Access to Electricity and Primary Education Nexus in Central Africa

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ABSTRACT

Access to electricity, a fundamental element of contemporary life, is essential for economic success. Its impact extends to the fundamental foundations of industrial development and has the power to improve a wide range of industries, including healthcare, transportation, utilities, and education. This article aims to analyse the effect of electricity access on primary education in Central Africa over the period 1997-2019. To this effect, we employ data mainly from the World Development indicator on 9 countries of Central Africa. Using the pooled ordinary least squares estimation technique, the results indicate that access to electricity contributes positively and significantly to primary educational attainment in Central Africa during the study period. The results are Robust to the use of alternative estimation strategy and eventual endogeneity problems in the results are account through the two stage least square estimation techniques which confirm our baseline results as well as the nature of the relationship between access to electricity and primary education in Central Africa. These results have important implications for policies in overcoming barriers to electricity access.

KEYWORDS

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1. Introduction

Educational systems deploy multiple inputs to serve students-policies, infrastructure, management, teachers and many others. Education inputs are the means used in an education system to achieve education objectives. The quality of education move hand in hand with the quality of both human and material resources available for teaching. Empirical evidence from developed and developing countries indicates that the quality of the teaching force is one of the most influential factor in promoting learning (Bruns and Luque 2014; Barber and Mourshed 2007; Hanushek and Rivkin 2006). This presents a challenge for education in Africa given the limited inputs of the teaching force especially with the broad expansion in student enrollment (Lauwerier and Akkari 2015). A key input for educational development is the availability of electricity. Electricity is beneficial for students in the sense that it enable them to complete their assignments on time and acquire current information. Looking at the benefit on Teacher's side, it enable them to make copies of school assignments or connect to the internet to research what activities or materials are available online thereby providing students with the quality of education they deserve. Electricity at schools facilitates the use of a bundle of information and communications technologies, attracts students and enhances their learning experience. It can also enhance staff retention and lead to better teacher training. On a global scale, electrified schools also provide teachers with better training, new skills and techniques for improved practices in the classroom.

All advanced economies have secured the availability and reliability of electricity supply to underpin productivity increases, competitiveness boosts and ultimately economic growth (Ferguson et al., 2000). Worldwide there are over 1.3 billion people who still lack access to electricity and this is seen as a major hindrance to economic and human development (Squires, 2015). This phenomenon is observed mostly in developing countries, and Central Africa in particular is not exempted. The electricity sector is of potential value to economic growth and social development (Fujii et al., 2018), but nonetheless, its degree of potentiality to contribute to the region's economy is questionable based on the numerous challenges faced by the sector. For example, it is alleged that Cameroon suffers from approximately ten electrical outages per month which last an average of two hours each (Ramachandran et al., 2009). Most recently, 2014 data compiled by UNESCO from 46 countries in sub-Saharan Africa showed that the vast majority of schools report having no electricity and that 4 out of 5 primary schools have no electricity (UNESCO Institute for Statistics, 2014). Again, the rates of electrification in Central Africa as a whole are very low with the cost of accessing energy services perceived to be very high and unaffordable by the poor.

In spite of the fact that Central Africa is faced with these numerous electrical problems, yet we noticed that efforts have been made to improve the supply in the region compare to past years. This evidence is clearly seen in figure (2) with the evolution of access to electricity in Central Africa and ties up with the observations of the International Energy Agency (OECD 2016) which stipulates that there have been large improvements in electricity source.

On the other hand, some key objectives of the Millennium Development Goals (MDG) and Sustainable Development Goals are centered on education, precisely MDG2 aimed at achieving universal primary education and SDG4 with the focus of quality education. The education system in Central African countries is organized as Nursery, primary, secondary and higher education. Primary school which is our main focus here runs from grade one to six and the average starting age of pupils being six years according to the World development Indicators (2022). Primary Educational attainment in this study is captured using three main variables; primary educational achievement, primary school enrollment and primary completion rate, with its evolution over time apparent in figure 1.
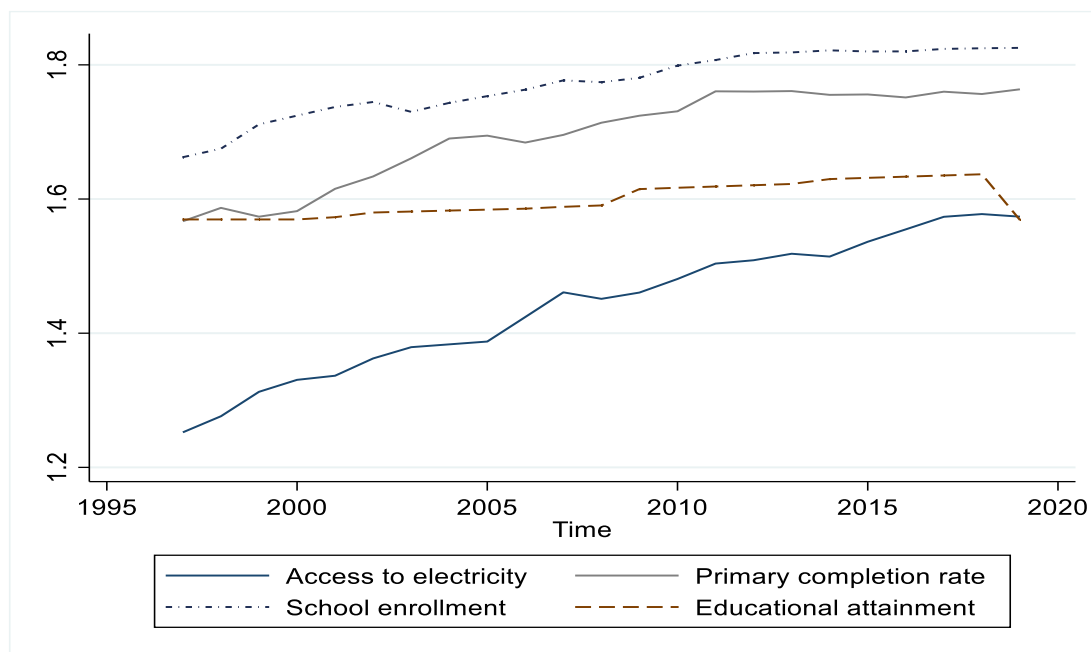
**Figure 1.** Access to electricity Versus Primary Educational attainment.

Source: Author's construction using WDI data.

As seen in Figure 2, Central African countries still stand backward as concerned with electricity supply. Tracing back in the years 2000, only Gabon, Equatorial Guinea and Sao Tome and Principe where having a share of population with access to electricity greater than 50% (73.6%, 65.56% and 52.9% respectively). While these shares were to some extend high for these countries, the situation was alarming for the Democratic Republic of Congo, Central Africa Republic and Chad who all had less than 7% share of their population with electricity access. Two decades later, the Democratic Republic of Congo stand at 19.1%, Central Africa Republic at 14.3% and Chad, 8.4% share of population with electricity access. In the sub-region, Gabon still lead with a share of 90.3%. Regarding these progress in the sector, we want to believe that electricity is the driving force behind primary education in the region.
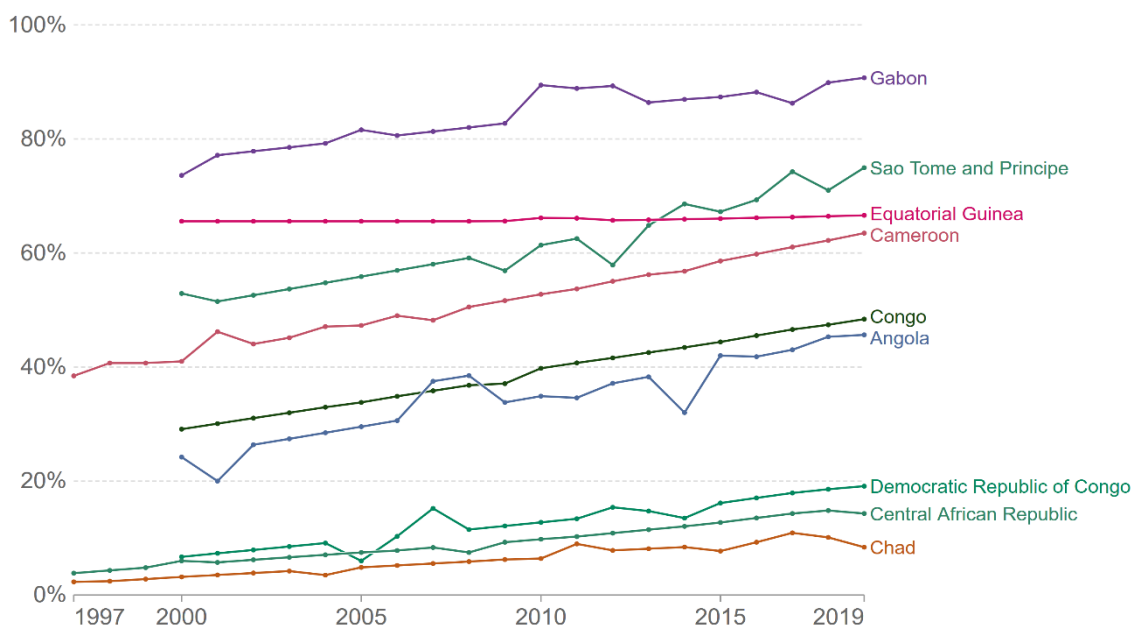
Figure 2. Access to electricity in Central Africa (1997-2019).

Source: Authors Construction from World Bank Data.
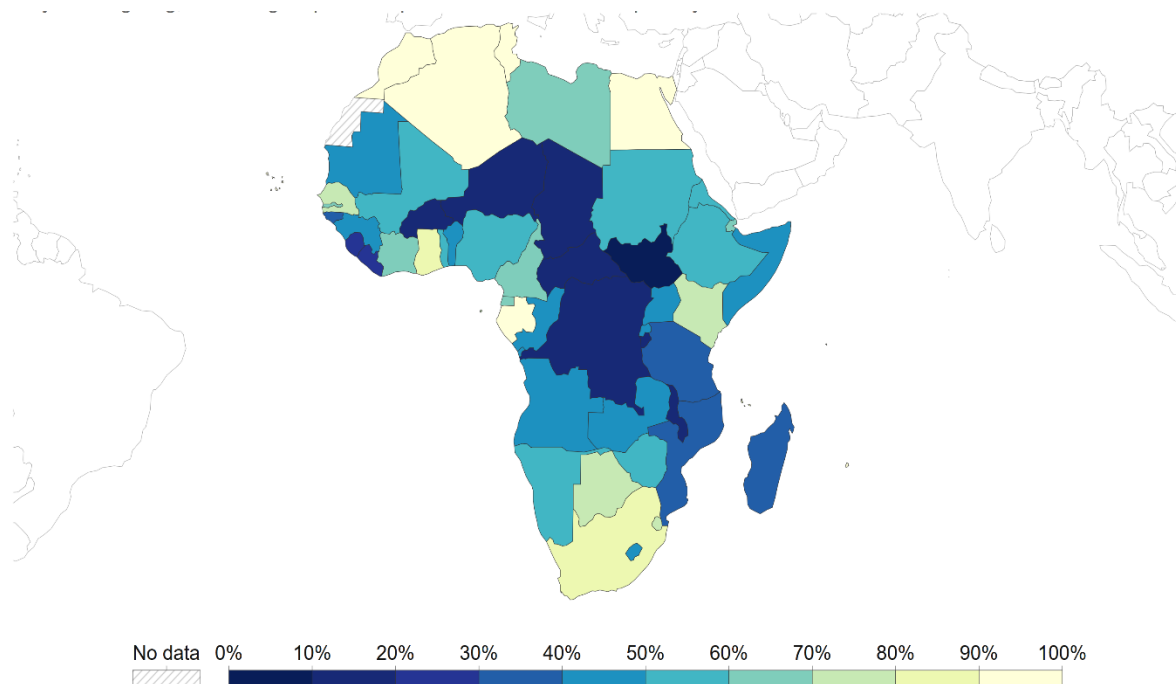
Figure 3. Cross Country spatial distribution of electricity access.

Source: Authors Construction from World Bank Data.

According to Barron and Torero (2017) and the World Health Organization (2016). Children in particular are the ones who suffers burden of the lack of electricity access in Africa, because of the illnesses related to indoor air pollution, the lack of access to information and the time spent collecting traditional fuels such as biomass and coal, among other things. A lack of access to electricity sources heavily impacts education. Without electricity, little-to-no school work may be done after dark. Schools that do not have access to electricity are not able to tap into modern technology, such as computers, which severely limits access to information. These factors, together with the impossibility of studying during dark hours, have a direct impact on pupil's performance and enrolment rates, which in turn affects human capital. More so, there is not a consensus in the empirical literature on the impact of access to electricity on educational attainment. While some papers do find a positive effect, many find no effect.

Based on the above presented facts, it is thus worthy questioning this effect with emphasis on primary education and Central Africa as case study. In this paper, we aim at analyzing this nexus given that primary education is a key determinant for the secondary and higher education. To this effect, we hypothesize that electricity access is positively associated with better primary education outcomes in Central Africa.

The contribution of this paper is twofold. First, we advance the received literature on electricity-education nexus (Dinkelman, 2011; Bridge et al., 2016; Alam et al., 2018; Oum, 2019; Banerjee et al., 2021; Nano, 2022), by empirically documenting the relationship between electricity access and educational attainment for the case of primary pupils, and particularly for Central African countries where energy and educational problems are still very alarming. The few studies devoted to the relationship between electricity and education, both at the micro and macro level examined the nexus with respect to education as a whole without a looking at the organizational decomposition of the respective education system. To the best of our knowledge, no study focused mainly on primary education specifically, which appears to be of great importance that MDG2 advocates it for all.

Secondly, this study estimates several linear models employing data covering the period 1997 to 2019. The

findings clearly shed light on the positive and significant impact of electricity access on primary education in Central Africa. The breaking down of the composite measure of educational attainment used in its different components which are: school enrollment, Completion rate and educational achievement suggests that they are individually correlated to electricity access and are affected by the latter. The Central Africa region is relevant as case study given that this sub region still lacks behind both in terms of access to electricity and education. As such, this paper equally contributes to recommendations in light with policy implications redirected towards the increase provision of electricity in the sub region.

The rest of the paper is organized as follows. Section 2 provides a review of the related literature; section 3 presents the methodology and data; Section 4 presents empirical findings; and Section 5 concludes this discussion and provides future policy directions.

2. Literature Review

2.1. Electricity Access and Education: what do we know?

Because electricity can offer so many different services in the classroom, it would be tragic if schools lack it. Early morning or late-night sessions can be held thanks to lighting. The integration of ICTs like computers and televisions into the classroom is made easier by the availability of electricity. Electrified schools have been correlated with increases in test scores and graduation rates and can help principals hire and keep more skilled teachers. For example, in Argentina, classes at non-electrified schools could not begin until mid-morning, when the room was sufficiently lit for reading. The availability of electricity made it possible to continue teaching into the early morning and after dark. It also encouraged students who lived on campus to stay for extended periods (Alazraki and Haselip, 2007). Similarly in Kenya, lighting has made it possible for current teachers to deliver additional instruction early in the morning and late at night to make up for material that was inadequately covered during regular hours because of a staffing shortage (Kirubi et al., 2009). According to one research, electricity "allows lower-income people access to lighting, communication, as well as a variety of educational delivery opportunities... A major impact of electrification has been reducing illiteracy and improving the quality of education" (Diniz et al., 2006). The opposite is true: schools without electricity typically perform worse than electrified counterparts. Both teachers and students are affected by the quite bad infrastructure (Skelton, 2014).

Access to energy promotes economic growth and prosperity and has a positive impact on income, expenditure and education (Bhuiyan et al., 2022). Even though many studies suggest that greater access to electricity will improve educational attainment, the impact remains theoretically and empirically unclear as there could be multiple mechanisms at work. One possible mechanism is that access to electricity increases demand for low skilled labor. This would increase the opportunity cost for students to stay in school and would lead to a drop in educational attainment (Squires, 2015). Another mechanism could be that access to electricity brings in manufacturing jobs which require more high skilled labor, thereby increasing the returns to human capital, which would cause students to be more likely to stay in school. There are a myriad of other possible mechanisms, which makes the impact of electricity on educational attainment uncertain.

2.2. Empirical literature

As earlier mentioned, the effect of access to electricity on education is not clear. On one hand, many studies argue that electricity can increase educational attainment (Khandker et al., 2014; Olanrele et al., 2020; Oum, 2019) by reducing the amount of manual labor needed in the home or by extending the number of daylight hours allowing for more time to study. On the other hand, electricity can reduce educational attainment by increasing the

opportunities of students in the labor market, raising the opportunity cost of staying in school (Squires, 2015).

Existing literatures suggests that with each additional year of education and with access to electricity, the positive effect of electricity has a greater impact on household income (Cabraal et al., 2005). There is considerable empirical evidence both at micro and macro level showing that electricity access is associated with higher education outcomes.

Talking of studies at the micro level, Acharya and Sadath (2019) Used household-level survey data in India and a multidimensional energy poverty index to study the role of Energy poverty on economic development. They find that education plays a crucial role in impeding the spread of energy poverty. Further, evidence suggests that children with electricity spend more time studying than similar children without electricity (Khandker et al., 2014). The study also finds that the positive effect on educational attainment is stronger for girls than boys, and thus improves average schooling in rural India

In the same light, Olanrele et al. (2020) examines the impact of access to electricity on health and education in Nigeria. Using primary data from 12 rural communities, the key empirical findings revealed that children study hour reduces with household access to grid electricity. Expenditure on electricity significantly decreases children study hour, electrification decreases indoor air pollution and household electricity expenditure increases. Also, Diallo and Moussa (2020) investigates the effect of household's access to electricity on poverty in Côte d'Ivoire. The study revealed a positive and significant effect of access to electricity on household consumption per capita. The results also highlight that the lower the regional rate of access to electricity, the higher the regional poverty rate. This literature is relevant for our study given the direct relationship existing between education and poverty. In fact, Countries with inadequate education lead to a greater number of people in poverty (Van der Berg, 2008).

Oum (2019) assess the extent of energy poverty, as well as its implications on the well-being of the people, such as in education and health, using the Lao Economic Consumption Survey (LECSs). He finds that energy poverty negatively impacts households' average school years and health status, thus argues that while ensuring access to electricity should be prioritized, it should be accompanied by policies promoting opportunities to generate income and reduce all forms of energy poverty.

Similarly, Nano (2022) attempted to provide a medium-term analysis of the effect of village-level electricity access on kids' schooling in rural Nigeria. The results of the analyses show that electricity access leads to an increase in school enrolment and a decrease in the grade-for-age gap; a measure of educational performance.

Looking at the works on electricity access and education at a macro level, Banerjee et al. (2021) critically examines the effect of energy poverty on health and education outcomes for 50 developing countries in the period 1990–2017. The empirical results show that lower energy poverty is associated with higher health and education outcomes. However, they find that access to electricity has a more substantial positive effect on development outcomes than energy use.

Ouedraogo et al., (2021) investigates the effects of access to electricity on health capital in a panel of 24 sub-Saharan African countries over the period 1990-2018. Using Ordinary Least Squares regressions and instrumental variables-two stage least squares method, they find that access to electricity improves health capital in the region. Again, Akram (2022) examine whether access to electricity causes the education of pupils across BRICS countries for the period 1993–2018. Using Granger and Dumitrescu–Hurlin panel causality tests, his results show that access to electricity causes the education of pupils. The findings suggest providing greater access to electricity for the further improvement of education in India, Russia, and South Africa.

Contrary to the above findings, Squires (2015) estimate the effect of access to electricity on school attendance and educational attainment in Honduras and found out that access to electricity reduces educational attainment. The reduction in education is accompanied by an increase in childhood employment, suggesting that improve labor market opportunities, due to electricity access, and therefore an increase in dropout rates.

In a global sense, looking at the various studies conducted on the topic both at the micro and macro level, the nexus is mostly between electricity access and education as a whole. None of these studies lay emphasis on primary education; one of the main focus of the Millennium Development Goals (MDG 2). This is the first paper examining the nexus between access to electricity and primary education in the context of Central Africa.

3. Methodology

3.1. Data

The data used in this study are from the World Development Indicators of the World Bank (2022). They cover 9 countries of Central Africa over the period 1997-2019. The period of study is justified by the availability of data. The Dependent variables, the main independent variable and control variables are chosen following the existing literature on the nexus between access to electricity and education.

Dependent variables used for this study are educational attainment variables captured by Primary educational achievement (which is the percentage of population that attained or completed primary education), Primary School enrollment (the ratio of children of official school age who are enrolled in school to the population of the corresponding official school age.) and Primary completion rate (the number of new entrants (enrollments minus repeaters) in the last grade of primary education, regardless of age, divided by the population at the entrance age for the last grade of primary education).

The main independent variable of interest is access to electricity. Access to electricity is measured by the percentage of the population with access to electricity collected from industry, national surveys and international sources.

Following the determinants of primary educational attainment, some control variables are selected for our study (Wilson, 2001; Picot and Hou, 2011; Badr et al., 2012; Knight and Shi, 1993) so as to avoid omission variable bias. These variables are:

GDP per capita (constant 2010 US$), this is gross domestic product divided by mid-year population. A country's economy becomes more productive as the proportion of educated workers increases since educated workers can more efficiently carry out tasks that require literacy and critical thinking. Countries with a greater portion of their population attending and graduating from schools see faster economic growth than countries with less-educated workers. Literature on theme indicate that primary schooling increases labour productivity in both urban and rural sectors, and that the economic returns to such investment are typically high. (Colclough, 1982).

Trained teachers in primary education (% of total teachers). Trained teachers in primary education are the percentage of primary school teachers who have received the minimum organized teacher training required for teaching in a given country. Quality teacher is a key role in improving learning outcomes (Cosentino and Sridharan, 2017). Analysis from sub-Saharan Africa found that teacher content and pedagogical knowledge significantly improve student achievement (Bold et al., 2017).

Primary school starting age (years) defined as the age at which students would enter primary education. Guo et al. (2017) provide supportive evidence that there exists a significant positive causal effect of later primary school entrance on years of schooling and starting primary school education when the children are more mature intellectually would be a choice that benefit the children more in the long-run education attainment.

Primary school Pupil-teacher ratio, the average number of pupils per teacher in primary school. According to Waita et al. (2016), Pupil-teacher ratio is a significant predictor of pupil's performance. They found that Pupil-teacher ratio have statistically significant effect on pupil's performance in primary schools.

Primary education pupils which is the total number of pupils enrolled at primary level in public and private schools. Regular school attendees perform differently from the chronic absentees. There is also a positive

relationship between school attendance and academic performance positive linkage between school attendance and academic performance (Sekiwu et al., 2020).

Repeaters (% of total enrollment). Repeaters in primary school are the number of students enrolled in the same grade as in the previous year, as a percentage of all students enrolled in primary school. The literature on the effects of grade retention on subsequent academic achievement concluded that grade retention had a negative effect on educational achievement (Jimerson, 2001; Sipple et al., 2004). However, most of the studies in this light are plagued by significant methodological limitations, the most important being a lack of a comparison group of promoted peers equivalent prior to retention on educational achievement and other variables predictive of achievement.

Primary education duration (years). Primary duration refers to the number of grades in primary school. As concern with school duration, Díaz and Pérez (2018) revealed that for children in elementary school one additional grade of primary education has a negative impact on enrollment rate.

The descriptive statistics and sources of all variables related to the aforementioned variables are apparent in table 1.

Table 1. Descriptive Statistics and Data source.

Variable	Definition	Mean	Std. Dev.	Min	Max	Source
Educ Achiev	The % of population that completed primary education	1.599	.357	.932	1.945	World Bank (2022)
Completion	Gross intake ratio to the last grade of primary education	1.695	.159	1.19	2.032	World Bank (2022)
Schoolenroll	Ratio of children of official school age who are enrolled in school to the population of the corresponding official school age.	1.772	.152	1.352	1.985	World Bank (2022)
Electricity	Percentage of population with access to electricity	1.442	.425	.362	1.958	World Bank (2022)
GDP	Gross domestic product divided by midyear population	.433	.051	.334	.543	World Bank (2022)
Trainedteachers	% of primary school teachers who have received the minimum organized teacher training	1.832	.15	1.438	2.134	World Bank (2022)
Startingage	The age at which students would enter primary education	6.15	.358	6	7	World Bank (2022)
Ratio	The average number of pupils per teacher in primary school	1.634	.188	1.075	2.047	World Bank (2022)
Pupils	The total number of pupils enrolled at primary level in public and private schools.	5.859	.766	4.214	7.225	World Bank (2022)
Duration	The number of grades (years) in primary school	5.797	.528	4	6	World Bank (2022)

Source: Author's construction using WDI data.

3.2. Empirical model

To investigate the effects of access to electricity on primary educational attainment over the period 1997-2019, we developed the following empirical model based on the works of Oum (2019) who examined the impact of energy poverty on education and health in Laos PDR.

$$Educ_{it} = \beta_0 + \beta_1 Elec_{it} + \theta X_{it} + \mu_i + \eta_t + \varepsilon_{it} \tag{1}$$

Where i is the country subscript (i= 1,..., 9); t is the time subscript (t= 1997,..., 2019); βs are unknown

parameters to be estimated; Ɵ is the vector of parameters associated with control variables; µ is the individual specific error; η is the time specific error; Educ is Educational attainment measured by Primary educational achievement, primary school enrollment and Completion rate; Elec is access to electricity in percentage of the population; X represent a vector of control variables which comprises GDP per capita (GDP), Trained teachers(TT), starting age (SA), pupil-teacher ratio (PTR), number of pupils (NP), Repeaters (R), and Primary duration (PD); Ɛ is the error term.

From the above, we can then rewrite our equation (1) as:

$$Educ_{it} = \beta_0 + \beta_1 Elec_{it} + \beta_2 GDP_{it} + \beta_3 TT_{it} + \beta_4 SA_{it} + \beta_5 PTR_{it} + \beta_6 NP_{it} + \beta_7 R_{it} + \beta_8 PD_{it} + \mu_i + \eta_t + \varepsilon_{it} \quad (2)$$

Given the decomposition of educational attainment into three components; Primary educational achievement, primary school enrollment and primary completion rate, we further decompose equation 2 into three models respectively which is the base of our regression analysis. Hence, we derive:

$$Achievement_{it} = \beta_0 + \beta_1 Elec_{it} + \beta_2 GDP_{it} + \beta_3 TT_{it} + \beta_4 SA_{it} + \beta_5 PTR_{it} + \beta_6 NP_{it} + \beta_7 R_{it} + \beta_8 PD_{it} + \mu_i + \eta_t + \varepsilon_{it} (3)$$

Where Achievement stands for primary educational achievement and represent the percentage of population that attained or completed primary education. Given that this is just an aspect of primary educational attainment, we go further to model primary school enrollment as a function of electricity access and determinants of education. This model is resume in equation 4.

$$School_{it} = \beta_0 + \beta_1 Elec_{it} + \beta_2 GDP_{it} + \beta_3 TT_{it} + \beta_4 SA_{it} + \beta_5 PTR_{it} + \beta_6 NP_{it} + \beta_7 R_{it} + \beta_8 PD_{it} + \mu_i + \eta_t + \varepsilon_{it} \quad (4)$$

With School designating primary school enrollment and representing the ratio of children of official school age who are enrolled in school to the population of the corresponding official school age.   Finally, we model primary education completion rate as a function of access to electricity and determinants of education which constitute the foundation for our third model as presented in equation 5.

$$Completion_{it} = \beta_0 + \beta_1 Elec_{it} + \beta_2 GDP_{it} + \beta_3 TT_{it} + \beta_4 SA_{it} + \beta_5 PTR_{it} + \beta_6 NP_{it} + \beta_7 R_{it} + \beta_8 PD_{it} + \mu_i + \eta_t + \varepsilon_{it} (5)$$

Where Completion stands for primary education completion rate and represent the number of new entrants (enrollments minus repeaters) in the last grade of primary education, regardless of age, divided by the population at the entrance age for the last grade of primary education.

3.3. Estimation technique

We begin the estimation process by employing the ordinary least squares (OLS) analysis in order to gain an understanding of the empirical relationships between access to electricity and primary educational attainment in Central African countries[1] over the period 1997–2019. This method has the advantage of providing the best robust estimates in the presence of heteroscedasticity (Robinson, 1987). Sensitivity test is done with the use of an alternative estimation strategy; the fixed effect Discroll and Kray. This technique is employed because, with increasing globalisation, the world has become a planetary village, in such a way that an event that occurs in one part of the world can rapidly spread across the other parts. The literature suggests the use of the Discroll and Kraay estimator (Driscoll and Kraay, 1998) in tacking eventual cross sectional dependence problems Furthermore, the selected control variables are endogenous, and therefore, our regressions may suffer from potential endogeneity problems. To deal with this, and regarding the configuration of our panel, with the use of the Two Stage Least Squares (2SLS) analysis.

4. Results and discussion

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[1] The countries included in the sample are: Angola, Cameroon, Central African Republic, Chad, Congo Republic, Democratic Republic of Congo, Equatorial Guinea, Gabon and Sao Tome and Principe.

Figure 2 display two-way scatter plots of educational attainment variables with respect to access to electricity in Central Africa. All the three graphs indicate a positive trend implying that an improvement or increase of electricity access will respectively increase primary completion rate, primary school enrollment and primary educational achievement in Central Africa.
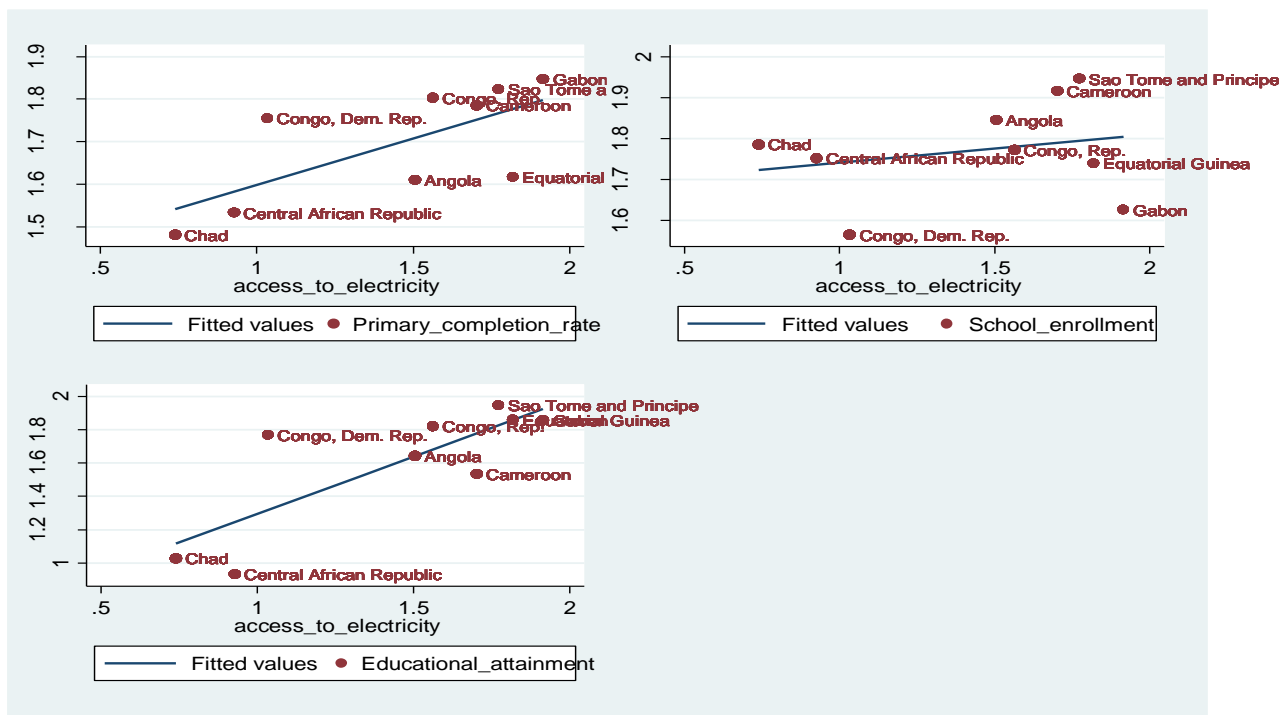
Figure 4. Scatter plot with fit: Access to electricity and educational attainment.

Source: Author's construction using WDI data.

4.1. The effect of access to electricity on educational attainment

Table 1 reports our baseline findings of the effect of access to electricity on educational attainment in Central Africa. In model (1), educational attainment which is the dependent variable is captured using achievement of primary education defined in the methodology section as the percentage of population that attained or completed primary education. Model (2) measures primary educational attainment with primary school enrollment as dependent variable, while in model (3), we used primary completion rate. Based on our findings, access to electricity affect positively and significantly primary education in Central Africa during the studied period. Econometrically, a 1unit increase in electricity access leads to a 0.516 unit increase in primary achievement, 0.191unit increase in primary school enrollment and 0.291unit in completion rate respectively. Economically, this positive effect is justified given the fact that electricity access facilitates the introduction of ICTs into the classroom such as computers, lighting and extended studying hours, enhanced staff retention and teacher training and improve sanitation and health, gender empowerment, and community resilience (Diniz et al., 2006; Van der Berg, 2008). These results accord with the works of Khandker et al., (2014); Oum (2019); Olanrele et al., (2020); Banerjee et al., (2021) and Nano (2022) who equally came up with positive relationships between electricity access and education.

Table 2. Baseline results with independent and control variables (pooled OLS).

	(1) Educational Achievement	(2) School Enrollment	(3) Completion rate
Electricity	0.516***	0.191***	0.291***
	(0.0396)	(0.0285)	(0.0198)
GDP	2.239***	0.778***	0.576***
	(0.295)	(0.212)	(0.147)
Trainedteachers	0.326***	-0.197**	0.177***
	(0.114)	(0.0818)	(0.0568)
Startingage	0.126***	0.0112	-0.149***
	(0.0449)	(0.0323)	(0.0225)
Ratio	0.952***	0.361***	0.108**
	(0.103)	(0.0740)	(0.0514)
Pupils	0.00251	-0.0281	-0.0272**
	(0.0263)	(0.0190)	(0.0132)
Repeaters	0.000208	-0.00753***	-0.00383***
	(0.00211)	(0.00152)	(0.00106)
Duration	0.0200	0.00138	0.103***
	(0.0260)	(0.0187)	(0.0130)
Constant	1.868***	1.843***	1.931***
	(0.546)	(0.393)	(0.273)
Observations	207	207	207
R-squared	0.793	0.411	0.739

Source: Author's computations using WDI data.

Notes: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.

In order to avoid omission variable bias in our model, we include control variables in the regression. The econometric results reveal that, GDP per capita positively affect educational achievement, school enrollment and completion rate. Changes in the structure of school infrastructures, facilities and enrollments has important budgetary implications for many countries and these ameliorated schooling conditions boost the educational performance of the pupils. This finding corroborates those of Colclough (1982) on the nexus education and economic growth. Furthermore, the number of trained teachers is seen to positively affect both educational achievement and completion rate, but affect school enrollment negatively. (Bold et al., 2017) regarding this relationship shows that teacher quality is a key determinant of student learning. Again, the age at which primary pupils commence school was examined in relation to educational attainment, and the empirical findings suggest a positive linkage regarding educational achievement and school enrollment, but a negative effect on completion rate. This finding ties with the works of Guo et al. (2017) who documented a significant positive causal effect of late primary school entrance on years of schooling. They added that, starting primary school education when the children are more mature intellectually would be benefiting choice for the pupils in their long-run education attainment. The ratio pupils-teachers equally affect educational attainment positively and significantly. More specifically, a unit increase in this ratio lead to a 0.952 unit increase in education achievement, 0.361 unit increase in school enrollment and 0.108 unit increase in completion rate respectively. This result accords with those of Waita et al. (2016), who found that Pupil-teacher ratio have statistically significant effect on pupil's performance in primary schools and that Pupil-teacher ratio was regarded as a significant predictor of pupil's performance. As for the variable repeaters, it positively contributes to educational achievement given that retention in the same grade to an extend enable accumulation of knowledge. This same variable is negatively correlated with both school enrollment as well as primary completion rate. Findings on the effects of repeaters on academic achievement concluded that grade retention had a negative effect on educational achievement (Jimerson, 2001; Sipple et al., 2004). This can be as a result of discouragement by the students after failure causing them to drop from school

thereby leading to low completion rate. Finally, our results postulate a positive effect of Primary education duration on educational attainment. Though the coefficients are weak, it is seen that the more pupils stay to complete the primary cycle, the better their knowledge achievement and completion rate. Duration equally increase the school population due to the aggregation of old and new students, reason for the positive effect related to school enrollment. These findings are in contradiction with those of Díaz and Pérez (2018) who revealed that for children in elementary school, one additional grade of primary education has a negative impact on enrollment rate and educational performance.

4.2. Robustness of the results

The baseline results presented in table 2 employs the pooled OLS technique in regressing the stated model. Although the Pooled OLS regression model produces unbiased estimates of the population values, yet time-constant and time-varying unobserved heterogeneity are likely to be a problem which may bias the outcomes of our findings. Also, given the fact that our panel regroup 9 countries of Central Africa, we thus suspect a cross-sectional or "spatial" dependence highlighted by Driscoll and Kraay, (1998) which is not taken in to account by the OLS estimator as used in baseline. Failure to account for this dependence will result in inconsistently estimated standard errors.

To this effect, we run a fixed effect Discroll and Kray on our stated model using the same variables as apparent in table 3.

Table 3. Effect of access to electricity on Primary educational attainment (Discroll and Kraay).

	(1) Educational Achievement	(2) School Enrollment	(3) Completion rate
Electricity	0.0128***	0.150**	0.294***
	(0.0575)	(0.0930)	(0.0522)
GDP	1.415***	1.398**	0.748**
	(0.411)	(0.648)	(0.275)
Trainedteachers	0.00783	0.0705	0.0142
	(0.0340)	(0.0807)	(0.0511)
Startingage	-0.00835	0.0132	-0.0955**
	(0.0161)	(0.0258)	(0.0360)
Ratio	-0.113**	0.122	0.249***
	(0.0462)	(0.128)	(0.0456)
Pupils	0.0464***	0.0977***	0.0800***
	(0.0154)	(0.0215)	(0.0166)
Repeaters	0.00199**	-0.00284*	-0.00553***
	(0.000808)	(0.00158)	(0.000686)
Duration	-0.0148***	-0.00830	0.0247**
	(0.00268)	(0.0213)	(0.00879)
Constant	0.963***	0.0753	0.602**
	(0.185)	(0.466)	(0.273)
Observations	207	207	207
R-squared	0.308	0.330	0.714
Number of groups	9	9	9

Source: Author's computations using WDI data.

*Notes: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.*

Once again, the association of electricity access with primary educational attainment is positive and statistically significant. The use of an alternative estimation strategy (Discroll and Kraay) is consistent with previous estimates. Actually, the signs of access to electricity regressed with educational attainment variables remains

positive and significant highlighting the fact that brightness comes with brighter educational outcomes. Though we observe slight variations in the coefficients, the effects remained virtually the same. Thus, the baseline findings remained significant and are therefore, robust to the presence of cross-sectional dependence.

4.3. Endogeneity account

The previous results obtained, though statistically significant could suffer from reverse causality or potential endogeneity may bias the results and question our findings. To handle the endogeneity problem in the literature, two instrumental variables methods are widely used: The generalized method of Moments (GMM) and the Two stage least squares (2SLS). Due to the configuration of the sample size and time (N=9 countries and T=23 years respectively), we adopt the 2SLS. Motivation for using the 2SLS to account for endogeneity is because it provides a way to obtain consistent parameter estimates and Acoording to Maydeu-Olivares et al. (2019), it consistently estimates the parameters of a regression model in the presence of correlated errors between the predictors and the outcome's errors.   We notice once more that the results are robust to alternative specifications as well as to variations in estimation techniques. The result of this exercise is apparent in table 4.

Table 4. Effect of access to electricity on Primary educational attainment (2SLS).

	(1) Educational Achievement	(2) School Enrollment	(3) Completion rate
Electricity	0.817***	0.508***	0.493***
	(0.129)	(0.105)	(0.0704)
GDP	2.979***	1.557***	1.072***
	(0.449)	(0.362)	(0.244)
Trainedteachers	0.356***	0.165	0.198***
	(0.130)	(0.105)	(0.0705)
Startingage	0.159***	0.0459*	-0.127***
	(0.0527)	(0.0426)	(0.0287)
Ratio	0.725***	0.601***	0.0446
	(0.148)	(0.120)	(0.0807)
Pupils	0.0641*	0.0368**	-0.0141*
	(0.0389)	(0.0314)	(0.0211)
Repeaters	0.00232	-0.00530**	-0.00241*
	(0.00255)	(0.00206)	(0.00138)
Duration	0.0176**	0.00107*	0.102***
	(0.0295)	(0.0238)	(0.0161)
Constant	0.736***	0.650***	1.171***
	(0.770)	(0.622)	(0.419)
Observations	207	207	207
R-squared	0.733	0. 440	0.602

Source: Author's computations using WDI data.

*Notes: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.*

In all cases, our main variable of interest remains statistically significant and its magnitude does not change much. The results in Table 4 show that the coefficients associated with access to electricity remained positively and statistically significant, indicating that electricity access boost primary education in Central African Economies. The results of the diagnostic tests show that all models are well specified. Our baseline estimates are therefore robust to control of endogeneity.

5. Conclusion

The main objective of this paper was to examine the effect of electricity access on primary education in Central Africa over the period 1997-2019. Using pooled OLS estimation technique, our results reveal that access to electricity contribute both positively and significantly to primary educational attainment in Central Africa during the study period. These results are robust with the use of alternative estimation strategies; Fixed effect Discroll and kraay and Two Stage Least Squares (2SLS) estimation techniques. Our results reveal that improving access to electricity in the region has important benefits on primary education.

Based on the results, we recommend the governments of Central African counties to pay more attention or multiply efforts so as to increase access to electricity for the betterment of the primary education sector. Providing access to electricity will not only help the education sector through improving literacy, but also by providing a better way of life in the region.

Additionally, Governments could provide once-off catch-up programs that target children or dropout (and reintegrate out-of-school children) through a program to get them ready for the next year. This policy is relevant regarding the negative effect of repeaters on school enrollment. Last but not the least, the government may adopt alternative energy sources such as solar electrification of schools. This will avoid the frequent electricity failure which generally comes with a slowdown in educational activities.

Our study does not come without limitations. The first one is that, we limit only to one determinant of educational attainment (electricity access) amongst others meanwhile alternative sources could be envisaged. Secondly, the study zone is limited to only 9 African countries from a large group with similar characteristics.   With regard to these limitations, the present study provides some research opportunities. In future research, the effect of electricity on education can be tested for all African countries given that as shown in figure 3 the Share of the population with access to electricity for most of these countries is on average less than 50%.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Acharya, R. H., & Sadath, A. C. (2019). Energy poverty and economic development: Household-level evidence from India. Energy and Buildings, 183, 785-791. https://doi.org/10.1016/j.enbuild.2018.11.047

Akkari, A., & Lauwerier, T. (2015). The education policies of international organizations: Specific differences and convergences. Prospects, 45, 141-157. https://doi.org/10.1007/s11125-014-9332-z

Akram, V. (2022). Causality Between Access to Electricity and Education: Evidence From BRICS Countries. Energy RESEARCH LETTERS, 3(2), 32597. https://doi.org/10.46557/001c.32597

Alam, M. S., Miah, M. D., Hammoudeh, S., & Tiwari, A. K. (2018). The nexus between access to electricity and labour productivity in developing countries. Energy Policy, 122, 715-726. https://doi.org/10.1016/j.enpol.2018.08.009

Alazraki, R., & Haselip, J. (2007). Assessing the uptake of small-scale photovoltaic electricity production in Argentina: the PERMER project. Journal of Cleaner Production, 15(2), 131-142. https://doi.org/10.1016/j.jclepro.2005.12.015

Badr, M., Morrissey, O., & Appleton, S. (2012). Determinants of educational attainment in MENA (No. 12/03). CREDIT Research Paper. http://hdl.handle.net/10419/65455

Banerjee, R., Mishra, V., & Maruta, A. A. (2021). Energy poverty, health and education outcomes: evidence from the developing world. Energy economics, 101, 105447. https://doi.org/10.1016/j.eneco.2021.105447

Barber, M., & Mourshed, M. (2007). How the world's best performing systems come out on top. https://hdl.handle.net/20.500.12365/17300

Barron, M., & Torero, M. (2017). Household electrification and indoor air pollution. Journal of Environmental Economics and Management, 86, 81-92. https://doi.org/10.1016/j.jeem.2017.07.007

Bhuiyan, M. A., Zhang, Q., Khare, V., Mikhaylov, A., Pinter, G., & Huang, X. (2022). Renewable energy consumption and economic growth nexus—a systematic literature review. Frontiers in environmental science, 412. https://doi.org/10.3389/fenvs.2022.878394

Bold, T., Filmer, D., Martin, G., Molina, E., Stacy, B., Rockmore, C., ... & Wane, W. (2017). Enrollment without learning: Teacher effort, knowledge, and skill in primary schools in Africa. Journal of Economic Perspectives, 31(4), 185-204. https://doi.org/10.1257/jep.31.4.18

Bridge, B. A., Adhikari, D., & Fontenla, M. (2016). Electricity, income, and quality of life. The Social Science Journal, 53(1), 33-39. https://doi.org/10.1016/j.soscij.2014.12.009

Bruns, B., & Luque, J. (2014). Better teachers for Latin America and the Caribbean: new evidence on how to raise teacher quality and student learning. Washington, DC: World Bank.

Cabraal, R. A., Barnes, D. F., & Agarwal, S. G. (2005). Productive uses of energy for rural development. Annu. Rev. Environ. Resour., 30, 117-144. https://doi.org/10.1146/annurev.energy.30.050504.144228

Colclough, C. (1982). The impact of primary schooling on economic development: a review of the evidence. World Development, 10(3), 167-185. https://doi.org/10.1016/0305-750X(82)90008-0

Cosentino, C., & Sridharan, S. (2017). IMPROVING TEACHER QUALITY.

Diallo, A., & Moussa, R. K. (2020). The effects of solar home system on welfare in off-grid areas: Evidence from Côte d'Ivoire. Energy, 194, 116835. https://doi.org/10.1016/j.energy.2019.116835

Díaz Serrano, L., & Pérez Reynosa, J. H. (2018). Impact of Duration of Primary Education on Enrollment in Secondary Education: Panel Data Evidence from Developing Countries. http://hdl.handle.net/2072/351582

Diniz, A. S. A. C., França, E. D., Câmara, C. F., Morais, P. M. R., & Vilhena, L. (2006, May). The important contribution of photovoltaics in a rural school electrification program. In 2006 IEEE 4th World Conference on Photovoltaic Energy Conference (Vol. 2, pp. 2528-2531). IEEE. 10.1109/WCPEC.2006.279760

Dinkelman, T. (2011). The effects of rural electrification on employment: New evidence from South Africa. American Economic Review, 101(7), 3078-3108. https://doi.org/10.1257/aer.101.7.3078

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

Ferguson, R., W. Wilkinson, and R. Hill (2000). Electricity use and economic development. Energy Policy 28(13), 923–934 https://doi.org/10.1016/S0301-4215(00)00081-1

Fujii, T., Shonchoy, A. S., & Xu, S. (2018). Impact of electrification on children's nutritional status in rural Bangladesh. World Development, 102, 315-330. https://doi.org/10.1016/j.worlddev.2017.07.016

Guo, C., Xuening, W., & Meng, C. (2017). The Effect of Age at School Entry on Educational Attainment and Labor Market Outcomes: Evidence from China. Unpublished manuscript.

Hanushek, E. A., & Rivkin, S. G. (2006). Teacher quality. Handbook of the Economics of Education, 2, 1051-1078. https://doi.org/10.1016/S1574-0692(06)02018-6

Jimerson, S. R. (2001). Meta-analysis of grade retention research: Implications for practice in the 21st century. School psychology review, 30(3), 420-437. https://doi.org/10.1080/02796015.2001.12086124

Khandker, S. R., Samad, H. A., Ali, R., & Barnes, D. F. (2014). Who benefits most from rural electrification? Evidence in India. The Energy Journal, 35(2). 10.5547/01956574.35.2.4

Kirubi, C., Jacobson, A., Kammen, D. M., & Mills, A. (2009). Community-based electric micro-grids can contribute to rural development: evidence from Kenya. World development, 37(7), 1208-1221. https://doi.org/10.1016/j.worlddev.2008.11.005

Knight, J., & Shi, L. (1993). The determinants of educational attainment in China (pp. 285-330). Palgrave Macmillan UK. https://doi.org/10.1007/978-1-349-23026-6_9

Maydeu-Olivares, A., Shi, D., & Rosseel, Y. (2019). Instrumental variables two-stage least squares (2SLS) vs. maximum likelihood structural equation modeling of causal effects in linear regression models. Structural Equation Modeling: A Multidisciplinary Journal, 26(6), 876-892. https://doi.org/10.1080/10705511.2019.1607740

Nano, E. (2022). Electrifying Nigeria: The impact of rural access to electricity on kids' schooling (No. 03-2022). Graduate Institute of International and Development Studies Working Paper. http://hdl.handle.net/10419/253255

OECD, I. (2016). Energy and air pollution: world energy outlook special report 2016.

Olanrele, I. A., Lawal, A. I., Dahunsi, S. O., Babajide, A. A., & IseOlorunkanmi, J. O. (2020). The impact of access to electricity on education and health sectors in Nigeria's rural communities. Entrepreneurship and Sustainability Issues, 7(4), 3016-3035. 10.9770/jesi.2020.7.4(30)

Ouedraogo, I., Jiya, A. N., & Dianda, I. (2021). Access to electricity and health capital accumulation in Sub-Saharan Africa. Conference Paper: 2021 International Development Economics Conference (ICDE2021). https://doi.org/10.13140/RG.2.2.28833.22882 [Google Scholar]

Oum, S. (2019). Energy poverty in the Lao PDR and its impacts on education and health. Energy Policy, 132, 247-253. https://doi.org/10.1016/j.enpol.2019.05.030

Pan, L., Dwumfour, R. A., & Kheng, V. (2022). Lightening the Path to Financial Development: The Power of Electricity.

Picot, G., & Hou, F. (2011). Preparing for success in Canada and the United States: The determinants of educational attainment among the children of immigrants. Statistics Canada Analytical Branch Studies Working Paper, (332). http://dx.doi.org/10.2139/ssrn.2016608

Ramachandran, V., Gelb, A. H., & Shah, M. K. (2009). Africa's Private Sector: What's Wrong with the Business Environment and what to Do about it. CGD Books.

Robinson, P. M. (1987). Asymptotically efficient estimation in the presence of heteroskedasticity of unknown form. Econometrica: Journal of the Econometric Society, 875-891. https://doi.org/10.2307/1911033

Sekiwu, D., Ssempala, F., & Frances, N. (2020). Investigating the Relationship between School Attendance and Academic Performance in Universal Primary Education: The Case of Uganda. African Educational Research Journal, 8(2), 152-160. http://hdl.handle.net/20.500.12493/418

Sipple, J. W., Killeen, K., & Monk, D. H. (2004). Adoption and adaptation: School district responses to state imposed

learning and graduation requirements. Educational Evaluation and Policy Analysis, 26(2), 143-168.

https://doi.org/10.3102/01623737026002143

Skelton, A. (2014). Leveraging funds for school infrastructure: The South African 'mud schools' case study. International Journal of Educational Development, 39, 59-63. https://doi.org/10.1016/j.ijedudev.2014.07.008

Squires, T. (2015). The impact of access to electricity on education: evidence from Honduras. Job Market Paper, Brown University, 1-36.

UNESCO Institute for Statistics (2014). A view inside schools in Africa: Regional education survey. Paris: UNESCO.

Van der Berg, S. (2008). How effective are poor schools? Poverty and educational outcomes in South Africa. Studies in Educational Evaluation, 34(3), 145-154. https://doi.org/10.1016/j.stueduc.2008.07.005

Waita, K. J., Mulei, K. O., Mueni, K. B., Mutune, M. J., & Kalai, J. (2016). Pupil-teacher ratio and its impact on academic performance in public primary schools in Central Division, Machakos County, Kenya. European Journal of Education Studies.

Wilson, K. (2001). The determinants of educational attainment: Modeling and estimating the human capital model

and education production functions. Southern Economic Journal, 67(3), 518-551.

https://doi.org/10.1002/j.2325-8012.2001.tb00355.x

World Health Organization. (2016). World health statistics 2016: monitoring health for the SDGs sustainable development goals. World Health Organization.