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TECHNOLOGY ACCESS, INCLUSIVE GROWTH AND POVERTY REDUCTION IN NIGERIA: EVIDENCE FROM ERROR CORRECTION MODELING APPROACH

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Abstract: *This study examines the role of information and communication technology (ICT), access to electricity and transport infrastructure in reducing poverty and promoting inclusive growth in Nigeria for the period 1980-2014 using the error correction modeling approach (ECM). The results indicate that access to electricity and transport infrastructure is negative and statistically significant in both the incidence and the depth of poverty reduction and therefore conclude that this lead to inclusive growth. In particular, we show that access to ICT negatively influences the incidence of poverty, but the relationship is not robust when the measure of poverty is the poverty gap.*

Keywords: Technology; Inclusive Growth; Poverty and Nigeria

JEL Classification: O3, O33, O4, O40

Introduction

Despite the vast advances that are being made in the spheres of science and technology, income disparities are ever widening for both the world's rich and poor nations (Suregeni, 2008). The trends in poverty reduction have worsened even in the face of economic growth because the beneficiaries (the poor) are not able to participate and contribute effectively in development efforts. More than a decade of strong growth has reduced poverty in Sub-Saharan Africa (SSA), but high inequality and resource dependence have dampened the poverty-reducing effect of income growth (World Bank, 2013).

Notwithstanding the remarkable progress in SSA in the last decade, the existing large number of poor people signals that the development challenges remain. Further-

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more, in many countries in the region, inequality has grown even as living standards have risen. This shows that the benefits of growth have not been shared equitably. The basic economic infrastructures are inadequate. For example, approximately 29% of roads are paved, barely a quarter of the population has access to electricity, and there are fewer than three landlines available per 100 people (ITU, 2009; World Bank, 2008). The combination of poor infrastructure and poverty still makes it difficult for entrepreneurs to access financial resources and information

Though, Nigeria had experienced a rise in GDP growth in the last decade averaging well-over 5% between 2000 and 2013, the level of poverty and income inequalities of its citizenry raise the concern that the benefits of the country's GDP growth has not broadened access to sustainable socioeconomic opportunities for more people. Inclusive growth raises the pace of growth and enlarges the size of the economy by leveling the playing field for investment and increasing productive employment opportunities (World Bank, 2008 and Ianchovichina and Lundstrom, 2009). Similarly, technology can affect poverty reduction by accelerating growth impulses via economic infrastructure (Transportation, electricity, communication) and social infrastructure (Housing, health, education).Aigbokan (1999) submitted that public infrastructure provides services that are part of the consumption bundle of residents, increase aggregate demand, provide short-run stimulus to the economy and serves as an input into private sector production. Social infrastructure such as education and health on the other hand has greater positive externalities by raising social marginal productivity (SMP) above private marginal. As part of the many consequences of poverty, Aku, *et. al* (1997) submitted that poverty results in economic and social deprivation as a result of denial from full participation in social, political and economic activities. Poverty, arguably, can be reduced at a faster rate when inclusive growth strategies are applied and when special income distribution policies are undertaken (Shorrocks and Vander Hoeven, 2004). The impact of information communication technology (ICT) on income growth and poverty alleviation are undeniable, and greater adoption of ICTs in lower-income groups will accelerate income gains at the base of the economic pyramid (The Global Information Technology Report, 2015).

Although it may seem that people on the whole are better off the level of poverty with the proliferation of technology; opinion however, is divided as to whether technology has a major role to play. Using an econometric approach that separate the short and long run impact of the relationship between technology access and poverty will be an important contribution to the deabate. Again, the relationship between ICTs and poverty does not come out clearly in most literature as the few empirical works in this line have mixed results with regards to the impact of technology access on poverty reduction and growth. While some authors found ICT to be growth enhancing and poverty reducing (Pigato, 2001,Koutroumpis, 2009; Gruber and Koutroumpis, 2010; Stiroh, 2010; Kooshki and Ismail, 2011), there are few evidences that show the negative effect of ICT on economic growth (Jacobsen, 2003).This necessitates the need for further studies that can improve technology-poverty related analysis that can contribute to inclusive growth policies.

The emerging questions arising from the foregoing are: how and to what extent can access to technology promote inclusive growthand reduce the level of poverty in Nigeria? What is the link between ICT infrastructure and poverty? Can access to technology affect poverty reduction by accelerating growth impulses via economic infrastructure in the case of Nigeria? In addressing the theses questions, the broad objective of this paper is geared towards evaluating the impact of technology on inclusive growth through poverty reduction in Nigeria. Specifically, the study link ICT access to poverty and also determines the relationship between poverty and economic infrastructure for the period 1980-2014.

Furthermore, in term of theory, this paper assesses the influence of technology on inclusive growth through poverty reduction within the basic growth-poverty model suggested by Ravallion and Chen (1997), as well as the frameworks posited by Dollar and Kraay (2002) and Anyanwu and Erhijakpor (2012) while error correction mechanism (ECM) is employed to capture the impact of technology and economic infrastructure variables and their influence on inclusive growth. It is expected that economic infrastructure and access to improved technology and other explanatory variable will impact positively and change the conditions of the country through inclusive growth.

Literature Review

Meaning and Determinants of Inclusive Growth

There is a vast growing empirical and theoretical literature on the determinants of inclusive growth and how the concept may be operationalised. However, consensus in this line is yet to be achieved. There is surprising little clarity as to what actually constitute inclusive growth, with important differences in approach among key institutions and governments: For the Organisation for Economic Cooperation and Development (OECD), inclusive growth is where the gap between the rich and the poor is less pronounced and the growth dividend (the benefits of growth) is shared in a fairer way that results in "improvements in living standards and outcomes that matter for people's quality of life (e.g. good health, jobs and skills, clean environment, community support)." The World Bank: defines inclusive growth by its pace and pattern – growth that is sufficient to lift large numbers out of poverty and growth that includes the largest part of the country's labour force in the economy. The International Policy Centre for Inclusive Growth (IPC-IG)98 places its emphasis on participation – so that in addition to sharing in the benefits of growth, people actively participate in the wealth process and have a say in the orientation of that process. For the Asia Development Bank (ADB), tackling discrimination of the most marginalised groups is an intrinsic part of the inclusive growth process, as well as a key outcome. Groups that have suffered discrimination are those that have been left behind in poverty reduction and economic development efforts – helping these groups to participate in and benefit from economic activities is a cornerstone of inclusive growth.

Inclusive growth is often used interchangeably with a suite of other terms, including 'broad-based growth' 'shared growth', and 'pro-poor growth'. Some inclusive growth definitions are interchangeable with the absolute pro-poor growth definition (Ravallion, 2004; Ianchoivicna and Lundstrom, 2009; Klasen 2010). Absolute definition of pro-poor growth is the most relevant when poverty reduction is the objective (DFID, 2004). In this case the aim is to increase the rate of growth to achieve the greatest pace of poverty reduction. Other studies acknowledge that reducing both, poverty and inequality is at the heart of the meaning of inclusive growth (Ali and Son, 2007; Rauniyar and Kanbur, 2010; UNDP, 2013). There are arguments that focusing on inequality, the relative definition could lead to sub-optimal outcomes for both poor and non-poor households. The Commission on Growth and Development (2008) considers systematic inequality of opportunity "toxic" as it will derail the growth process through political channels or conflict. However, these are not the only attributes that constitute the concept of inclusiveness. Deininger and Squire (1998) use land distribution as a proxy for asset inequality and show that high asset inequality has a significant negative effect on growth. Birdsall and Londono (1997) show that income inequality does not seem to play a role in expanding growth outcomes after controlling for initial asset inequality.

Inclusive growth is a rapid and sustained poverty reduction strategy that allows people to contribute to and benefit from economic growth. For this growth to be sustainable in the long run, it should be broad-based across sectors and inclusive of the large part of the country's labor force with emphasis on policies that remove constraints to growth and create a level playing field for investment. In this way, inclusive growth ensures that everyone participates in the decision-making that leads to the growth itself. Inclusive growth implies participation and benefit-sharing as it makes everyone to share equitably the benefits of growth (World Bank, 2008). In consistence with the findings in the Growth Report: Strategies for Sustained Growth and Inclusive Development (Commission on Growth and Development, 2008), Inclusive growth interlinked with both the pace and pattern of growth for achieving a high, sustainable growth record, as well as poverty reduction.

A summary of the different definitions from the literature reviewed above points out that inclusive growth should meet the following requirements: increase in income measures and GDP, decrease in inequality, decrease in poverty, increase benefit to groups, including the most marginalized, consider participation (not just distribution outcome) and increase in non-income measures of wellbeing, such as opportunities.

Though, the definitions mostly differ as to whether they are aligned to the absolute or relative pro-poor concept, they all recognize that increasing the standards of living of all, while including the poor into economic and social participation is the central proposition of the concept.

A sizable body of literature have shown that a high pace of growth over extended periods of time is a necessary, and often the main contributing factor in reducing poverty (Deininger and Squire (1998), Dollar and Kraay (2002), Ravallion (2001) and Bourguignon (2003). Ianchovichna and Lundstrom (2009) propose a framework that identify and prioritize country specific constraints to inclusive growth with reference to Zambia. The result of their findings shows that high indirect costs, market coordination failure, low access to secondary and tertiary education and weak governance are the biggest factors that impede inclusiveness. Anand *et al* (2013) use a panel regression on average 5-year data from 1970-2010 for 143 countries. The results show that macroeconomic stability, human capital and structural changes are the key determinants of inclusive growth in the emerging markets. However, the connection between ICTs and inclusive growth was found to be negative and insignificant.

Anyanwu (2013a) uses a number of different empirical models to examine the link between poverty and other economic indicators ranging from the ordinary least square (OLS), to Feasible Generalised Least Squares (FGLS), two-stage Least Squares instrumental variables (2SLS) and Generalised Methods of Moments Instrumental Variables (IV - GMM). The results show that higher levels of income inequality, primary education, mineral rents, inflation, and higher level of population increase poverty. On the other hand, higher real per capita GDP, and secondary education have negative effect on poverty. Trade openness is found to positively but insignificantly correlated with the headcount.

Vargas, *et al* (2013) found that low provision of public goods, like transport infrastructure, access to electricity, water and sanitation system, government failures (fragile fiscal situation, weak institutions and corruption) and market failures (little diversification of exports, inability of business to broaden production) are the constraining factors for inclusiveness in Nicaragua

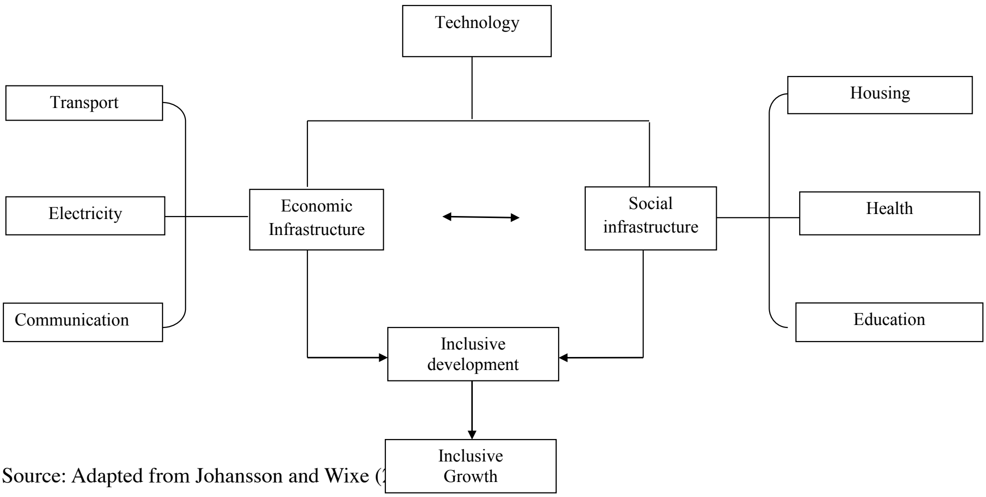
Technology Access and Inclusive Growth

Technology can have a strong impact on the incidence and depth of poverty by supporting inclusive growth. ICT services can be a powerful stimulus to increase productivity across sectors, leading to increase employment and income levels and a reduction in poverty (ADB, 2012). The endogenous growth literature has shown that technology is crucial for economic growth and that continued increase in the level of resources spent on the creation of new technologies would lead to a continued increase in economic growth (Romer 1990, Grossman and Helman, 1991 and Aghion and Howitt, 1992)

Technology can affect poverty reduction by accelerating growth impulses via economic infrastructure and social infrastructure. Hence, access to technology is not a goal in itself, but a means for achieving development goals, decreasing poverty and increasing opportunities (Pigato, 2001). Figure 1 highlights the mechanisms by which technology can reduce poverty and promote inclusive growth. The framework shows the interactions and interdependences among economic and social infrastructure that can affect the outcome in terms of inclusive growth.

Different authors have in last decades documented the role and impact and contribution of ICT investment to economy growth both in a single country and multi country studies, developed and developing countries. Some studies analyzed the variation of the ICT contribution across countries and suggesting policy implications related to each country's efforts to encourage investment in ICT towards boosting the growth of economy. However, the empirical results of the previous studies are dependent on econometric techniques used and data period. The dominant impact of ICT on economic growth and productivity is positive (Jorgenson and Stiroh, 2000, Jorgenson, 2001.

Figure 1: The influence of technology on inclusive growth



Source: Adapted from Johansson and Wixe (

Oliner and Sichel, 2004,). Brynjolfsson and Yang 1996,hiu, 2010, Motohashi 1997 and Kraemer and Dedrick 2001, Roller and Waverman 2001 Jacobsen 2003 and Waverman et al.2005, Koutroumpis (2009), Gruber and Koutroumpis P (2010), Timmer and van Ark (2005), Stiroh (2010), Kooshki and Ismail (2011). Although ICT is well known as a driving engine of economic growth, there are few evidences that show the negative effect of ICT on economic growth (Jacobsen, 2003).

The relationship between ICTs and poverty however does not come out clearly in most literature sources. Pigato's (2001) examine the patterns of utilization, ownership and affordability of ICTs within countries in SSA and South Asia. The author found that SSA and South Asia have the lowest ICT access and within countries there is urban/rural and rich/ divide. The study suggests ways through which information and ICTs can best be used in poverty alleviation strategies. Samiullah and Rao, (2000) argued that ICTs, if appropriately deployed have huge potential to address the differential needs of urban and rural people and foster sustainable development by creating information rich societies and supporting livelihoods.

Kenny et. al. (2000) conducted an empirical study where they argued that econometric studies have found increasing evidence of a causal link between telecommunications development and economic development; however, most evidence springs from the high returns on investment in the telecommunications sector.

Empirical Model and Data

Empirical Model

The empirical model used in this study is based on the basic growth-poverty model proposed by Ravallion, and Chen (1997), as well as the frameworks posited by Dollar and Kraay (2002), and Anyanwu (2013b). Controlling for income level and its distribution, the relationship between certain variable and poverty is investigated. By using the basic growth-poverty model, this study investigates the links between access to technology and poverty. Access to technology is represented by three different variables, namely, access to electricity, total network of paved roads per kilometers of total roads and the number of fixed and mobile subscriptions per capita. Controlling for income level and its distribution, the correlation between technology and poverty is investigated. Furthermore, additional control variable that is secondary education is included in the model. Estimating the same equations on the poverty gap is giving information about the influence of these variables on the depth of poverty.

The full model of the estimated relationship between the three different explanatory variables and poverty is presented in equations 1, 2 and 3. Equation 1 represents the linkages between poverty and electricity whereas the second equation is used to access the relationship between poverty and ICT. Equation 3 describes the estimated relationship between poverty and transport infrastructure.

$$\log P_i = \alpha + \beta_1 \log(gdppc_i) + \beta_2 \log(gini_i) + \beta_3 \log(enrol_i) + \beta_4 \log(elec_i) + ... + \varepsilon_i \quad (1)$$

$$\log P_i = \alpha + \beta_1 \log(gdppc_i) + \beta_2 \log(gini_i) + \beta_3 \log(enrol_i) + \beta_4 \log(ictpc_i) + ... + \varepsilon_i \quad (2)$$

$$\log P_i = \alpha + \beta_1 \log(gdppc_i) + \beta_2 \log(gini_i) + \beta_3 \log(enrol_i) + \beta_4 \log(road_i) + ... + \varepsilon_i \quad (3)$$

In the equations above, P is the measure of poverty in country i, α is a constant parameter, β_1 is the growth elasticity of poverty with respect to income given by Y. β_2 is the elasticity of poverty with respect to income inequality given by the Gini coefficient, whereas β_3 is the elasticity of poverty with respect to the additional control variable education. β_4 is the elasticity of poverty with respect to one of the variables of interest, such as, the elasticity of poverty to electricity, roads and ICT in Equation 1, 2 and 3, and ε represents the error term. The empirical model uses two different poverty measures i.e. poverty headcount and poverty gap, the same equations is analysis with respect to the poverty gap as dependent variable.

Data

The dependent variables used in this model are two different poverty measures, which are poverty headcount ratio (PHR) and poverty gap (PG). Headcount ratio is the relation between number of people living below certain level of income, referred as poverty line, and the total population in the country. This level of income is analysed after the main expenses for food and shelter as well as non-food consumption is extracted from the total income. International poverty lines are also adjusted for inflation over years, in order to remain constant in real terms and to enable meaningful comparison of poverty over time. The study from Ravalion and Chen (2008) used improved price data from the 2005 International Comparison Program to adjust for change of prices in cost of living, and suggested a new poverty threshold at $1,25 dollars a day, according to 2005 Purchasing Power Parity. From 2008, this poverty line is internationally accepted and used until today (previous poverty line was $1 and $1.08 dollars a day).

Another dependent variable is Poverty gap that measures the depth of poverty, which is the amount of income by which the average income of the poor falls short of the poverty line. The poverty gap is expressed as a percentage of the poverty headcount ratio.

The explanatory variables are access to electricity (LELEC), ICT per capita (LICT) and roads infrastructure (LROAD). The variable access to electricity represents percentage of the population with access to electricity. Electricity access refers to the situation where people can acquire modern sources of energy at affordable prices (Kanagawa and Nakata, 2008). ICT variable is a proxy for communication technology representing communication infrastructure. It is a sum of fixed line and mobile phone subscriptions. Fixed telephone lines are those that connect a subscriber's terminal equipment to the public switched telephone network (PSTN). Mobile cellular telephone subscriptions are those that provide access to PSTN using cellular technology. Having advanced communication infrastructure and technology implies decreased costs and more available subscriptions to society through lower prices.

Since there is no existing indicator for access to roads, the network of paved roads is proxy for transport infrastructure.

The standard control variables used in the basic growth model are income (LGDPPC) and inequality (LGINI). Real Gross Domestic Product as an income measure represents the level of income earned by the population. The Gini index represents measurement of inequality through measuring income distribution of a country's residents. This number, which ranges between 0 and 1, is based on residents' net income and helps to define the gap between the rich and the poor. Secondary education enrolment (LENROL) is used as additional control variable to reflect possible interdependences between usage of technology and level of education. The full description of the data is contained in appendix A.

Discussion of Results

Preliminary Discussions (Summary statistics, Correlation analysis and Unit root tests)

The result of the summary statistics (Table 1,Appendix B) revealed that the variables were of good fit with mean values of 669.7491 for LGDPPC and probability value of 0.000. It was followed by LPHR with mean values of 39.55136and with probability value of 0.0300. This has an implication for the impact of technology access and inclusive growth in Nigeria. Moreover, the mean value of LELEC was 24.07676 with probability value of 0.027 while LICT was 0.3414 with probability value of 0.0247and more importantly road infrastructure has mean value of 6.6090 and probability value of 0.0256.The result of correlation matrix as shown by Table 2 (appendix B) indicates that most of the variables were not highly correlated. The result indicates that LPG and LELEC correlated at 0.5824 and that of LPHR and LELEC correlated at 0.6695. This shows that the entire variable behaved normally for the regression analysis. The correlation matrix between LICT and LPHR show 0.6903 and this implies that ICT per capita and poverty headcount ratiocould matter in explaining the impact of inclusive growth on poverty reduction in Nigeria.

The study makes use of Augmented Dickey- Fuller unit root procedure to test for non-stationarity of the underlying time series. The ADF test shows the null hypothesis of unit root against the alternative of stationarity of the series. The results (Table 3) show that all the variables contain unit root. However, Stationarity is achieved after first differencing of the variables. Hence, the study conclude that all the variables are integrated of order I(I), an indication of possible long run relationship among the variables.

Table 3: Unit root results

Variables	ADF level and intercept(s)		ADF first Diff, trends and intercepts		Decision(s)
	Value	Critical values	Values	Critical values	
LPG	-1.2022	-2.9314	-6.5124**	-3.5207	**I(1)**
LPHR	-1.2205	-3.5924	-6.4989**	-3.5207	**I(1)**
L ELEC	-0.9336	-3.5924	-6.4478**	-3.5207	**I(1)**
LENROL	-1.8956	-2.9314	-4.0606**	-3.5207	**I(1)**
LGDPPC	2.0907	-2.9314	-7.3312**	-3.5207	**I(1)**
LGINI	-1.2453	-2.9314	-6.4760**	-3.5207	**I(1)**
LICT	-1.6412	-2.9314	-4.8090**	-3.5207	**I(1)**
LRoad	-1.8442	-3.5180	-6.3519**	-3.5207	**I(1)**

Sources: author's computation from E-view 7

Table 4: Co-integration results

Co-integration Rank Test (Trace)				Co--integration Rank Test (Maximum Eigenvalue)			
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Hypothesized No. of CE(s)**	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**
None *	0.943816	244.2396	159.5297	None *	0.943816	120.9233	52.36261
At most 1	0.581489	123.3164	125.6154	At most 1	0.581489	36.58415	46.23142
At most 2	0.470568	86.73223	95.75366	At most 2	0.470568	26.70995	40.07757
At most 3	0.389154	60.02227	69.81889	At most 3	0.389154	20.70225	33.87687
At most 4	0.374944	39.32002	47.85613	At most 4	0.374944	19.73637	27.58434
At most 5	0.270576	19.58365	29.79707	At most 5	0.270576	13.25098	21.13162
At most 6	0.134792	6.332672	15.49471	At most 6	0.134792	6.080986	14.26460
At most 7	0.005975	0.251686	3.841466	At most 7	0.005975	0.251686	3.841466

*denotes rejection of the hypothesis at the 0.05 level ** Mackinnon –Haug-Michelis (1999) p-values both trace and maximum Eigenvalue indicates 1 co-integrating eqns at the 0.05 level

To test the hypothesis regarding the number of co-integrating vectors, the Johansen co-integration procedure performs two tests-Trace (λtrace) and Max-eigenvalue (λmax). Both Trace test and Max-Eigen value statistics indicate one co-integrating equation at 5% level of significance. Based on this, we can reject the null hypothesis (H_o) which says that there are no co-integrating vectors and conclude that the variables under consideration are bound together by long-run equilibrium relationship under the assumption of no deterministic trend (Table 4).

Results and Analysis

The results on the linkages between poverty and the three variables of interest are presented in three different tables below. Table 5 shows the outcome of the estimated relationship between poverty and access to electricity. Table 6 presents the correlations between poverty and ICT, while the relationship between poverty and transportation infrastructure (road paved) is presented in Table 7.

In order to restrict the long-run behavior of the endogenous variables to converge to their co-integrating relationships, while allowing for short-run adjustment dynamics, we estimate the Error Correction Model (ECM). An Error Correction Model is designed for use with non-stationary series that are known to be co-integrated. We over parameterized the first differenced form of the variables in equation (1)-(3) and used Schwarz Information Criteria and Akaike Information Criteria (AIC) to guide parsimonious reduction of the model.

The relationship between poverty and electricity access is depicted in Table 5. For instance, poverty gap (LPG) used as dependent variable is statistically significant especially with the explanatory variables - secondary enrolment. Furthermore, income level and Gini index coefficient is statistically significant at 5% level. In addition, the variable - access to electricity is positive and statistically significant at 5%. At the other end, when Poverty headcount rate (LPHR) is used as the dependent variable, income inequality (measured as Gini index) and income level (GDPPC) are statistically significant. The variable access to electricity is negative and insignificant. The negative coefficient implies that the access to electricity is negatively correlated with the number of people living below poverty line, which is expected. The results, however, reveal lower elasticity of headcount poverty rate with respect to electricity access.

The results obtained from the estimation of the model on access to electricity on poverty are in line with previous empirical studies that did not find significance of both electricity and education on the poverty headcount (Suregeni, 2008). Previous studies have pointed out some neutral, even negative impacts of electricity on poverty. This is further explained by the fact that electrification infrastructure opens up opportunities to those who have a minimum amount of income, as a required threshold and therefore are better placed to take advantage of technology for poverty alleviation (Jalilian and Weiss, 2006).

From the table, it was observed that the model was good fitted and appropriate for the analysis. The result obtained from the dynamic model indicates that the overall coefficient of determination (R2) shows that 99.58 and 99.09 percent variations of (LPG) and (LPHR) are explained by the variables in the equation. The adjusted R-squared for both the independent variables shows that having removed the influence of the explanatory variables, the dependent variable is still explained by 99.42 percent for (LPG) and 98.78 for (LPHR) of the model. The significant value of the F-Stat further confirmed the fitness of the model. The Durbin Watson Statistics was close to 2.0, for (LPG) and was above 2.0 for (LPHR) an indication that there was no serial correlation in the model and hence, the assumption of linearity is not violated.

Other diagnostic checks were also carried out to see if there is a problem in the residuals from the estimation of a model, which is an indication that the model is not efficient, such that parameter estimates from such model may be biased. Results from various tests such as, the Breusch-Pagan-Godfrey serial correlation LM test, the Breusch-Pagan-Godfrey heteroskedasticity and autoregressive conditional heteroskedasticity(ARCH) tests in this study are presented in table (11) appendix A

Our results show that the residual from the error correction model is normally distributed because the P-value of the series was insignificant. The null hypothesis of no serial correlation as confirmed by Serial Correlation LM Test cannot be rejected since the test statistics are also not significant. The tests also confirm the absence of heteroskedasticity using both the Breusch-Pagan-Godfrey heteroskedasticity and ARCH tests, hence indicating that the model is well behaved.

The negative and significant coefficient of the error correction term (ECM) reveals which of the variables adjust to correct imbalance in the dependent variables whilst the variable coefficients show the short-run effects of the changes in the explanatory variables on the dependent variable. The results confirm that both poverty gap and poverty headcount ratio in Nigeria has an automatic mechanism, and deviations from equilibrium are corrected in the short run. The speed of adjustment of about -0.02 for poverty gap and -0.12 for poverty headcount ratio indicates that when poverty gap or poverty headcount ratio is above or below its equilibrium level, it adjusts by 2% or 12% within the first year. Therefore, the pace of adjustment toward the equilibrium is fast in case of any shock to poverty gap or poverty headcount ratio.

Table 5: Model (1) access to electricity Parsimonious short run regression estimate

Dependent variable D(PG)				Dependent variable D(PHR)			
Variable	**Coefficient**	**t-Statistic**	**Prob**	**Variable**	**Coefficient**	**t-Statistic**	**Prob**
D(LPG(-1))	-0.024474	-0.447294	**0.6581**	**C**	0.497726	2.038209	**0.0507**
D(LGINI)	0.568932	64.90365	**0.0000****	**D(LPHR(-2))**	-0.010528	-0.581527	**0.5654**
D(LGINI(-1))	0.014414	0.437174	**0.6653**	**D(LGINI)**	1.375192	54.71559	**0.0000****
D(LGINI(-2))	-0.002330	-0.282194	**0.7799**	**D(LGINI(-1))**	-0.025695	-0.932968	**0.3585**
D(LGDPPC)	-0.000700	-3.083334	**0.0046****	**D(LGDPPC)**	-0.002505	-3.365309	**0.0022****
D(LGDPPC(-1))	0.000115	0.508584	**0.6150**	**D(LGDPPC(-1))**	0.000623	0.883837	**0.3841**
D(LGDPPC(-2))	-0.000211	-0.938396	**0.3561**	**D(LGDPPC(-2))**	-2.96E-05	-0.039297	**0.9689**
D(LENROL)	-0.553646	-1.021417	**0.3158**	**D(LENROL(-1))**	-2.608057	-1.635540	**0.1127**
D(LENROL(-2))	-0.073962	-0.143926	**0.8866**	**D(LELEC(-1))**	-0.013083	-0.556572	**0.5821**
D(LELEC(-2))	0.133231	18.48187	**0.0000****	**D(LELEC(-2))**	-0.028493	-1.194872	**0.2418**
C	0.018375	0.233495	**0.8171**	**ECM(-1)**	-0.123103	-2.17517	**0.0526****
ECM(-1)	-0.024125	2.113802	**0.0102****	**R-squared**	0.990980	Mean dependent	**1.550750**
R-squared	0.995857	Mean dependent	0.686500	**Adjusted R-squared**	0.987870	S.D. dependent	**8.739546**
Adjusted R-squared	0.994230	S.D. depend	3.845515	**S.E. of regression**	0.962535	Akaike info criterion	**2.989924**
S.E. of regression	0.292106	Akaike in	0.619925	**Sum Squared**	26.86775	Schwarz criterion	**3.454366**
Sum squared	2.389126	Schwarz cr	1.126589	**Log likelihood**	-48.79849	Hannan-Quinn cr	**3.157852**
Log likelihood	-0.398503	Hannan-Qu	0.803119	**F-statistic**	318.6207	Durbin-Watson st	**2.102046**
F-statistic	611.9236	Durbin-Watson	1.994308	**Prob (F-statistic)**	0.000000		
Prob(F-statistic)	0.000000						

**denotes rejection of the null hypothesis at the 0.05 significant level

Table 6 displays the estimated relationship between access to ICT and poverty. From the table we observe noticeable influence of access to communication technology on poverty incidence that is somehow different from access to electricity. Only the Gini index is statistically significant and affect poverty gap in the equation. All other explanatory variables are negative and insignificant in explaining the effect of poverty depth in the economy. In a similar vein, only Gini index and income level are statistically significant in explaining the relationship between ICT and poverty depth. Therefore, the results show statistical significance and negative relationship between the usage of ICT and poverty incidence. Secondary enrollment is negative and significant when poverty gap is used as dependent variables. It implies that higher educational attainment decrease the in depth of poverty. Results obtained are in line with Suregeni, (2008) and Anand et al (2013) estimating the relationship between access to information and communication technologies and the incidence of poverty. Anand et al (2013) opined that the insignificance of the coefficient due to lack of data on ICT investments in emerging market.

From the table (6) above, it was observed that the model was good fitted and appropriate for the analysis. The result obtained from the dynamic model indicates that the overall coefficient of determination (R2) shows that 94.66 and 99.07 percent variations of (LPG) and (LPHR) are explained by the variables in the equation. The adjusted R-squared for both the independent variables shows that having removed the influence of the explanatory variables, the dependent variable is still explained by 92.56 percent for (LPG) and 98.79 for (LPHR) of the model. The significant value of the F-Stat further confirmed the fitness of the model. The Durbin Watson Statistics was close to 2.0 for both (LPG) and (LPHR) an indication that there was no serial correlation in the model and hence, the assumption of linearity is not violated. All other tests carried out confirmed the appropriateness of the model. The negative and significant coefficient of the error correction term (ECM) reveals which of the variables adjust to correct imbalance in the dependent variables whilst the variable coefficients show the short-run effects of the changes in the explanatory variables on the dependent variable. The results confirm that both poverty gap and poverty headcount ratio in Nigeria has an automatic mechanism, and deviations from equilibrium are corrected in the short run. The speed of adjustment of about -0.06 for poverty gap and -0.03 for poverty headcount ratio indicates that when poverty gap or poverty headcount ratio is above or below its equilibrium level, it adjusts by 6% or 3% within the first year. Therefore, the pace of adjustment toward the equilibrium is fast in case of any shock to poverty gap or poverty headcount ratio.

Table 6: Model 2 Parsimonious short run regression estimate

Dependent variable D(LPG)				Dependent variable D(LPHR)			
Variable	Coefficient	t-Statistic	Prob	Variable	Coefficient	t-Statistic	Prob
C	0.319793	1.167467	0.2529	C	0.354717	1.533041	0.1357
D(LPG(-2))	-0.056548	-0.303196	0.7640	D(LPHR(-2))	-0.006734	-0.374045	0.7110
D(LGINI)	0.579093	18.93935	0.0000**	D(LGINI)	1.375645	55.25134	0.0000
D(LGINI(-1))	-0.011822	-0.396596	0.6947	D(LGINI(-1))	-0.019005	-0.699746	0.4895
D(LGINI(-2))	0.024128	0.213424	0.8325	D(LGDPPC)	-0.002195	-2.608971	0.0140
D(LGDPPC)	-0.000828	-1.000132	0.3258	D(LGDPPC(-1))	0.001048	1.280070	0.2103
D(LGDPPC(-1))	-0.000664	-0.671391	0.5075	D(LENROL(-1))	-2.374068	-1.533179	0.1357
D(LENROL)	-1.239262	-0.624409	0.5374	D(LICT)	0.931071	0.486984	0.6298
D(LENROL(-1))	-0.553523	-0.287269	0.0760*	D(LICT(-1))	1.188824	0.655357	0.5172
D(LICT(-1))	-1.586405	-0.752773	0.4579	ECM(-1)	-0.032559	-3.171970	0.0546
D(LICT(-2))	0.882524	0.442899	0.6612	R-squared	0.990733	Mean depen	1.550750
ECM(-1)	-0.066491	-2.343600	0.0337	Adjusted R-squared	0.987953	S.D. depend	8.739546
R-squared	0.946619	Mean dep	0.686500	S.E. of regression	0.959249	Akaike info crit	2.966987
Adjusted R-squared	0.925648	S.D. dependent	3.845515	Sum squared	27.60479	Schwarz-criterion	3.389207
S.E. of regress	1.048580	Akaike info cr	3.176076	Log likelihood	-49.33974	Hannan-Qui	3.119648
Sum squared	30.78657	Schwarz-crite	3.682740	F-statistic	356.3635	Durbin Watson	1.974889
Log likelihood	-51.52153	Hannan-Quinn	3.359270	Prob (F-statistic)	0.000000		
F-statistic	45.13909	Durbin-Wats	1.997969				
Prob (Fstatistic)	0.000000						

* and ** denotes rejection of the null hypothesis at the 1% and 5% significant levels respectively

The results obtained on the estimated relationship between roads and poverty are shown in Table (7).The signs of the coefficients demonstrate the expected negative relation between poverty measure and roads infrastructure.The correlation between transport infrastructure (road) and poverty is higher when the poverty measure is the poverty gap. It shows that there is negative relationship between poverty gap and road infrastructure but statistically significant at 5% level. In addition, Gini index and income level are key explanatory variable in the model negative and statistically significant. The relationship between road infrastructure and poverty headcount ratio is statistically significant and negative. Secondary enrollment is negative and statistically significant in the model. Results obtained are in line with previous studies on the relationship between road infrastructure and poverty alleviation (Jalilian and Wies, 2004; Khander et al., 2006; Lucas, 2012 and Xueliang, 2013). The comparison across various coefficients representing technology access, estimated by the full model, demonstrates the highest lowest of ICT on the poverty incidence. Both electricity access and road infrastructure access have the highest effect on the depth of poverty. In respectful of the measure used as a dependent variable, road infrastructure is negatively and significantly correlated with poverty, meaning that the amount of paved roads is related to reduce poverty as well as decreased depth of poverty.

Table 7: Model 3 road paved way Parsimonious short run regression estimate

Dependent variable D(LPG)				**Dependent variable D(LPHR)**			
Variable	**Coefficient**	**t-Statistic**	**Prob**	**Variable**	**Coefficient**	**t-Statistic**	**Prob**
C	-0.027152	-0.352429	**0.7272**	**C**	0.171489	0.576541	**0.5689**
D(LPG(-1))	-0.026765	-0.504492	**0.6179**	**D(LPHR(-1))**	0.963453	1.634639	**0.1133**
D(LGINI)	0.568447	68.84585	**0.0000****	**D(LGINI)**	1.369084	54.78777	**0.0000****
D(LGINI(-1))	0.019712	0.618138	**0.5415**	**D(LGINI(-1))**	-1.352432	-1.667769	**0.1065**
D(LGDPPC)	-0.000710	-3.221061	**0.0032****	**D(LGDPPC)**	-0.002670	-3.698537	**0.0009****
D(LGDPPC(-1))	0.000139	0.634350	**0.5310**	**D(LGDPPC(-1))**	0.002860	1.862126	**0.0731*****
D(LGDPPC(-2))	0.000113	0.511965	**0.6127**	**D(LGDPPC(-2))**	-0.000757	-0.897322	**0.3772**
D(LENROL)	-0.782948	-1.450335	**0.1581**	**D(LENROL(-1))**	-3.024737	-1.673317	**0.1054***
D(LENROL(-1))	0.539309	0.980849	**0.3351**	**D(LENROL(-2))**	2.335938	1.233329	**0.2277**
D(LROAD)	-0.011995	11.470957	**0.0413****	**D(LROAD)**	-0.065430	-3.264625	**0.0509****
D(LROAD(-2))	-0.479890	19.03868	**0.0000****	**D(LROAD(-2))**	-0.073259	-4.862510	**0.0957****
ECM(-1)	-0.027686	3.134821	**0.0937*****	**ECM(-1)**	-0.053898	-2.680264	**0.0040****
R-squared	0.996079	Mean dep	0.686500	**R-squared**	0.991738	Mean dep	1.550750
Adjusted R-squared	0.994539	S.D.	3.845515	**Adjusted R-squared**	0.988492	S.D. dependent	8.739546
S.E. of regress	0.284181	Akaike info	0.564914	**S.E. of regr**	0.937519	Akaike in	2.952167
Sum squared	2.261247	Schwarz cr	1.071578	**Sum squared**	24.61039	Schwarz cri	3.458830
Log likelihood	0.701717	Hannan-Qui	0.748108	**Log likelihood**	-47.04333	Hannan-Q	3.135360
F-statistic	646.6732	Durbin-Watson	1.982188	**F-statistic**	305.5527	Durbin-Watson	2.045669
Prob (F-statistic)	0.000000			**Prob(F statistic)**	0.000000		

* , ** and *** denotes rejection of the null hypothesis at the 1%, 5% and 10% significant levels respectively

The result obtained from the dynamic model indicates that the overall coefficient of determination (R2) shows that 99.60 and 99.17 percent variations of (LPG) and (LPHR) are explained by the variables in the equation. The adjusted R-squared for both the independent variables shows that having removed the influence of the explanatory variables, the dependent variable is still explained by 99.45 percent for (LPG) and 98.84 for (LPHR) of the model. The significant value of the F-Stat further confirmed the fitness of the model. The Durbin Watson Statistics was close to 1.98, for (LPG) and was above 2.04 for (LPHR) an indication that there was no serial correlation in the model and hence, the assumption of linearity is not violated.

Other diagnostic checks were also carried out to see if there is a problem in the residuals from the estimation of a model, which is an indication that the model is not efficient, such that parameter estimates from such model may be biased. Results from various tests such as, the Breusch-Pagan-Godfrey serial correlation LM test, the Breusch-Pagan-Godfrey heteroskedasticity and autoregressive conditional heteroskedasticity (ARCH) tests in this study are presented in Table 8-10 (see appendix B)

Our results show that the residual from the error correction model is normally distributed because the P-value of the series was insignificant. The null hypothesis of no serial correlation as confirmed by Serial Correlation LM Test cannot be rejected, since the test statistics are also not significant. The tests also confirm the absence of heteroskedasticity using both the Breusch-Pagan-Godfrey heteroskedasticity and ARCH tests, hence indicating that the model is well behaved. The negative and significant coefficient of the error correction term (ECM) reveals that the independent variables adjust to correct imbalance in the dependent variables, whilst the variable coefficients show the short-run effects of the changes in the explanatory variables on the dependent variable. The results confirm that both poverty gap and poverty headcount ratio in Nigeria has an automatic mechanism, and deviations from equilibrium are corrected in the short run. The speed of adjustment of about -0.02 for poverty gap and -0.05 for poverty headcount ratio indicates that when poverty gap or poverty headcount ratio is above or below its equilibrium level, it adjusts by 2% or 5% within the first year. Therefore, the pace of adjustment toward the equilibrium is fast in case of any shock to poverty gap or poverty headcount ratio.

Summary, Conclusion and Recommendations

Inclusive growth has been the focus of attention in the economic circles over the last few decades now. In line with inclusive growth concept, this study investigates empirically technology access, inclusive growth and poverty reduction in Nigeria for the period 1980-2014. The role of inclusive growth in reducing poverty is emphasized more in this study through the access to electricity, access to ICT and transport infrastructure (road). The study used the error correction modeling approach (ECM) to measure the impact of technology access on poverty reduction and other independent variables. Other diagnostic test such as Serial correlation LM, Breusch-Pagan Godfrey and ARCH test were performed to determine the robustness of the model. The results indicate that access to electricity and transport infrastructure is negative and statistically significant in both the incidence and the depth of poverty reduction. Access to information and communication technology (ICT) show robust and negatively influence the incidence of poverty, but the relationship is not robust when the measure of poverty is the poverty gap. Hence, it can be concluded that technological access does not promote inclusive growth in Nigeria.

As a policy recommendation, government would need to promote access to finance as a prerequisite for poverty reduction in order to achieve inclusive growth.

Government spending can be of profound importance, since it can easily target the poor through certain programmes or projects that address social and economic inclusion. Furthermore, there should be more investment in transport infrastructure in order to bring the economy closer to inclusive growth targets. The impact of ICTs on economic growth, together with targeted policy interventions that will increase their impact on poverty alleviation will also help to relieve the plight of those in absolute poverty and improve the well-being of citizens, hence, the government should encourage better access to information through investment in ICT technology with a view to raising people's standard of living above the poverty line.

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Appendix A

Table 3: Data Description and Sources

Variables	Definition	Source
Poverty headcount ratio	Log of poverty headcount ratio is the percentage of population living on less than 1.25 a day at 2005 international prices	PovcalNet data base (World Bank)
Poverty gap	The mean shortfall of incomes from the poverty line (counting the non-poor as having zero shortfall), expressed as a percentage of the poverty line.	PovcalNet data base (World Bank)
Access to electricity	Percentage of population with access to electricity.	World Development Indictors (World Bank) 2016
Roads, paved per km	Total network of paved roads per kilometers of total roads.	World Development Indictors (World Bank) 2016
ICT per capita	Fixed lines: sum of active number of analogue fixed telephone lines, (VoIP) subscriptions, fixed wireless local subscriptions and fixed public payphones. Mobile subscriptions: number of postpaid and active prepaid accounts.	World Development Indictors (World Bank) 2016
Income	Gross Domestic Product per capita measured in current US$	World Development Indictors (World Bank) 2016
Gini index	Measure of income distribution.The extent to which the distribution of income deviates from a perfect distribution.	World Development Indictors (World Bank) 2016
Secondary Education	Total enrollment in secondary education, regardless of age.	World Development Indictors (World Bank) 2016

Appendix B

Table 1: Summary statistics

	LPG	LPHR	LELEC	LENROL	LGDPPC	LGINI	LICT	LROAD
Mean	17.83545	39.55136	24.07676	14.77310	669.7491	27.17455	0.341327	6.609035
Median	24.43000	57.94500	41.83774	14.95501	389.5894	39.34000	0.284103	11.86296
Maximum	32.16000	68.65000	48.00000	16.01902	3005.514	46.50000	1.177806	12.17764
Minimum	0.000000	0.000000	0.000000	12.78427	153.0762	0.000000	0.000000	0.000000
Std. Dev.	13.97848	30.52402	22.29490	0.946759	695.0915	20.93379	0.306787	6.103658
Skewness	-0.425816	-0.511209	-0.165696	-0.749847	2.192665	-0.521512	0.980456	-0.181882
Kurtosis	1.344299	1.333720	1.050438	2.502709	6.918470	1.332768	3.434896	1.033980
Jarque-Bera	6.355470	7.006678	7.169457	4.576697	63.40680	7.090532	7.396242	7.328857
Probability	0.041680	0.030097	0.027744	0.101434	0.000000	0.028861	0.024770	0.025619
Observations	44	44	44	44	44	44	44	44

Sources: author’s computation from E-view 7

Table 2: Correlation matrix

	LPG	LPHR	LELEC	LENROL	LGDPPC	LGINI	LICT	LROAD
LPG	1.000000							
LPHR	0.994416	1.000000						
LELEC	0.582497	0.669547	1.000000					
LENROL	0.769358	0.788704	0.751537	1.000000				
LGDPPC	0.200909	0.226070	0.387483	0.510471	1.000000			
LGINI	0.993694	0.997912	0.853389	0.776959	0.212296	1.000000		
LICT	0.670886	0.690313	0.714717	0.759164	0.260846	0.654465	1.000000	
LROAD	0.889112	0.870481	0.997642	0.733150	0.331975	0.857918	0.706909	1.000000

Sources: author's computation from E-view 7

Table 8: Residual Diagnostic Tests Model 1 with poverty gap & poverty head-ratio (access to electricity)

Poverty Gap	F-Statistics	P-Value	Poverty headcount	F-Statistics	P-Value
Serial correlation LM-	0.147531	0.8637	**Serial correlation LM-**	1.086828	0.3547
ARCH	0.078138	0.7814	**ARCH**	0.010465	0.9191
Breusch-Pagan -Godfrey	0.299591	0.9906	**Breusch-Pagan Godfrey**	0.244563	0.9966

Table 9: Residual Diagnostic Tests Model 2 with poverty gap & poverty head-ratio (ICT and poverty)

Poverty Gap	F-Statistics	P-Value	Poverty headcount	F-Statistics	P-Value
Serial correlation LM	1.0497	0.3677	**Serial correlation LM-**	0.7041	0.5053
ARCH	0.0297	0.8641	**ARCH**	0.0724	0.7893
Breusch-Pagan -Godfrey	0.2149	0.2149	**Breusch-Pagan -Godfrey**	0.1059	0.999

Table 10: Residual Diagnostic Tests Model 3 with poverty gap & poverty head-ratio transport infrastructure and poverty

Poverty gap	F-Statistics	P-Value	Poverty headcount	F-Statistics	P-Value
Serial correlation LM-Test	0.2928	0.7490	**Serial correlation**	0.5788	0.5676
ARCH	0.0659	0.7987	**ARCH**	0.0450	0.8331
Breusch-Pagan -Godfrey	0.2948	0.9913	**Breusch-Pagan -Godfrey**	0.2992	0.9804