280)	(0.199)	(0.123)	(0.303)	(0.243)	(0.213)
Population aged 0-14	-1.277***	-1.483***	-1.277***	0.0404	-1.342**	-1.313***	-1.239***
	(0.314)	(0.367)	(0.349)	(0.215)	(0.532)	(0.426)	(0.373)
Child mortality rate	0.635***	0.595***	0.635***	-0.113**	0.817***	0.735***	0.529***
	(0.0867)	(0.115)	(0.0843)	(0.0519)	(0.128)	(0.103)	(0.0900)
Constant	16.88***	17.80***	15.78***	0.941	14.26***	14.94***	16.66***
	(2.451)	(2.812)	(2.344)	(1.443)	(3.571)	(2.858)	(2.504)
$Adj.\ R^2$	0.764	-	-	-	-	-	-
Observations	1,374	1,050	1,374	1,374	1,374	1,374	1,374

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Concluding remarks

Although policymakers generally advocate for increased spending on education to enhance school performance, much of the literature lending empirical credence to this position is based on methods of moment procedures such as OLS and 2SLS estimations. These procedures can mask important findings across different quantiles of the conditional distribution. This study examined the effects of government education expenditure on enrolment at pre-primary and primary school levels and dropout rates at primary schools in 74 low- and lower-middle-income countries using a panel dataset from 1990 to 2021 and a myriad of econometric techniques.

Our analysis confirmed our initial assumption that, despite their relative strength, OLS and 2SLS masks crucial results across different quantiles. While the findings that public spending enhances school enrolment and reduces dropout rates are consistent and robust, the levels of significance vary across quantiles. Our findings also support the view that budgetary allocations and other socioeconomic indicators are important in improving school performance in LMICS. GPDP per capita, share of urban population, population aged 0-14, and child mortality rates are all significant determinants of school performance.

We documented interesting results across different quantiles of the conditional distribution for pre-primary enrolment and dropout rates at the primary level. First, the effect of public spending on pre-primary school enrolment was insignificant in low-enrolling countries. Second, the effect of public spending on dropout rates was insignificant in countries with the lowest dropout rates. The regression results were not different for the method of moments procedure and the quantile via moments for primary school enrolment. However, we do not fully explore why public spending is ineffective on pre-primary school enrolment in low-enrolling areas and on the number of out-of-school children of primary school age in areas with the fewest out-of-school children. While the ineffectiveness of public spending in further reducing school dropout rates in countries with the lowest out-of-school children is obvious, investigating why public spending is ineffective in enhancing pre-primary school enrolment in low-enrolling countries is an important question to answer in subsequent research.

Declaration of interest

The research received funding from Education Above All.

Data availability

The dataset analysed during the current study are publicly available in the World Development Indicators of the World Bank (https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators).

References

Ablo, E., & Reinikka, R. (1998). Do budgets really matter? Evidence from public spending on education and health in Uganda. *Evidence from Public Spending on Education and Health in Uganda (June 1998)*. https://ssrn.com/abstract=604999

Amin, A. A., & Ntembe, A. (2021). Public spending on education and learning outcomes in Senegal. *The Journal of Developing Areas, 55*(4), 297-314. https://doi.org/10.1353/jda.2021.0091

Ammermüller, A., Heijke, H., & Wößmann, L. (2005). Schooling quality in Eastern Europe: educational production during transition. *Economics of Education Review*, *24*(5), 579-599. https://doi.org/10.1016/j.econedurev.2004.08.010

Asongu, S. A., Ndour, C. T., & Ngoungou, J. C. (2024). The effects of gender political inclusion and democracy on environmental performance: evidence from the method of moments by quantile regression. *Politics & Policy*. https://doi.org/10.1111/polp.12576

Baker, D. P., Goesling, B., & LeTendre, G. K. (2002). Socioeconomic status, school quality, and national economic development: A cross-national analysis of the "Heyneman-Loxley effect" on mathematics and science achievement. *Comparative education review*, *46*(3), 291-312. https://doi.org/10.1086/341159

Kelly, A., & Elliott-Kelly, C. (2018). Towards a philosophy of equity in educational effectiveness research: Moving from utilitarianism to a Rawlsian paradigm. *School Effectiveness and School Improvement*, *29*(4), 529-544. https://doi.org/10.1080/09243453.2018.1470990

Baker, I. (2024). Federations of academic departments: performance-based funding and academic field-level expenditures at Russell group universities. *Journal of Education Policy*. https://doi.org/10.1080/02680939.2024.2393827

Buchinsky, M. (1994). Changes in the US wage structure 1963-1987: Application of quantile regression. Econometrica: *Journal of the Econometric Society, 62*(2), 405-458. https://doi.org/10.2307/2951618

Card, D., & Krueger, A. B. (1992). Does school quality matter? Returns to education and the characteristics of public schools in the United States. *Journal of political Economy*, *100*(1), 1-40. https://doi.org/10.1086/261805

Card, D., & Krueger, A. B. (1994). *The economic return to school quality: A partial survey* (No. 713). Working Paper 334. Princeton University, Industrial Relations Section, Princeton, N.J. Processed.

Chipenda, C., & Cochrane, L. (2024). Out-of-school children in the context of new policy trajectories and interlocking crises in Zimbabwe: a transformative social policy perspective. *SN Social Sciences*, *4*(7), 1-30. https://doi.org/10.1007/s43545-024-00938-1

Coleman, J. S. (1968). Equality of educational opportunity. *Integrated education*, *6*(5), 19-28. https://doi.org/10.1080/0020486680060504

Dolton, P., & Marcenaro-Gutierrez, O. D. (2011). If you pay peanuts, do you get monkeys? A cross-country analysis of teacher pays and pupil performance. *Economic Policy*, *26*(65), 5-55. https://doi.org/10.1111/j.1468-0327.2010.00257.x

Driscoll, J. C., & Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics, 80*(4), 549-560. https://doi.org/10.1162/003465398557825

Eide, E., & Showalter, M. H. (1998). The effect of school quality on student performance: A quantile regression approach. *Economics Letters, 58*(3), 345-350. https://doi.org/10.1016/S0165-1765(97)00286-3

Ferber, S., & Baten, J. (2024). Nutrition matters: numeracy, child nutrition and schooling efficiency in sub-Saharan Africa in long-term perspective. *The Journal of Development Studies, 60*(7), 1–25. https://doi.org/10.1080/00220388.2024.2322974

Filmer, D., & Pritchett, L. (1999). The impact of public spending on health: does money matter? *Social Science & medicine*, *49*(10), 1309-1323. https://doi.org/10.1016/S0277-9536(99)00150-1

Frola, A., Delprato, M., & Chudgar, A. (2024). Lack of educational access, women's empowerment and spatial education inequality for the Eastern and Western Africa regions. *International Journal of Educational Development*, *104*, 102939. https://doi.org/10.1016/j.ijedudev.2023.102939

Fuller, B., & Clarke, P. (1994). Raising school effects while ignoring culture? Local conditions and the influence of classroom tools, rules, and pedagogy. *Review of educational research*, *64*(1), 119-157. https://doi.org/10.3102/003465430640011

Glewwe, P. W., Ravina, R., Hanushek, E. A., & Humpage, S. D. (2011). School resources and educational outcomes in developing countries: A review of the literature from 1990 to 2010. 17554. Cambridge, Mass: *National Bureau of Economic Research*. https://doi.org/10.3386/w17554

Glewwe, P., & Jacoby, H. G. (1995). An economic analysis of delayed primary school enrolment in a low-income country: the role of early childhood nutrition. *The Review of Economics and Statistics*, 156-169. https://doi.org/10.2307/2110001

Greene, W. H. (2018). Econometric Analysis. 8th ed. New York: Pearson

Gupta, M. S., Tiongson, M. E., & Verhoeven, M. (1999). Does higher government spending buy better results in education and health care? *IMF Working Paper No. 99/21*

Gustafsson, J. E. (2003). What do we know about effects of school resources on educational results? *Swedish Economic Policy Review*, *10*(2), 77-77.

Hanushek, E. A. (1981). Throwing money at schools. *Journal of Policy Analysis and Management*, *1*(1), 19-41. https://doi.org/10.2307/3324107

Hanushek, E. A. (1986). The economics of schooling: Production and efficiency in public schools. *Journal of economic literature*, *24*(3), 1141-1177. https://www.jstor.org/stable/2725865

Hanushek, E. A. (1989). The impact of differential expenditures on school performance. *Educational researcher*, *18*(4), 45-62. https://doi.org/10.3102/0013189X01800404

Hanushek, E. A. (1994). Money might matter somewhere: A response to Hedges, Laine, and Greenwald. *SageJournals, 23*(4), 5-8. https://doi.org/10.3102/0013189X023004005

Hanushek, E. A. (1995). Interpreting recent research on schooling in developing countries. *The World Bank Research Observer, 10*(2), 227-246. https://doi.org/10.1093/wbro/10.2.227

Hanushek, E. A. (2003). The failure of input-based schooling policies. *The Economic Journal, 113*(485), F64-F98. https://doi.org/10.1111/1468-0297.00099

Hanushek, E. A. (2020). In Bradley S., Green C.(Eds.), Chapter 13 - Education production functions (2nd ed.). *The Economics of Education*. https://doi.org/10.1016/B978-0-12-815391-8.00013-6

Hanushek, E. A., & Kimko, D. D. (2000). Schooling, labor-force quality, and the growth of nations. *American Economic Review, 90*(5), 1184-1208. https://doi.org/10.1257/aer.90.5.1184

Hanushek, E.A., Woessmann, L. (2017). School resources and student achievement: A review of cross-country economic research. In: Rosén, M., Yang Hansen, K., Wolff, U. (eds), Cognitive abilities and educational outcomes. Methodology of educational measurement and assessment (149–171). Springer, Cham. https://doi.org/10.1007/978-3-319-43473-5_8

Harbison, R. W., & Hanushek, E. A. (1992). Educational performance of the poor: lessons from rural Northeast Brazil. Oxford University Press.

Hedges, L. V., Laine, R. D., & Greenwald, R. (1994). An exchange: Part I: Does money matter? A meta-analysis of studies of the effects of differential school inputs on student outcomes. *Educational Researcher, 23*(3), 5-14.

Heyneman, S. P., & Loxley, W. A. (1982). Influences on academic achievement across high- and low-income countries: A re-analysis of IEA data. *Sociology of education*, 13-21. https://doi.org/10.2307/2112607

BenDavid-Hadar, I. (2018). Funding education: Developing a method of allocation for improvement. *International Journal of Educational Management*, *32*(1), 2-26. https://doi.org/10.1108/IJEM-07-2016-0161

Heyneman, S. P., & Loxley, W. A. (1983). The effect of primary-school quality on academic achievement across twenty-nine high-and low-income countries. *American Journal of sociology*, *88*(6), 1162-1194.

Hossain, N., & Hickey, S. (2019). The problem of education quality in developing countries. The politics of education in developing countries: From schooling to learning, 1, 1-21. https://doi.org/10.1093/oso/9780198835684.003.0001

Jackson, C. K., Johnson, R. C., & Persico, C. (2016). The effects of school spending on educational and economic outcomes: evidence from school finance reforms. *The Quarterly Journal of Economics, 131*(1),157–218. https://doi.org/10.1093/qje/qjv036

Jacques, C., & Brorsen, B. W. (2002). Relationship between types of school district expenditures and student performance. *Applied Economics Letters, 9*(15), 997-1002. https://doi.org/10.1080/13504850210148161

Jacques, C., & Brorsen, B. W. (2002). Relationship between types of school district expenditures and student performance. *Applied Economics Letters*, *9*(15), 997-1002. https://doi.org/10.1080/13504850210148161

Koengkan, M., & Fuinhas, J. A. (2021). Is gender inequality an essential driver in explaining environmental degradation? Some empirical answers from the CO2 emissions in European Union countries. *Environmental Impact Assessment Review, 90*, 106619. https://doi.org/10.1016/j.eiar.2021.106619

Koenker, R., Bassett, G. (1978). Regression quantiles. *Econometrica, 46*(1): 33–50. https://doi.org/10.2307/1913643

Kremer, M. R. (1995). Research on schooling: What we know and what we don't: A comment on Hanushek. *The World Bank Research Observer*, *10*(2), 247-254. https://doi.org/10.1093/wbro/10.2.247

Lee, J. W., & Barro, R. J. (2001). Schooling quality in a cross–section of countries. *Economica*, *68*(272), 465-488. https://doi.org/10.1111/1468-0335.d01-12

Machado, J. A., & Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics, 213*(1), 145-173. https://doi.org/10.1016/j.jeconom.2019.04.009

McEwan, P. J. (2015). Improving learning in primary schools of developing countries: A meta-analysis of randomized experiments. *Review of Educational Research, 85*(3), 353–394. https://doi:10.3102/0034654314553127

Michaelowa, K. (2001). Primary education quality in francophone Sub-Saharan Africa: Determinants of learning achievement and efficiency considerations. *World Development*, *29*(10), 1699-1716. https://doi.org/10.1016/S0305-750X(01)00061-4

Mingat, A., & Tan, J. (1998). The mechanics of progress in education: Evidence from cross-country data. *Policy Research Working Papers,* (2015), *54*. https://ssrn.com/abstract=597256

Mingat, A., & Tan, J. P. (1998). *The mechanics of progress in education: evidence from cross-country data* (No. 2015). World Bank Publications. https://doi.org/10.1596/1813-9450-2015

Oseni, I. O., Akinbode, S. O., Babalola, D. A., & Adegboyega, S. B. (2020). Government spending and school enrolment in sub-Saharan Africa: A system GMM approach. *Journal of Economics and Management*, *40*(2), 91-108. https://doi.org/10.22367/jem.2020.40.05

Pesaran, M.H., 2004. General Diagnostic Tests for Cross-section Dependence in Panels. The University of Cambridge, Faculty of Economics. https://doi.org/10.17863/ CAM.5113. *Cambridge Working Papers in Economics*, n. 0435.

Powell, J. L. (1986). Censored regression quantiles. *Journal of Econometrics, 32*(1), 143-155. https://doi.org/10.1016/0304-4076(86)90016-3

Rajkumar, A. S., & Swaroop, V. (2008). Public spending and outcomes: Does governance matter? *Journal of Development Economics, 86*(1), 96-111. https://doi.org/10.1016/j.jdeveco.2007.08.003

Schultz, T. P. (1988). Expansion of public-school expenditures and enrolments: intercountry evidence on the effects of income, prices, and population growth. *Economics of Education Review, 7*(2), 167-183. https://doi.org/10.1016/0272-7757(88)90042-8

Sequeira, T., & Robalo, P. (2008). Schooling Quality in a Cross Section of Countries: a replication exercise and additional results. *Economics Bulletin*, *9*(9), 1-7. http://economicsbulletin.vanderbilt.edu/2008/volume9/EB-08I20008A.pdf

Tan, J. P., & Mingat, A. (1992). *Education in Asia: A comparative study of cost and financing*. World Bank Publications.

Toma, E. F. (1996). Public funding and private schooling across countries. The Journal of Law and Economics, 39(1), 121-148. https://doi.org/10.1086/467345

UNESCO. (2020). Global Education Monitoring Report 2020: Inclusion and education: All means all. Paris, UNESCO. https://doi.org/10.54676/JJNK6989

Vegas, E., & Coffin, C. (2015). When education expenditure matters: An empirical analysis of recent international data. *Comparative Education Review*, *59*(2), 289-304. https://doi.org/10.1086/680324

Velez, E., Schiefelbein, E., & Valenzuela, J. (1993). Factors affecting achievement in primary education: A review of the literature for Latin America and the Caribbean. Human Resources Development and Operations Policy, World Bank.

Westerlund, J. (2007). Testing for error correction in panel data. *Oxford Bulletin of Economics and statistics, 69*(6), 709-748. https://doi.org/10.1111/j.1468-0084.2007.00477.x

Zhu, H., Li, Z., & Guo, P. (2018). The impact of income, economic openness and interest rates on housing prices in China: evidence from dynamic panel quantile regression. *Applied Economics, 50*(38), 4086-4098. https://doi.org/10.1080/00036846.2018.1441512

Appendix

Table 1A Summary of related studies

S/N	**Author(s)**	**Region/country**	**Dependent variable**	**Independent variable**	**Method(s)**	**Result**
1.	Kiesling (1967)	New York, USA	Average score in basic subjects in grades 4, 5 & 6	Log of expenditure per pupil	Partial regression	*Positive* in large school districts, *Negative* in small school districts
2.	Heyneman & Loxley (1983)	29 High and LICs	School enrolment	Test scores	Correlation regression	*Positive* & *strong* effect in HICs relative to LICs
3.	Schultz (1988)	89 countries from I960-1980	School enrolment in primary and secondary schools	Government expenditure as a percent of GNP Real income per adult	Linear regression	Positive
3.	Hanushek (1989)	USA	standardized achievement test scores Dropout rates Attendance rates	Expenditure per pupil Teacher salary	Literature review (vote counting)	No relationship
4.	Hedges et al. (1994)	USA	Academic achievement	Per pupil expenditure	Review: meta-analysis	Positive
5.	Toma (1996)	5 EU countries (Belgium, France, New Zealand, Ontario, USA)	Achievement in mathematics	Public funding	OLS 2SLS	Positive
6.	Ablo & Reinikka (1998)	Uganda (1991-1995)	Primary School enrolment Health clinics	Budget allocations	Descriptive statistics	Negative
7.	Filmer & Pritchett (1999)	Cross-sectional data from developing	Infant mortality rate Under-5 mortality rate	Public spending on health as a share of GDP	OLS 2SLS	No relationship

		countries (UNICEF, 1992)				
8.	Gupta et al. (1999)	Cross-sectional data from 50 Developing and transition countries	Primary and secondary school enrolment Educational attainment Infant Mortality rate Child Mortality	Public spending as a share of GDP in education	OLS 2SLS	Positive Positive Negative Negative
9.	Lee & Barro (2001)	Panel of IAEP[2] countries from 1964 -1991	Test scores in mathematics, science & reading Repetition rates Dropout rates	Average teacher salary Education expenditure per pupil	SUR	Positive
10.	Jacques & Brorsen (2002).	1990 Okalhoma public school districts	Standardised test scores	Spending on instruction	MLE	Positive
11.	Ammermüller et al. (2005).	7 Eastern European transition countries (1994/95)	Mathematics and Science Study	Class size (small class size ->hiring more teachers-> more spending	WLS (CRLR) FE	Positive
12.	Sequeira & Robalo (2008)	Panel of IAEP	Repetition rate Dropout rate	Education expenditure per pupil as a ratio of GDP	SUR FE regression	No relationship
13.	Rajkumar & Swaroop (2008)	91 countries over three years: 1990, 1997 and 2003	Primary education failure rate Under-5 mortality rate	Public primary education spending (share in GDP) Public health spending (share in GDP)	OLS 2SLS	No relationship However, positive and significant in countries with good governance
14.	Dolton & Marcenaro-Gutierrez (2011).	39 OECD countries	Standardised pupil score	Salary advancement	OLS	Positive
15.	Vegas & Coffin (2015)	PISA data (2006, 2009 & 2012)	Performance in mathematics	Education expenditure per secondary pupil	Linear regression	Positive below a threshold of $8000
16.	Jackson et al. (2016)	Panel of US districts (1970 to 2010	High school graduate	Per pupil spending	2SLS DiD	Positive

[2] International Assessment of Education Progress

17.	Hanushek & Woessmann (2017)	Review of Cross-country studies	Students' achievement	Educational spending Class size	Studies using quasi-experimental methods	No/weak relationship
18.	Oseni et al. (2020)	24 countries from SSA from 2000-2016	Gross primary school enrolment	Government expenditure per student, primary (% of GDP per capita)	System-GMM	Positive
19.	Amin & Ntembe (2021)	Senegal (1971-2018)	-Completion rate -enrolment rate	Public expenditure on education	ARDL model	Positive

*Not*e: OLS, Ordinary least squares; WLS, Weighted least squares; SUR, seemingly unrelated regression; GMM, generalized method of moments; ARDL, autoregressive distributed lag model; 2SLS, two-stage least squares.

Table 2A Robustness of the moment coefficient method

	(1) DK RE	(2) DK FE	(3) DK FE
VARIABLES	Pre-primary enrolment	Primary school enrolment	Out-of-school children
Public edu. spending	0.163*	0.0801***	-0.205**
	(0.0882)	(0.0143)	(0.0906)
GDP per capita	0.286***	0.115***	-0.718***
	(0.0800)	(0.0266)	(0.150)
Urban population	1.063***	0.487***	-0.953***
	(0.140)	(0.0374)	(0.299)
Population aged 0-14	0.618***	1.027***	-1.277**
	(0.163)	(0.114)	(0.475)
Child mortality rate	-0.981***	-0.219***	0.635***
	(0.0733)	(0.0493)	(0.100)
Constant	-1.535	-1.284**	15.78***
	(1.284)	(0.514)	(2.682)
Observations	1,590	2,033	1,374
Number of groups	68	74	72

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The Results in Table 2A are based on Driscoll and Kraay fixed effects. Public education spending has a significant effect on school performance at various levels.