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Education, Electricity Access, and Income Inequality in Nigeria

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ABSTRACT

Education and electricity access are argued to be important determinants in the income inequality literature, especially with regard to developing countries. This present study explores in Nigeria the roles of both education and electricity access, as well as the interaction of the aforementioned variables for income inequality over the period of 1990-2019. Utilizing Autoregressive Distributed Lag (ARDL) estimation preceded by the Augmented Dickey-Fuller (ADF) unit root test and ARDL bounds test for cointegration, the study found that while there was no long-run relationship between income inequality and it's determining variables, including education and electricity access, in the short run, electricity access was significant for reducing income inequality, while education was not significant for income inequality in Nigeria. On the other hand, education in the presence of greater electricity access was found to play a significant role in raising income inequality in Nigeria. The policy implications derived from the study findings emphasized the need for greater creation of employment opportunities by the Nigerian government, while electricity is made affordable for greater access by the Nigerian populace and is adequate in supply. Recommendations were also proffered based on the findings of the study.

Keywords: Education, Electricity Access, Income Inequality, Autoregressive Distributed Lag Estimation, Nigeria, Sub-Saharan Africa
JEL Classifications: K32, O11,O15

1. INTRODUCTION

Income inequality is defined as the extent to which income is unevenly distributed throughout a population. It is much pronounced in developing countries in general and Sub-Saharan Africa (SSA) countries including Nigeria in particular (Adeleye et al., 2020). Todaro and Smith (2020) highlight various measures of income inequality including the Lorenz curve, and the Gini coefficient alternatively referred to as the Gini Index. The aforementioned measures can be used to compare income inequality across cities, countries, country regions, and continents of the world.

The increased focus on income inequality as a topical issue in economic and social research the world over may be argued as resulting from income inequality being a persistent issue over the years and having attendant adverse consequences for developing country growth and development. Further arguable is the notion that income inequality is related to the political development of a country. Hence conflict, strife, and so on prevalent especially in countries characterized by low levels of political development, may result on account of income inequality as individuals or groups agitate for reduced income disparities within a setting-be it a country, state, city, and so on Consistent with the aforementioned, income inequality is highlighted as an economic development issue in the development economics literature with Piketty (2015) highlighting the increased focus on income inequality to have resulted since the 1980s. Developing countries of the world, especially those in SSA undertook structural adjustment Programme reforms in the 90s, towards

promoting their economic development and featuring reforms aimed at liberalizing their economies. The aforementioned reforms are argued to have resulted in the promotion of greater income inequalities in the countries rather than reducing the pre-existing income inequalities. Further, studies highlight the consequences of income inequality such as social vulnerability and health issues (OECD, 2018; Kanbur and Stiglitz, 2015).

SSA countries despite recording impressive growth levels, increasing income inequalities amongst other inequalities continue to give cause for concern. Kuznets (1955) however rationalizes the association of income inequality and economic progress based on the inverted U-Hypothesis which holds that at lower levels of economic growth, rising income inequalities are observed on account of development activities. However, as a country advances in its growth and becomes more developed beyond a threshold, income inequality declines with the country experiencing higher economic growth. Thus developing countries characterised by low growth levels and being at an early stage of development will have income inequality more pronounced than developed countries. Various reasons are argued as explaining Kuznet's inverted–U hypothesis amongst which is the decline in returns to education over time as the country becomes developed, and which takes place on account of the labour market becoming saturated such that demand for educated individuals' declines (Todaro and Smith, 2020). Similarly, the co-existence of agriculture and industry in developing countries may explain higher income inequality in developing countries relative to developed countries as the agriculture sector relative to the industrial sector dominates developing country economy employment. In such developing countries, modern sector enlargement progresses at a slow rate, in contrast to developed countries where the reverse is the case and is reflected by the advanced level of modern sector enlargement in such developed countries.

Nigeria as a developing country and a country in SSA features relatively high and rising levels of income inequality for which various factors may be attributed such as a high rate of corruption and poor governance as highlighted by Ogbeide and Agu (2015). Over the past three decades, Nigeria according to World Bank (2022) has recorded a Gini index on average of 0.35 with values as high as 0.42 recorded. This reflects the extent of income inequality in Africa's most populous nation - Nigeria. The National Bureau of Statistics (NBS) revealed that as of 2019, 40% of the total population i.e. almost 83 million people, lived below the poverty line per year in Nigeria (NBS, 2020).

Education and electricity access, in particular, are central socio-economic challenges in Nigeria and to that effect may play a role in the prevalent level of income inequality in Nigeria. Education playing a role in income inequality is highlighted by a number of literature based on evidence from other countries of the world (Leiva and Pino, 2020; Danquah and Ohemeng, 2017). However, in the context of Nigeria where <50% of the population has electricity access, despite high school enrolment rates, especially at the primary level, income inequality remains rather high based on statistics from the World Bank World Development Indicators (World Bank, 2022). It may therefore be argued that education as a merit good and electricity required to meet the energy needs of citizens for education amongst other uses, has a role to play in development. Consequently, reduced income inequalities may be a conduit through which development may result.

On account of the added value of human capital as an individual's education level, as well as employment opportunities increase, an individual has an increased ability to earn more income (Abdullah et al., 2015; Cingano, 2014). Hence an increase in human capital resources boosts an individual's chances of employment in the labour market. This may be more so as education may provide a platform for innovation which as highlighted by Ongo et al. (2024) may play a role in income inequality, Palaz et al. (2013) argue based on evidence from Turkey that combining advanced levels of education with primary school education reduces the adverse effect on the income distribution of primary school education. In relation Blanden and Machin (2004) further highlights the human skills and increases in human productivity amongst other benefits resulting from education. The aforementioned gives rise to higher monetary incentives and greater scope for better jobs resulting in the poor especially, accessing better economic opportunities. The differential in the level of awareness of the returns or benefits of education between the educated and uneducated further triggers inequality between the aforementioned groups of people. Moniruzzaman and Emran (2021) argue that the net influence of education on inequality depends on whether irrespective of economic insolvency or not a particular individual continues his/her education. Hence, it is worth verifying the impact of education on the distribution of income. However, Hovhannisyan et al. (2019) identified an inverse association between education and income inequality which they explained as resulting where educational attainment enhances labour productivity and allows for higher and more equitable wage distribution.

Likely to influence the potential contribution of education to income inequality amongst other factors is electricity access. Electricity access is popularly viewed in the energy and environmental sustainability literature as a means to raise standards of living. The more people with electricity access, the better their living standard. Electricity access in relation to education may promote the use of Information and Communication Technology devices which will consequently promote efficiency in the delivery of quality education in addition to the quality of student learning of taught material. Further given the low carbon content of electricity relative to other unclean forms of energy, greater electricity access promotes a conducive learning environment that is free of pollution from carbon emissions associated with other forms of energy. Many of the alternative forms of energy to that of electricity are unclean. However, it is the unclean energy that remains the most accessible to the common man in a developing country such as Nigeria on account of the generally low incomes realized by most individuals in the country. In addition, greater electricity access in regard to education may promote the enabling environment for foreign direct investment inflow to the education sector that will contribute to advancing education in Nigeria. Olanrele et al. (2020) further highlight that lighting resulting from electrification can be utilized for entertainment, reading, and leisure in the course of enabling access to information that leads to formal and even non-formal education.

Further as a result of electrification and consequently lighting, student learning can be done any time of the day or night both at home and in classrooms in schools. It also supports the smooth operation of learning infrastructure such as smartboards and other Information and Communications Technology (ICT) equipment and may incentivize educationists to deliver quality education to students in classrooms in educational institutions. Consequently, the value of electricity access for education and by extension correlates with education as Economic growth, income inequality, poverty, sustainable development, and so on are enhanced. Lower-income individuals are availed of lighting, communication, as well as a variety of educational delivery opportunities with the aid of electricity access as Diniz et al. (2006) argue. UNDESA (2014) in addition highlights that through the reduction of illiteracy and raising education quality, an invaluable effect of electrification is evidenced and cannot be over-emphasized for any country of the world. The aforementioned are consistent with the argument of the broader literature relating electricity to economic growth (Gershon et al., 2020; Matthew et al., 2018), with education as one of many routes through which a link between electricity and economic growth may be established.

Fuso Nerini et al. (2018) argue electricity access is a strategy for economic advancement and the reduction of poverty and income inequalities. Economic empowerment including employment opportunities may result as productive opportunities are taken advantage of on account of greater electricity access. Consequently, the aforementioned will give rise to reduced income inequality. For instance, Foreign direct investment inflow which results in employment creation and inflow of technology to the host country, potentially contributing to reduced income inequality may be boosted on account of greater electricity access. However, where a country suffers from a high cost of electricity access, epileptic power supply may result as observed in recent times in Nigeria where foreign enterprises in Nigeria have now relocated to Ghana attracted by the stable and affordable electricity supply obtainable. Thus, the observed rising income inequality in Nigeria amongst other consequences has inevitably resulted. Entrepreneurship which is a major source of employment and in relation to innovation will also give rise to greater employment and economic empowerment in a developing country such as Nigeria requires greater electricity access if it is to act as a means to bring about a significant decline in income differentials.

Thus based on the aforementioned, electricity access and education working independently and collectively may contribute to reduced income inequalities. However, it is pertinent to consider in the context of a developing country such as Nigeria whether electricity access on account of the cost may exacerbate existing income inequalities. While Nigeria has embraced education as compulsory for individuals aged 6-15 years, electricity access may at best be argued as a luxury, as very few households have electricity access. This is despite the steady rise in global electricity access in recent decades, such that in 1990, just over 71% of the world population had access while by 2018, this had risen to over 87% (Ritchie and Roser, 2020). Further, while developed countries have embraced electricity access as a necessity for living, in developing countries and particularly SSA countries such as Nigeria poor electricity access remains a hindrance to the yearnings of individuals for better living standards. Consequently, poor electricity access in developing countries such as Nigeria is a factor increasing the divide in incomes between the affluent and the poor.

Previous studies relating income inequality to education or electricity access are limited and have mostly taken the form of panel data studies exploring groups of countries together (Ongo et al., 2024; Igawa and Managi, 2022; Nguyen and Nasir, 2021; Acheampong et al., 2021; Sarkodie and Adams, 2020; Palaz et al., 2013). However, those with a specific focus on important SSA countries as Nigeria are few. Except for Guza et al. (2020) focusing on education amongst other income inequality determinants in Nigeria while excluding electricity access, and Sarkodie and Adams (2020a) with emphasis on South Africa focusing on electricity access while excluding education, no study on individual SSA countries to the best of the researcher's knowledge explored the roles of both electricity access and education, including the interaction of electricity access with education on income inequality. Thus this study seeks to fill the aforementioned research gap in the literature on electricity access, education, and income inequality, especially for a country such as Nigeria where despite high education enrolment rates, electricity access while a necessity for raising welfare standards is limited. Studies on specific countries such as Nigeria enable an in-depth analysis of critical issues such as the roles of electricity access and education on income inequality which will give rise to country-specific recommendations to address income inequality and which are limited in the literature. Specifically, three hypotheses are formulated to be tested in this study as follows: (1) Income inequality is significantly influenced by education in Nigeria (2) Electricity Access is significant in reducing income inequality in Nigeria, and (3) income inequality is affected as Electricity Access interacts with education.

The subsequent sections of this study are as follows. Section 2 is a discussion of relevant and related recent literature on education, electricity access, and income inequality. The data as well as the empirical methodology of the study are discussed in section 3, while the empirical results are presented and discussed in section 4. Section 5 is the conclusions and policy implications of the study.

2. LITERATURE REVIEW

Inequality in income distribution has been a widespread issue, especially in emerging economies over decades past and is explained by various theories in the development literature as Kuznets' inverted U-Hypothesis (Kuznets, 1955) Greenwood-Jovanovic hypothesis (Greenwood and Jovanovic, 1990) and the dual sector model of development which include theories as that of Lewis Two-Sector model (Todaro and Smith, 2020), all giving credence to the existence of income inequality. The aforementioned three theories all explain income inequality in relation to the nature of structural change, however, the former two theories argue non-linearity between each of growth and financial development respectively with income inequality, consequently highlighting that income inequality while rising in the earlier stages of growth of a country later declines as a country progresses in its

growth and development. The expansion of the modern industrial sector that plays a role in the advancement of a country over time may explain the reduced income inequality in the latter years of a country according to the Kuznets' inverted U-Hypothesis. However, with respect to the Greenwood-Jovanovic hypothesis financial development which enables greater access to credit in the latter years of growth of a country compared to the earlier years of growth may explain reduced income inequality over time in a country. The Lewis Two-Sector model, on the other hand, may explain income inequality as it arises from the co-existence of the traditional sector (which is the agricultural sector) and modern industrial sector in a developing country (characterized by low growth), with the modern sector of the country, on account of high labour productivity paying higher wages. Consequently, the high wages paid by the modern industrial sector attract labour (employees) from the traditional (agriculture) sector where labour productivity is low, and associated with that lower wages are paid for labour in the sector.

In respect of income inequality, considerable focus on education as a major determinant is evident in the empirical literature. Several studies suggest that countries that are progressing in various areas are those that spend on educational development (Nurvita et al., 2022; Krstić et al., 2020; Dachito et al., 2020; Psacharopoulos and Patrinos, 2018). Brueckner et al. (2020) argue in linking education to both income inequality and trade that education improves a worker's capability to alternate between sectors. This implies that education aids a worker to adapt to unanticipated changes in the economy. Further, Hovhannisyan et al. (2019) identified an inverse association between education and income inequality based on the study of a sample of developing and developed countries where it was found that educational attainment enhances the output of labour and enables wage distribution that are higher and distributed more equitably. Consequently, the income inequality gap declines. This is consistent with arguments relating Economic and social infrastructure improvements to income differentials as that by Zolfaghari et al. (2020) who highlight that Economic infrastructure expenses on energy, and education amongst other infrastructure reduce income differentials, although the magnitude varies. Hence a mix and ideal allocation of economic and social infrastructures should be considered so that inequality is reduced, particularly in deprived areas. In relation Sarkodie and Adams (2020a) find an adverse influence of education on income differentials in the long run and Friderichs et al. (2023) highlight a likely decline in income inequality arising from enhanced quality of school as educational attainment rises in South Africa respectively. Similarly, Olopade et al. (2020) emphasize the value of education for an economy and based on their study on Nigeria further highlight the necessity of awareness and incentives that will give rise to a knowledge-based economy for economic progress and consequently recommend strategies that will enable education be infused into Nigeria's growth system. However, Parsons (2023) from the viewpoint of Human capital, distinguishes between net and market Gini coefficients in measuring income inequality for a heterogeneous panel of 203 countries comprising low and African countries and other developed countries and finds heterogeneous associations between Human capital and Gini coefficient among different groups of countries wherein only for African countries and countries classified as low income, a direct correlation of human capital with Gini coefficients was found. ICT may in addition aid income inequality reductions through its interaction with education as Nga Ndjobo and Ngah Otabela (2023) discover based on evidence from 89 developing countries from 2000 to 2015.

Further income inequality may be reduced when the head of a household is educated as discovered by Wędrowska and Muszyńska (2022) in Poland using survey data. Also, education expansion as highlighted by Tasseva (2021) may adversely affect income inequality in Household net incomes based on evidence from Great Britain where since the 2000s there has existed an unprecedented rise in education attainment over the past years. This was explained by the household net income distribution realizing larger income gains in the middle and top than at the bottom. Ethnic minorities may also experience a decline in income inequality as positive returns to education are realized as highlighted by Campos et al. (2016). However, a non-linear link between education and income inequality as found by Moniruzzaman and Emran (2021) for Bangladesh based on quantile regressions suggested that education has dwindling positive returns for lower quantile households relative to upper quantile households, implying a declined differential with rising education, but at a declining rate. In contrast, Hui (2020) argues a significant Inverted-U link between higher education and income inequality in the United States as income inequality is aggravated as the bonus of higher education is significant resulting from the scarcity of higher education. Further even among highly educated workers' income inequality is argued by Tang and Wang (2021) to exist on account of inequality in wages due to the factors: preference, promotion, and search friction. However, the value of verifying the influence of education on the dispersion of income may lie in the continuity of education of the individual irrespective of economic insolvency or not (Moniruzzaman and Emran, 2021).

Energy is inseparably associated with important Sustainable Development Goals (SDGs) including poverty reduction, health, food, security, and climate change (World Bank, 2017). Various studies have investigated the influence of energy and electricity provision on economic growth, with few focussed on poverty and income inequality (Ongo et al., 2024; Song et al., 2023; Adams and Klobodu, 2016; Shahbaz et al., 2013; Attigah and Mayer-Tasch, 2013). Electricity Access is a condition for economic advancement, a decline in poverty, and a deterioration of income differentials (Fuso Nerini et al., 2018). Also in the context of Nigeria, Afolayan et al. (2019) report reduced unemployment associated with increased electricity consumption in Nigeria. Electrification as a benefit lies in its capability to improve access to productive opportunities, through bringing about a decline in transaction costs thereby resulting in industrial advancement, which aids in adding value to the assets of the poor and consequently decreases income differentials (Rao and Pachauri, 2017; Calderon and Servén, 2004). It is pertinent for modern energy services to be accessed so that basic social needs are fulfilled, and as Oyuke et al., (2016) highlight, electricity access is the lifeline for families to meet their most basic needs, and the connection needed to plug Africa into the grid of the global economy. Further, the importance of electricity access for reducing income inequality may differ

between regions of a country as found by Danquah and Ohemeng (2017), as electricity access in addition to public transportation was found as the most important community factor for reducing income inequalities relative to the north.

Lee et al. (2022) capturing four aspects of energy security including availability, accessibility, develop-ability, and acceptability find evidence for a panel of countries that, as economic development improves a U-shape impact of energy security on income inequality results. In relation Nguyen and Nasir (2021), distinguish between the accessibility and reliability dimensions of energy poverty which are argued to improve with economic development, while the affordability dimension of energy poverty is the worst in countries with a middle level of economic development and greater income differential. On the other hand, parametric compared to non-parametric model estimates in relating income inequality to renewable and non-renewable energy consumption in a panel data set of countries by Beldi and Ghazouani (2024) reveal that energy consumption is not influenced by income inequality. However, varying periods are discovered based on non-parametric model estimates during which there exist direct and indirect associations between energy consumption and income inequality. Concerning the aforementioned, rising income inequalities may result in Carbon emissions based on evidence from 32 selected Sub-Saharan African countries by Ogede et al. (2024). This is consistent with findings by Simionescu and Cifuentes-Faura (2024) that energy poverty is exacerbated by income inequality found for a panel data of countries comprising Poland, Hungary, Czech Republic, and Slovakia over the period of 2005 to 2022. Further Acheampong et al. (2021) find electricity access, modern and clean energy, as well as rural and urban electrification moderate the influence of economic growth and education to boost global income inequality, while various potential channels aiding energy access, to influence global income inequality included employment, economic growth, education, gender empowerment, industrialization, and health. The causality between energy poverty and income inequality is however brought to light by Nguyen and Nasir (2021) as findings revealed that a surge in income inequality causes greater energy poverty, while in return, a dwindling in energy poverty appears to bring about income inequality decline. On the other hand, Dong and Hao (2018) find an inverted U-shaped link between per capita electricity consumption and GDP per capita in China.

3. METHODOLOGY

This study aims to explore the roles of education and electricity access respectively as well as the interaction between education and electricity access on income inequality in Nigeria. It is based on the theoretical framework of the dual sector model of development. The dual-sector model of development mirrors the Nigeria economy where the bulk of the population earns their livelihood from agriculture and few individuals make a living from the modern sector on account of the high level of skills (which may be acquired through education) that they are required to have to be employed by employers in the sector. Thus based on the arguments of the present study, education and electricity access independently and collectively affect income inequality in Nigeria as individuals in the agriculture sector acquire education aided by electricity access to improve their employability. The aforementioned individuals seek to meet the demand for skilled labour in the modern sector and are attracted to the sector by the higher pay in the modern sector relative to the agriculture sector in Nigeria. Consequently, the level of income inequality in Nigeria is affected.

The present study utilizes data over the period of 1990-2019. The scope of this study is chosen based on the 1990s when the government in Nigeria embraced education as compulsory for individuals aged 6-15 years hence giving rise to increased school enrolment in Nigeria. Also, the period may be argued to have featured widening income inequalities in Nigeria on account of Nigeria undertaking Structural Adjustment Programme (SAP) reforms, aimed at promoting a market-oriented Nigeria economy as well as concerted efforts of the Nigeria government at addressing poverty and in relation income inequalities in the early 2000s through policies as Nigeria Economic Empowerment and Development Strategy (NEEDS). The model specified for this study is adapted from Sarkodie and Adams (2020) and is specified as in equation (1)

$$GINI = f(EDUC, ELECTA, FDI, INSTQ) \quad (1)$$

Specifying equation (1) as an econometric model in line with the first hypothesis of the study that education significantly influences income inequality in Nigeria, and the second hypothesis that electricity access is significant in reducing income inequality in Nigeria, equation (2) which is the first of two models in the present study to be estimated results, and is denoted Model One.

3.1. Model One: Effect of Education and Electricity Access on Income Inequality

$$GINI_t = \alpha_0 + \alpha_1 EDUC_t + \alpha_2 ELECTA_t + \alpha_3 LogFDI_t + \alpha_4 INSTQ_t + \varepsilon_t \quad (2)$$

Where GINI: Gini index (Proxy for income inequality), EDUC: Education (measured using Primary School Enrolment), ELECTA: Electricity Access (measured as a percentage of the population), FDI: Foreign Direct Investment (Measured using Net Foreign Direct Investment (FDI) inflow in Billions of Naira), INSTQ: Institution Quality (measured using International Country Risk Guide (ICRG) Law and Order Index), ε: Stochastic error term, α_0: Constant of the model, α_1 … α_4: Coefficients of respective independent variables, t: time period (1990-2019).

From Equation (2), while GINI is the dependent variable of the model, EDUC, and ELECTA, are the central variables of interest of the study. FDI and INSTQ on the other hand are control variables in the model reflecting the role of other variables affecting income inequality aside the central variables of interest.

Testing the aforementioned first and second hypothesis of this study simultaneously based on Equation (2), the effects of each of Education (EDUC) and Electricity access (ELECTA) are reflected as follows:

With respect to Education:

$$\frac{\partial GINI}{\partial EDUC} = \alpha_1 \quad (2a)$$

Interpreting equation (2a), Education increases income inequality in Nigeria if $\alpha_1 > 0$ and is statistically significant. Conversely, Education will reduce income inequality in Nigeria where $\alpha_1 < 0$ and is statistically significant. A statistically insignificant α_1 regardless of its sign (whether positive or negative) implies that Education has no meaningful influence on income equality in Nigeria.

With respect to Electricity Access:

$$\frac{\partial GINI}{\partial ELECTA} = \alpha_2 \quad (2b)$$

Interpreting equation (2b), Electricity Access increases income inequality in Nigeria if $\alpha_2 > 0$ and is statistically significant. Conversely, Electricity Access will reduce income inequality in Nigeria where $\alpha_2<0$ and is statistically significant. A statistically insignificant α_2 regardless of its sign (whether positive or negative) implies that Electricity Access has no meaningful influence on income equality in Nigeria.

Equation (2) earlier specified is estimated using Auto Regressive Distributed Lag (ARDL) estimation on account of the observed time series properties of the variables (see further discussion in section 4). Hence, specifying the model in Equation (2) in the form of an Autoregressive Distributed Lag (ARDL) model featuring both short-run and long-run dynamics, we have equation (3).

$$\Delta GINI_t = \alpha_0 + \sum_{i=0}^{n}\alpha_1 \Delta EDUC_{t-i} + \sum_{i=0}^{n}\alpha_2 \Delta ELECTA_{t-i} + \sum_{i=0}^{n}\alpha_3 \Delta LogFDI_{t-i} + \sum_{i=0}^{n}\alpha_4 \Delta INSTQ_{t-i} + \beta_1 EDUC_{t-i} + \beta_2 ELECTA_{t-i} + \beta_3 LogFDI_{t-i} + \beta_4 INSTQ_{t-i} + \mu_t \quad (3)$$

Where GINI: Gini index (Proxy for income inequality), EDUC: Education (measured using Primary School Enrolment), ELECTA: Electricity Access (measured as a percentage of the population), FDI: Foreign Direct Investment (Measured using Net Foreign Direct Investment (FDI) inflow in Billions of Naira), INSTQ: Institution Quality (measured using International Country Risk Guide (ICRG) Law and Order Index), ε: Stochastic error term, t: time period (1990-2019). Further, the first difference equation in the aforementioned equation (3) is denoted as Δ, while parameter α stands for the drift component. α_1-α_4 reflects the short-run dynamics of the specified model and β_1-β_4 reflects the existence of a long-run relationship between GINI and its determining variables.

Further based on an extension of Equation (1) and in line with the third research hypothesis of the present study that income inequality is affected as electricity access interacts with education, the interaction of Education and Electricity Access is introduced into the second model for the present study in addition to the education and electricity access variables, as specified in equation (4) and is denoted Model two.

3.2. Model Two

$$GINI_t = \gamma_0 + \gamma_5 IN + \gamma_1 EDUC_t + \gamma_2 ELECTA_t + \gamma_3 (EDUC*ELECTA)_t + \gamma_4 Log\, FDI_t STQ_t + \mu_t \quad (4)$$

Where GINI: Gini index (Proxy for income inequality), EDUC: Education (measured using Primary School Enrolment), ELECTA: Electricity Access (measured as a percentage of the population), EDUC*ELECTA: interaction of Education and Electricity Access, FDI: Foreign Direct Investment (Measured using Net Foreign Direct Investment (FDI) inflow in Billions of Naira), INSTQ: Institution Quality (measured using International Country Risk Guide (ICRG) Law and Order Index), ε: Stochastic error term, γ_0: Constant of the model, $\gamma_1 \ldots \gamma_5$: Coefficients of respective independent variables, t: time period (1990-2019).

From Equation (4), while GINI is the dependent variable of the model, EDUC, ELECTA, and EDUC* ELECTA are the central variables of interest of the study with EDUC*ELECTA capturing the effect of the interaction of education and electricity access on income inequality. In particular, the interaction of education and electricity access measures the effect of education on income inequality in Nigeria as electricity access increases. FDI and INSTQ on the other hand are control variables in the model reflecting the role of other variables affecting income inequality aside from the central variables of interest.

Testing the aforementioned third hypothesis of this study based on Equation (5), the effect of education on income inequality as Electricity Access increases reflected by the interaction of Education (EDUC) and electricity access (ELECTA) in Equation (3) is reflected as follows:

$$\frac{\partial GINI}{\partial (EDUC)} = \gamma_1 + \gamma_3 ELECTA_t \quad (4a)$$

Interpreting equation (4a), if $\gamma_3 > 0$ and is statistically significant, Electricity access enables education which raises income inequality in Nigeria. However if $\gamma_3<0$ and is statistically significant, Electricity access enables education which reduces income inequality in Nigeria, A statistically insignificant γ_3 regardless of its sign (whether positive or negative) implies that income inequality in Nigeria is not meaningfully affected as electricity access interacts with education in Nigeria.

Equation (4) earlier specified is estimated using Auto Regressive Distributed Lag (ARDL) estimation on account of the observed time series properties of the variables (see further discussion in section 4) and hence equation (5) results.

$$\Delta GINI_t = \varphi_0 + \sum_{i=0}^{n}\varphi_1 \Delta EDUC_{t-i} + \sum_{i=0}^{n}\varphi_2 \Delta ELECTA_{t-i} + \sum_{i=0}^{n}\varphi_3 \Delta(EDUC*ELECTA)_{t-i} + \sum_{i=0}^{n}\varphi_4 \Delta Log\, FDI_{t-i} + \sum_{i=0}^{n}\varphi_5 \Delta INSTQ_{t-i} + \theta_1 EDUC_{t-i} + \theta_2 ELECTA_{t-i} + \theta_3 (EDUC*ELECTA)_{t-i} + \theta_4 LogFDI_{t-i} + \theta_5 INSTQ_{t-i} + \varepsilon_t \quad (5)$$

Where GINI: Gini index (Proxy for income inequality), EDUC: Education (measured using Primary School Enrolment), ELECTA: Electricity Access (measured as a percentage of the population), EDUC* ELECTA: interaction of Education and Electricity Access, FDI: Foreign Direct Investment (Measured using Net Foreign Direct Investment (FDI) inflow in Billions of Naira), INSTQ: Institution Quality (measured using International Country Risk Guide (ICRG) Law and Order Index), ε: Stochastic error term, t: time period (1990-2019). Further, the first difference equation in the aforementioned equation (4) is denoted as Δ, while parameter α stands for the drift component. ϕ_1-ϕ_5 reflects the short-run dynamics of the specified model and θ_1-θ_5 reflects the existence of a long-run relationship between GINI and its determining variables.

Thus comparing equations (2) and (4) as well as equations (3) and (5), the distinction in the specified models is the inclusion of the interaction of Education and Electricity Access in equations (4) and (5). Further note that the Log transformation of FDI as observed in equations (2), (3), (4), and (5) is necessary to standardize the coefficients of the model given the large size of FDI, while the choice of control variables employed in the models is in line with existing studies and also reflects peculiar features of Nigeria.

In addition, with respect to equations (3) and (5), the respective specified ARDL models have the appeal of enabling the validation of the existence of both short-run and long-run relationships where both relationships exist between the dependent variable and its determinant (explanatory) variables within the multivariate framework. Note however that the *αs* and *βs* (Equation (3)) and *γs* and *θ*s (Equation (5)) in the ARDL model still measure the effect of respective explanatory variables on the dependent variable.

The data employed for the present study was obtained from various sources. Data on Gini Index (proxy for income inequality) was sourced from the World Bank Poverty and income inequality platform, while primary school enrolment (proxy for education), Electricity Access (ELECTA), and Net Foreign Direct Investment Inflow (Proxy for FDI) were respectively sourced from the World Bank World Development Indicators. Data on the Law and Order index (proxy for institution Quality) was sourced from the International Country Risk Guide (ICRG) and captures the role of institutions in income inequality in a country. Further, except GINI where higher values depict greater income inequality and vice versa, in the case of all other variables, higher values reflect improvements in the variables.

4. RESULTS

Table 1 is a summary of the key characteristics of variables employed in this present study. They enable an assessment of variables concerning Nigeria over the period of 1990 to 2019. The Gini Index has been between 0.270 and 0.419 which reflects Nigeria as a developing nation characterised by high income inequality. Further, the mean of Primary School enrolment (Education) of 90.310% reflects the high level of primary school enrolment (proxy for education) in Nigeria. However, Electricity Access (ELECTA), Net FDI inflow, and ICRG Law and Order Index (proxy for institution quality) with means of 46.406%, N3.10 Billion, and 2.22 respectively, reflect that on average the respective indicators have been low, although the levels of the indicators are consistent with the categorization of Nigeria as a developing nation of the world. In addition, the standard deviations of all variables reflect considerable variation in the data set employed for this study which are expected features of time series data.

Analyzing data in line with the objectives of the present study, the time series properties of variables are examined using the Augmented Dickey-Fuller (ADF) unit root test. In particular, the ADF unit root test assesses variables for their level of integration which may be exploited in estimating the model for the study. The results of the ADF unit root test performed are presented in Table 2 where it is observed that except ELECTA and INSTQ respectively integrated of order zero, all other variables are integrated of order one.

Exploiting the observed time series properties of variables from Table 2, the Autoregressive Distributed Lag (ARDL) bounds test for cointegration was employed to assess the possibility of a

Table 1: Summarized descriptive statistics of variables

Descriptive Statistics	Gini Index (In Decimal Figures)	Primary School Enrolment (In Percentage)	Electricity Access (% of the Population)	Net FDI inflow (In Billions of Naira)	ICRG Law and Order Index (In Decimal Figures)
Mean	0.353	90.310	46.406	3.10	2.22
Median	0.364	90.104	47.591	1.99	2.00
Maximum	0.419	102.108	59.300	8.84	3.00
Minimum	0.270	78.663	27.300	0.30	1.00
SD	0.047	6.803	7.943	2.69	0.579
Skewness	−0.354	0.031	−0.450	0.83	0.176
Kurtosis	1.823	2.098	2.379	2.39	2.062
Observations	30	30	30	30	30

long-term association among the variables employed in the model estimated for this present study.

A long-term association between a dependent variable and its associated independent variables in a model is of particular importance in the economics literature as it reflects the added value of the independent variable for explaining changes in the dependent variable longer-term relative to the short term. Secondly, based on the aforementioned, such a longer-term explanation of a phenomenon of interest by independent variables is consistent with the notion of sustainable development-A pursuit of countries globally as reflected by sustainable development goals. Thus, the results of the ARDL bounds test based on equation (3) are presented in Table 3, where it is observed that the computed F-Statistic of the test of 2.156 given that it is less than the lower bound of the test (2.62) at the 5% level of significance indicates that there exists no long run relationship. i.e. No cointegration between GINI, the dependent variable of the study, and its explanatory variables including education and electricity access.

Further focussing on the interaction of Education and electricity access a la hypothesis three, the results of ARDL bounds test based on equation (5) are presented in Table 4, where it is observed that the computed F-statistic of the test of 0.982 given that it is less than the lower bound of the test (2.62) at the 5% level of significance indicates that there exists no long run relationship. i.e. no cointegration between GINI, the dependent variable of the study and its explanatory variables including education, electricity access and interaction of education and electricity access.

Note from Tables 3 and 4 that the adjustment in the number of observations to 27 from 30 is on account of the application of three lags of the independent variable in estimating the respective ARDL models specified in equations (3) and (5) based on the Akaike Information Criterion (AIC) model selection criteria. In addition, the degrees of freedom are determined by the number of independent variables in each respective specified model-equation (3) has four independent variables and hence degrees of freedom of 4, while equation (5) has five independent variables and hence degrees of freedom of 5.

The finding that a long-run relationship does not exist between the variables in the specified models for this study, implies that only a short-run ARDL model may be estimated with respect to testing all three hypotheses for the present study. Thus Table 5 shows the results of ARDL short-run model estimation of both equations (3) (Model One) and (5) (Model Two), where post-estimation model diagnostics as the Durbin-Watson statistic, Adjusted R-Squared, F-Statistic, and other ARDL estimated model residual tests observed indicate that the estimated models are valid. The Durbin-Watson Statistic of 1.908 (in respect of Model One) and 2.489 (In respect of Model Two) indicates the absence of serial correlation from ARDL regression estimates (since the statistics are respectively approximately 2). Further, the adjusted R-squared of 0.9915 (in respect of Model One) and 0.9989 (in respect of Model Two) implies that about 99.15% and 99.89% respectively of variations in GINI in Models One and Two are a result of variations in its explanatory variables.

Table 2: Augmented dickey-fuller (ADF) unit root test of variables

Variables	Augmented dickey-fuller (ADF)		Order of integration
	Levels	First difference	
GINI	−0.585 (0.9724)	−5.036*** (0.0019)	I (1)
EDUC	−1.933 (0.6116)	3.852** (0.0284)	I (1)
ELECTA	−5.261*** (0.0010)	−5.070*** (0.0021)	I (0)
Log FDI	−1.782 (0.6842)	−4.420*** (0.0083)	I (1)
INSTQ	−3.282** (0.0899)	−3.583*** (0.0498)	I (0)

P-values in parenthesis. *, **, *** denote significance at the 10%, 5% and 1% levels respectively. I(0) denotes that the variable is integrated of order zero, while I(1) denotes that the variable is integrated of order one.

Table 3: ARDL bounds test for cointegration results for the effect of education and electricity access on income inequality in Nigeria

Dependent variable: GINI				
F-stat value	Degrees of freedom	Significance level	Lower bound	Upper bound
2.156	4	0.05	2.86	4.02

No. of Observations: 27 (after adjustment)

Table 4: ARDL bounds test results for the effect of the interaction of education and electricity access on income inequality in Nigeria

Dependent variable: GINI				
F-stat value	Degrees of freedom	Significance level	Lower bound	Upper bound
0.982	5	0.05	2.62	3.79

No. of Observations: 27 (after adjustment)

The statistically significant F-Statistic also in respect of both equations (3) and (5) reflects that both ARDL models estimated are correctly specified. In addition, post-estimation model diagnostics in Table 6, based on tests of the ARDL residual indicate that the ARDL model is valid. This is because, Jarque-Bera Normality, Breusch-Godfrey Serial correlation, and Breusch-Pagan-Godfrey heteroskedasticity tests respectively all returned insignificant test statistics as P-values of the statistics associated with the respective tests are all <0.1 (10% level of statistical significance). This leads to the conclusion that ARDL residuals are normally distributed (insignificant Jarque-Bera test statistic), free of serial correlation (insignificant statistics from Breusch-Godfrey Serial correlation test), and are not heteroskedastic (insignificant statistics from Breusch-Pagan-Godfrey Heteroskedasticity test). Thus based on the aforementioned, we proceed to interprete the ARDL regression estimates based on equations (3) and (5) of the present study.

Based on Model One as specified in equation (3) of the present study, Education is insignificant for income inequality as evidenced by the statistical insignificance of the coefficient of Education of −0.000465 in Table 5. Thus education is not important in explaining income inequality in Nigeria despite its reduction in income inequality and this provides evidence against the hypothesis that income inequality is significantly influenced by education in Nigeria. The aforementioned finding of this present study contrasts with those of studies by Danquah and Ohemeng (2017), who argue a reduction in income inequalities on account

Table 5: ARDL short regression estimation results

Model	One	Two
Equation	(3)	(5)
Dependent Variable	GINI	GINI
C	0.335*** (0.0006)	0.856** (0.0113)
EDUC	−0.000465 (0.1610)	0.00237 (0.3500)
EDUC(−1)		−0.00706** (0.0130)
ELECTA	0.00140* (0.0563)	0.00530 (0.2693)
ELECTA(−1)	0.000177 (0.8046)	−0.0136** (0.0132)
ELECTA(−2)	−0.00130** (0.0368)	−0.000626 (0.3348)
ELECTA(−3)	−0.00106** (0.0485)	−0.000681 (03280)
EDUC*ELECTA		−0.000644 (0.2499)
EDUC*ELECTA(−1)		0.000155** (0.0122)
EDUC*ELECTA(−2)		0.00000203 (0.7291)
EDUC*ELECTA(−3)		0.00000827 (0.3126)
LogFDI	0.00378 (0.2468)	0.00709** (0.0260)
LogFDI(−1)	0.00142 (0.5895)	0.000511 (0.8208)
LogFDI(−2)	0.00133 (0.6052)	0.0000427 (0.9847)
LogFDI(−3)	−0.00700** (0.0174)	−0.00895** (0.0037)
INSTQ	−0.0117 (0.1310)	−0.00951* (0.0842)
INSTQ(−1)	−0.0404*** (0.0009)	−0.0679*** (0.0006)
INSTQ(−2)	−0.00709 (0.5321)	−0.003212 (0.6300)
INSTQ(−3)	0.0168** (0.0375)	0.0212*** (0.0039)
GINI(−1)	0.0915 (0.6500)	−0.331* (0.0753)
GINI(−2)	0.506*** (0.0099)	0.444** (0.0127)
GINI(−3)		0.347** (0.0291)
Durbin Watson Stat.	1.908	2.489
Adjusted R-squared	0.9800	0.9943
F-Statistic	85.859***	218.22***
No. of Observations (after adjustment)	27	27

P-values in Parenthesis. *, **,*** denote significance at the 10%, 5% and 1% levels respectively

Table 6: ARDL model residual test results

Model	One	Two
Equation	(3)	(5)
Normality test		
Jarque-Bera test statistic	0.5583 (0.7564)	0.0489 (0.9759)
Breusch-Godfrey serial correlation LM test		
F-Statistic	0.0243 (0.8792)	0.385 (0.5686)
Observations*R-Squared	0.0654 (0.7981)	2.369 (0.1237)
Breusch-Pagan-Godfrey Heteroskedasticity test		
F-Statistic	0.438 (0.9307)	2.159 (2.008)
Observations*R-Squared	10.098 (0.8135)	24.319 (0.2779)
Scaled explained sum of squares	1.220 (1.000)	0.909 (1.000)

P-values in parenthesis

of increased education. Further Hovhannisyan et al. (2019) cite evidence of an inverse association between education and income inequality in the decade of the 1990s and early 2000s from Zambia, Guatemala, and El Salvador while Nurdina (2021) found education infrastructure to raise income inequality, all of which are at variance with the finding as concerns education in the present study.

Further, in respect of present electricity access (ELECTA), its coefficient of 0.00140 in Table 5 is statistically significant reflective of the importance of electricity access for income inequality although it is found to raise income inequality in Nigeria. This contrasts with electricity access two periods previously (ELECTA(−2)), and three periods previously (ELECTA(−3)) which are both statistically significant for reducing income inequality given their respective statistically significant coefficients of −0.00130 and −0.00106. This may highlight the apparent difficulties encountered in electricity access contributing to reduced income inequality in Nigeria which requires a period of time for such efforts to realise returns. Thus the hypothesis that electricity access is significant in reducing income inequality in Nigeria is supported by the finding of the present study as concerns both two-periods lagged and three-periods lagged electricity access (ELECTA(−2) and ELECTA(−3)). The aforementioned findings of this present study are consistent with evidence from studies as Acheampong et al. (2021) who found that electricity access, improves global income inequality, and Nguyen and Nasir (2021) that energy poverty decline reduces income inequality. Electricity access further aids productive effort across all sectors especially industry and service sectors where electricity access is critical for output which gives rise to greater demand for labour and consequently income inequality declines as individuals are employed. One period lagged electricity access (ELECTA(−1)) from Table 5 Model One is however insignificant for income inequality with a coefficient of 0.000177.

With respect to the control variables from model one Table 5, the findings of this present study reveal that FDI takes three periods to significantly reduce income inequality in Nigeria, given the coefficient of LogFDI(−3) of −0.00700 which is statistically significant, while institution quality one period lagged (INSTQ(-1)) is also important for reducing income inequality in Nigeria as its coefficient of −0.0404 is statistically significant. However, three-period lagged institution quality (INSTQ(−3)) which has a coefficient of 0.0168 is significant and indicates that three-period lagged institution quality boosts present income inequality. Finally, the two–period lagged GINI index (GINI(−2))

is significant in boosting present income inequality given its coefficient of 0.506 which is statistically significant, while one one-period lagged GINI index is insignificant.

Model Two as specified in equation (5) of the present study was estimated using ARDL in testing the third hypothesis of the present study which focuses on the effect of the interaction of education and electricity access on income inequality. Thus the focus of the results interpretation is concerning the interaction of education and electricity access (EDUC*ELECTA). However, the hypothesis is importantly only supported if both the coefficients of Education (EDUC), electricity access (ELECTA), and the coefficient of the interaction of education and electricity access (EDUC*ELECTA) in the model estimation are simultaneously statistically significant. Thus given the statistical significance of the coefficient of one period lagged education (EDUC(-1)) of -0.00706 in Table 5, the statistical significance of the coefficient of one period lagged electricity access (ELECTA(-1)) of -0.0136 and the statistical significance of the coefficient of one period lagged interaction of education and electricity access (EDUC*ELECTA) of 0.000155. Thus the hypothesis that income inequality is affected as electricity access interacts with education is supported by the findings of the present study based on the findings from Model Two of the present study. In particular, the Model Two results from Table 5 reveal that greater education as electricity access increases boosts income inequality in Nigeria. This is consistent with the dual sector model of development such as that of the Lewis two-sector model, where the structure of a country features two sectors, and labour is absorbed by the modern sector from the traditional sector as modern sector employees acquire an education supported by greater electricity access which enhances their employability by the modern sector. Relating education to electricity access in affecting income inequality, according to Diniz et al. (2006) electricity allows the access of lower-income people to lighting, communication, as well as a variety of educational delivery opportunities.

Further in reducing illiteracy and improving the quality of education, the role of electrification cannot be over-emphasized for any country in the world (UNDESA, 2014). Greater education in the presence of increased electricity access while raising economic empowerment of Nigerians raises income inequality as the skilled individuals in the modern sector in the country rise and there now exists a supply of skilled labour, over that demanded by enterprises in the sector resulting in rising unemployment. Consequently, income inequality increases as both unskilled individuals who are unable to access education and previously unskilled individuals now skilled on account of acquiring an education with the aid of electricity access but unemployed co-exist. The unemployed modern sector employees result due to the limited opportunities for employment in the modern sector as opportunities are few, owing to a low rate of job creation. The lack of employment opportunities that could aid the reduction in the income gap between the rich and the poor is evident across Nigeria despite lots of employable graduates which explains the prevalence of rising income inequalities in Nigeria. This is however not peculiar to Nigeria alone but may also be observed across SSA countries in general. The finding of rising income inequalities despite increased education and electricity access contrasts with that of Acheampong et al. (2021) who report a negative effect on income differentials of the interrelation of electricity access and education for a global sample of countries and this may be on account of the present study being country-specific while that of the former was a panel data study. It thus highlights the value of performing a country-specific study as the present study in regards to education, electricity access, and income differentials in contrast to a panel data study. Brueckner et al. (2020) further support the twin roles of electricity access and education for income differential reduction. Investments in energy and education among other economic and social infrastructure investments were found by Brueckner et al (2020) to bring about income inequality decline in Iran, with the study highlighting that, especially in deprived areas, optimally allocating economic and social infrastructure is essential. Intuitively greater investments in both electricity and education amongst various economic and social infrastructure investments in a country may boost both energy and education access which will give rise to a decline in income inequality.

Finally, with respect to the control variables as specified in Model Two of this present study, there continues to be evidence as in Model One, of their role in income inequality with FDI in respect of their present and three-period lagged values of their coefficients, and Institution quality in respect of their present, one period lagged and three-period lagged coefficient values important for income inequality in Nigeria. Also, all lagged GINI index coefficients in light of their statistical significance reflect the importance of lagged income inequality for present income inequality.

5. CONCLUSION AND POLICY IMPLICATIONS

This present study examined the interconnected roles of education and electricity access for income inequality in Nigeria over the period of 1990 to 2019. The findings provide support for the hypothesis that electricity access is central to reducing income inequality while education is not significant for income inequality in Nigeria at least in the short run. However, the finding of greater electricity access in the presence of greater educational enrolment raising income inequality as reflected by evidence in support of the third hypothesis of the present study, highlights the necessity of the Nigeria government to pay attention to the need to create more productive employment opportunities as electricity access improves. The aforementioned is important as Nigeria strives for the achievement of sustainable development goals many of which hinge on electricity access. However, the lack of evidence relating education, electricity access, and the interaction of the aforementioned variables to income inequality in the long run in the present study may warrant further investigation by future studies as it has implications for the achievement of sustainable development by Nigeria which is long term in nature.

Some policy implications emanate from the findings of this study. First, efforts at reducing income inequality in Nigeria must necessarily focus on promoting greater education enrolment as well as electricity access. Greater education results in economic

empowerment, while greater electricity access across all sectors of the economy is necessary for powering economic development activities which will have a ripple effect on existing wide disparities in levels of income in Nigeria. Second, Education must go hand-in-hand with greater electricity access as electricity is related to education not only in terms of enabling the provision of education as electricity is utilized for various equipment used in teaching and the promotion of a conducive learning environment but also the quality of education provided. This will consequently give rise to quality skill acquisition of individuals taught, for contributing positively to the domestic economy. Third, employment opportunities need to be created at a faster rate than individuals are skilled as a result of greater electricity access and education so that skilled individuals can secure employment and excess supply of skilled workers in the Nigeria labour market (specifically in regards to modern sector employment) will be reduced to the benefit of the Nigeria economy as income inequality experiences a significant decline.

The following recommendations are made based on the findings of the present study. First, the Nigeria government should ensure greater access of individuals, households, and businesses to electricity, by not only ensuring that prices charged to customers for electricity by electricity distribution companies are affordable, but also that there is a consistent electricity supply for use by the users of electricity for powering productive activities. Second, adequate quality education infrastructure should be provided by the Nigerian government to cater to the sizeable number of admissions to educational institutions in Nigeria for an enabling environment to be created for individuals seeking to acquire quality education in Nigeria to boost their future employability prospects. Third, the quality of education delivered by education providers to graduates of educational institutions as well as its continued relevance to the Nigerian labour market should be monitored consistently by the Nigerian government. This will ensure that graduates of Nigerian educational institutions are well-educated and consequently are employable in the future by modern sector enterprises on account of the quality education that they have received. Fourth, the Nigerian government should undertake initiatives such as promoting the inflow of FDI to the modern sector of the country in particular and ensure that productive employment opportunities are created at a faster rate than that at which individuals are skilled in the sector. Consequently, skilled individuals will be attracted to the modern sector and will be able to secure employment in the sector, and the excess supply of skilled workers in the Nigerian labour market in the modern sector will be reduced. Fifth, the Nigerian government should undertake initiatives that will raise the productivity of labour in the agriculture sector resulting in a rise in wages. Consequently, the influx of erstwhile agriculture labour to the modern sector will be stemmed for a time pending when employment opportunities become available in the modern sector that can absorb skilled labour –resulting from individuals having acquired an education, moving to the modern sector from agriculture (traditional sector).

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REFERENCES

Abdullah, A., Doucouliagos, H., Manning, E. (2015), Does education reduce income inequality? A meta-regression analysis. Journal of Economic Surveys, 29(2), 301-316.

Acheampong, A., Dzator, J., Shahbaz, M. (2021), Empowering the powerless: Does access to energy improve income inequality? Energy Economics, 99, 105288.

Adams, S., Klobodu, E.K.M. (2016), Financial development, control of corruption and income inequality. International Review of Applied Economics, 30(6), 790-808.

Adeleye, B.N., Gershon, O., Ogundipe, A., Owolabi, O., Ogunrinola, I., Adediran, O. (2020), Comparative investigation of the growth-poverty-inequality trilemma in Sub-Saharan Africa and Latin American and Caribbean Countries. Heliyon, 6(12), e05631.

Afolayan, O.T., Okodua, H., Matthew, O., Osabohien, R. (2019), Reducing unemployment malaise in Nigeria: The role of electricity consumption and human capital. International Journal of Energy Economics and Policy, 9(4), 63-73.

Attigah, B., Mayer-Tasch, L. (2013), The Impact of Electricity Access on Economic Development. Eschborn, Germany: GIZ.

Beldi, L., Ghazouani, T. (2024), Nonparametric Analysis of the Relationship between Income Inequality and Energy Consumption in African Countries. Oxford, UK: Blackwell Publishing Ltd.

Blanden, J., Machin, S. (2004), Educational inequality and the expansion of UK higher education. Scottish Journal of Political Economy, 51(2), 230-249.

Brueckner, M., Van Long, N., Vespignani, J. (2020), Non-Gravity Trade. Globalization Institute Working Paper No 388.

Calderon, C.A., Servén, L. (2004), The Effects of Infrastructure Development on Growth and Income Distribution. World Bank Policy Research Working Paper No 3400.

Campos, B.C., Ren, Y., Petrick, M. (2016), The impact of education on income inequality between ethnic minorities and Han in China. China Economic Review, 41, 253-267.

Cingano, F. (2014), Trends in Income Inequality and its Impact on Economic Growth. OECD Social, Employment and Migration Working Papers, No. 163. Paris: OECD Publishing.

Dachito, A.C., Alemu, M., Alemu, B. (2020), The impact of public education expenditures on graduate unemployment: Cointegration analysis to Ethiopia. Journal of International Trade, Logistics and Law, 6(2), 62-78.

Danquah, M., Ohemeng, W. (2017), Unmasking the factors behind income inequalities in Ghana. International Journal of Social Economics, 44(7), 884-899.

Diniz, A.S.A.C., França, E.D., Câmara, C.F., Morais, P.M.R., Vilhena, L. (2006), The Important Contribution of Photovoltaics in a Rural School Electrification Program, Transactions of the IEEE. United States: IEEE. p2528-2531.

Dong, X.Y., Hao, Y. (2018), Would income inequality affect electricity consumption? Evidence from China. Energy, 142, 215-227.

Friderichs, T.J., Keeton, G., Rogan, M. (2023), Decomposing the impact of human capital on household income inequality in South Africa: Is education a useful measure? Development Southern Africa, 40(5), 997-1013.

Fuso Nerini, F., Tomei, J., To, L.S., Bisaga, I., Parikh, P., Black, M., Borrion, A., Spataru, C., Castán Broto, V., Anandarajah, G., Milligan, B, Mulugetta, Y. (2018), Mapping synergies and trade-offs between energy and the sustainable development goals. Nature Energy, 3(1), 10-15.

Gershon, O., Wopara, M.M., Osabohien, R. (2020), Energy Intensity and Economic Growth in Selected West African Countries. In: 2020 IEEE PES/IAS PowerAfrica. United States: IEEE. p1-5.

Greenwood, J., Jovanovic, B. (1990), Financial development, growth, and the distribution of income. Journal of Political Economy, 98(5 Part 1), 1076-1107.

Guza, G.M., Ishakb, S., Banic, Y., Madina, A. (2020), The determinants of income inequality in Nigeria: An auto-regressive distributive lag approach. International Journal of Innovation, Creativity and Change, 11(12), 218-234.

Hovhannisyan, A., Castillo-Ponce, R.A., Valdez, R.I. (2019), The determinants of income inequality: The role of education. Scientific Annals of Economics and Business, 66(4), 451-464.

Hui, X. (2020), An empirical analysis on the impact of higher education on income inequality. Journal of Applied Finance and Banking, 10(2), 181-193.

Igawa, M., Managi, S. (2022), Energy poverty and income inequality: An economic analysis of 37 countries. Applied Energy, 306, 118076.

Kanbur, R., Stiglitz, J. (2015), Dynastic Inequality, Mobility and Equality of Opportunity. CEPR Discussion Paper No DP10542. Available from: https://ssrn.com/abstract=2593825

Krstić, M., Filipe, J.A., Chavaglia, J. (2020), Higher education as a determinant of the competitiveness and sustainable development of an economy. Sustainability, 12(16), 6607.

Kuznets, S. (1955), Economic growth and income inequality. The American Economic Review, 45(1), 1-28.

Lee, C.C., Xing, W., Lee, C.C. (2022), The impact of energy security on income inequality: The key role of economic development. Energy, 248, 123564.

Leiva, Y., Pino, G. (2020), Analysis of the impact of school performance on income inequality in the long run: An application to Chilean municipalities. Growth and Change, 51(3), 1045-1080.

Matthew, O.A., Ede, C.U., Osabohien, R., Ejemeyovwi, J., Fasina, F.F., Akinpelumi, D. (2018), Electricity consumption and human capital development in Nigeria: Exploring the implications for economic growth. International Journal of Energy Economics and Policy, 8(6), 8-15.

Moniruzzaman, M., Emran, S.J. (2021), Education and inequality in rural Bangladesh: A longitudinal study. Asia-Pacific Journal of Rural Development, 31(1), 37-61.

National Bureau of Statistics (NBS). (2020), 2019 Poverty and Inequality in Nigeria: Executive Summary. Available from: https://nigerianstat.gov.ng/elibrary

Nga Ndjobo, P.M., Ngah Otabela, N. (2023), Can income inequality be affected by the interaction between ICTs and human capital?: The evidence from developing countries. Journal of Quantitative Economics, 21(1), 235-264.

Nguyen, C.P., Nasir, M.A. (2021), An inquiry into the nexus between energy poverty and income inequality in the light of global evidence. Energy Economics, 99, 105289.

Nurdina, W. (2021), Infrastructure and Income Inequality in Indonesia: 2009-2017. The Journal of Indonesia Sustainable Development Planning, 2(2), 129-144.

Nurvita, D., Rohima, S., Bashir, A., Mardalena, M. (2022), The role of public spending on education, health, and economic growth toward human development index in the local economy. Sriwijaya International Journal of Dynamic Economics and Business, 6(2), 197-210.

Ogbeide, E.N.O., Agu, D.O. (2015), Poverty and income inequality in Nigeria: Any causality? Asian Economic and Financial Review, 5(3), 439-452.

Ogede, J.S., Oduola, M.O., Tiamiyu, H.O. (2024), Income inequality and carbon dioxide (CO2) in sub-Saharan Africa countries: The moderating role of financial inclusion and institutional quality. Environment, Development and Sustainability, 26(7), 18385-18409.

Olanrele, I.A., Lawal, A.I., Dahunsi, S.O., Babajide, A.A., Ise Olorunkanmi, 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.

Olopade, B.C., Okodua, H., Oladosun, M., Matthew, O., Urhie, E., Osabohien, R., Adediran, O., Johnson, H.O. (2020), Economic growth, energy consumption and human capital formation: Implication for knowledge-based economy. International Journal of Energy Economics and Policy, 10(1), 37-43.

Ongo, E.B.N., Bitoto, F.E., Ondoua, B.B., Mbognou, C.N. (2024), Does innovation drive up income inequality in Africa? Journal of the Knowledge Economy, 2024, 1-27.

Organization for Economic Cooperation and Development (OECD). (2018), A Broken Social Elevator? How to Promote Social Mobility. Paris: OECD Publishing.

Oyuke, A., Penar, P.H., Howard, B. (2016), Off-Grid or 'off-on': Lack of Access, Unreliable Electricity Supply Still Plague Majority of Africans. Afrobarometer Research Paper no. 75. Available from: https://afrobarometer.org/sites/default/files/publications/dispatches/ab_r6_dispatchno75_electricity_in_africa_eng1.pdf

Palaz, S., Senergin, O., Oksuzler, O. (2013), The effect of differences in educational level on income distribution: The case of Turkey. Journal of Entrepreneurship and Development, 8(2), 119-131.

Parsons, B. (2023), Panel data analysis of the human capital index and income inequality: A panel of 203 countries for the period 1988-2018. Applied Econometrics and International Development, 23(1), 5-32.

Piketty, T. (2015), About capital in the twenty-first century. American Economic Review, 105(5), 48-53.

Psacharopoulos, G., Patrinos, H.A. (2018), Returns to investment in education: A decennial review of the global literature. Education Economics, 26(5), 445-458.

Rao, N.D., Pachauri, S. (2017), Energy access and living standards: Some observations on recent trends. Environmental Research Letters, 12(2), 025011.

Ritchie, H., Roser, M. (2020), Access to Energy. Available from: https://ourworldindata.org/energy

Sarkodie, S.A., Adams, S. (2020), Electricity access, human development index, governance and income inequality in Sub-Saharan Africa. Energy Reports, 6, 455-466.

Sarkodie, S.A., Adams, S. (2020a), Electricity access and income inequality in South Africa: Evidence from Bayesian and NARDL analyses. Energy Strategy Reviews, 29, 100480.

Shahbaz, M., Khan, S., Tahir, M.I. (2013), The dynamic links between energy consumption, economic growth, financial development and trade in China: Fresh evidence from multivariate framework analysis. Energy Economics, 40, 8-21.

Simionescu, M., Cifuentes-Faura, J. (2024), Evaluating the relationship between income inequality, renewable energy and energy poverty in the V4 countries. Energy Research and Social Science, 115, 103640.

Song, Y., Gao, J., Zhang, M. (2023), Study on the impact of energy poverty on income inequality at different stages of economic development: Evidence from 77 countries around the world. Energy, 282, 128816.

Tang, R., Wang, G. (2021), Educational mismatch and income inequality. Economic Modelling, 100, 105525.

Tasseva, I.V. (2021), The changing education distribution and income inequality in Great Britain. Review of Income and Wealth, 67(3), 659-683.

Todaro, M.P., Smith, S.C. (2020), Economic Development. Pearson, UK: Pearson.

United Nations Department of Economic and Social Affairs (UNDESA). (2014), World Urbanization Prospects: The 2014 Revision.

New York: United States.
Wędrowska, E., Muszyńska, J. (2022), Role of age and education as the determinant of income inequality in Poland: Decomposition of the mean logarithmic deviation. Entropy, 24(6), 773.
World Bank. (2017), State of Electricity Access Report. Washington, DC: World Bank Group.
World Bank. (2022), World Development Indicator. Available from: https://databank.worldbank.org/source/world-development-indicators
Zolfaghari, M., Kabiri, M., Saadatmanesh, H. (2020), Impact of socio-economic infrastructure investments on income inequality in Iran. Journal of Policy Modeling, 42(5), 1146-1168.