Towards Poverty Reduction in Sub-Saharan Africa: Does Digitalization Play a Role?

by

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Abstract

There has been an increasing level of poverty in Sub-Saharan Africa (SSA) as the region accommodates the largest number of poor people in the world. Digitalization has been identified as an important tool for poverty alleviation, inclusive and sustainable economic growth through mechanisms such as education, health, financial inclusion, among others. This study examines the direct and indirect effects of digitalization on poverty reduction through education, health and financial access in SSA countries. The Pooled Ordinary Least Square Regression, Fixed Effect, Random Effect Regression as well as the System Generalized method of Moments technique which controls for endogeneity of regressors and does not eliminate cross-country variations was employed for 45 SSA countries from 2000-2020. Data is sourced from World Development Indicator (WDI). Results showed that for education, digital use in terms of internet access has no significant effect on poverty in SSA. However, digital access measured by mobile subscription has a significant effect on poverty. For the health channel, internet use and mobile subscriptions increase poverty in SSA. The same findings relate to the financial access channel of poverty reduction. The study, therefore, recommends that digital services should be provided at lower cost and infrastructures that support the use of digital services be made readily available for SSA countries.

Keywords: Digitalization, Internet use, Mobile Subscription, Poverty, Sub-Saharan Africa

1. Introduction

Poverty is a multidimensional phenomenon that has plagued several countries of the world, particularly developing countries. The importance of poverty is reflected in the fact that it is the first Sustainable Development Goal (SDG) to be met by 2030.The World Bank defines extreme poverty as living on less than $1.90 a day, which puts 10 percent of the world's population below the global poverty line (World Bank, 2021). However, poverty extends beyond income as it affects every part of human existence. Poverty involves lack of access to water and sanitation, shelter, health, education, amongst others. These broader measures of poverty are regarded as the non-income dimensions of poverty according to the World Bank classification (Bahar, 2022).

The United Nations has recorded tremendous progress in the fight against poverty globally, being at the core of the Sustainable Development Goals. Before the COVID-19 pandemic, the share of the world's population living in extreme poverty fell from 10.1 per cent in 2015 to 9.3 per cent in 2017. This means that the number of people living on less than $1.90 per day dropped from 741 million to 689 million. However, in 2020, an increase of between 119 million and 124 million global poor was recorded, of which about 60 percent are in Southern Asia (UNSTAT Report, 2021). Extreme poverty remains relatively high in low-income countries particularly in sub-Saharan Africa. Sub-Saharan Africa is recorded as the poorest region in the world (Acemoğlu & Robinson, 2010; Sen, 2000), with an estimate of about 433 million poor people in 2018 (World Bank, 2020: 28). It has also been recorded that almost half of these 433 million poor people are concentrated in five countries in the region which are Nigeria, Democratic Republic of Congo, Tanzania, Ethiopia and Madagascar (Schoch & Lakner, 2020; World Bank, 2020).

Several attempts have been made by developing economies, including Sub-Saharan Africa countries to seek viable ways of poverty reduction and improve the quality of life of their citizens. This includes providing access to education, health, financial inclusion, amongst others. Financial inclusion alleviates poverty by providing direct access to financial products and services, leading to efficient resource allocation, thus providing better financial leverage to the underprivileged (Alimi and Okunade, 2020; Galor & Zeira, 1993; Aghion & Bolton, 1997). Similarly, the World Health Organization posits that improving the health and longevity of the poor is both a goal and a target for poverty reduction. This gives credence to the fact that health is an essential factor of human capital, which can have a positive impact on economic growth and poverty reduction. Increased investment in health can promote a living environment through social security measures and achieve inclusive growth for the poor.

The United Nations has also stressed the importance of education in poverty reduction, as it is the foundation for productive employment and better livelihood. However, countries in sub-Saharan Africa constitute 87% of the countries in the world where more than 30% of primary school-age girls are out of school. (World Economic Forum, 2021). Young girls and many other vulnerable groups of

children experience unique challenges detrimental to their access to education. Similarly, SSA countries are faced with a grim health situation, as the region bears about 24% of the global disease burden despite accounting for only 13% of the world's population. The reason for this is not far-fetched as the rate of healthcare investment in the region is abysmally low, constituting only about 1% of the world's healthcare expenditure (World Economic Forum, 2017).

There have been various financial reforms in the SSA region in a bid to ease and expand the availability of financial services such as credits, payment services and savings; thereby resulting in an increased financial depth in the region. However, despite these reforms, ease and access to formal financial services remain very low (Alimi and Okunade, 2020). Additionally, despite the importance of financial inclusion to ensure the disadvantaged population is incorporated into the fold of financial services, it has received little attention in SSA region.

Digitalization has been identified as an important tool for poverty alleviation, inclusive and sustainable economic growth. It connects remote populations to markets, promotes access to financial and social services, expand educational and employment opportunities, create platforms for innovation and increase people's freedoms and access to government services. While digitalization has made remarkable progress across developed countries, developing countries like SSA countries are still on track to end extreme poverty. There has been a remarkable digital transformation in Africa in recent years as the rate of individuals with internet penetration and mobile subscription has increased. The percentage of the population with internet access in Sub-Saharan Africa in 2021 was 43 percent while the percentage of unique mobile subscribers in 2021 was 46 percent. However, despite rising technological adoption rates, Africa still lags behind the global average of internet (60 percent) and unique mobile subscribers (67 percent) as of the end of 2021. This rapid expansion of mobile internet services is already contributing to the region's economic and social development.

The onset of the corona virus pandemic brought the importance of digitalization, particularly in health and education to the forefront. Digital teaching via the internet became necessary following the economic lockdown, as schools embraced online teaching. Online education provides learners unlimited access to resources from any location and at any time. Digital technology can also expand universal health coverage by eliminating a number of barriers such as costs, complicated access and lack of quality of care, while extending the range of services, particularly in regions where infrastructure and personnel are scarce or non-existent. This was evident during the Ebola Crisis in West Africa between 2014-2015 as well as during the COVID 19 pandemic. Mobile applications were employed as tools to share lifesaving information with people in rural communities. Despite these developments, SSA countries have not fully reaped the benefits of digitalization owing to factors like digital divide, digital skill shortages, infrastructure deficiencies, amongst other factors. This has contributed to the increasing poverty rates recorded in the region.

This study, therefore, seeks to examine the role of digitalization on poverty reduction in 45 SSA countries from 2000 to 2020. The study differs from others by considering three different measures that can be determinants in the digitalization and poverty reduction nexus. The measures used in this study are education, health and financial access. In line with the human capital theory, effective government expenditure on education and health can reduce poverty in countries. Digitalization can be a tool in augmenting the effectiveness of these measures on poverty reduction. Thus, digitalization will have different impacts on poverty reduction depending on the state of these measures in SSA countries. Most existing studies have either examined the direct effect of digitalization on poverty in SSA countries (Kohnert, 2021; Matake, 2022; Evans, 2019; Subramaniam, 2020), while very few studies have considered the indirect effect of digitalization on poverty reduction via the various determinants of poverty. Studies that have examined the indirect effect focus majorly on financial access and poverty (Ofori et al., 2021; Alimi and Okunade, 2020; Mushtaq, 2019), However, there is a dearth of literature on the interacting relationships of digitalization and education as well as digitalization and health and poverty reduction in SSA. Similarly, the study disentangles digitalization tools into digital access and digital use as they affect poverty in SSA countries. The rest of the study is structured as follows: Section 2 presents the literature review, while Section 3 covers the research methodology. Section 4 presents the results and Section 5 provides discussions and conclusion. Section 6 highlights the limitations of the study, and provides suggestions for future research in this endeavour.

2. Literature Review

2.1. Theoretical Review

There are different strands of theoretical literature on the determinants of poverty. However, the paradigm of poverty has a direct relationship with the alleviation measures adopted (Bradshaw, 2005). The Classical theory views poverty as a consequence of poor individual choices that have negative effects on productivity (Davis and Martinez, 2015). The Neo-Classical theory is an extension of the classical theory and presupposes the role of the unequal initial endowments of talents, skills and capital which determine productivity of an individual in generating poverty. Individuals seek to maximize their own well-being by making choices and investments. However, the Neo-Classical poverty theory considers other poverty determining factors that are beyond an individual's control, especially in the presence of market failures. These include; lack of social and private assets, market failures that exclude the poor from credit markets and cause certain adverse choices to be rational; barriers to education; immigrant status, poor health and advanced age; amongst others (Prasetyo and Thomas,2021).

The Keynesian theory of poverty follows the assumption that underdevelopment in its multidimensional nature causes poverty. Keynesian economists agree with the Classicals viewpoint that unequal endowment of talent, skills, and capital determines an individual's level of productivity.

Therefore, poverty is a result of economic underdevelopment and lack of human capital. The theory therefore emphasizes the importance of government functions, economic stability, and public goods. The theory stresses economic growth as the major determinant of poverty alleviation. Public spending on education, health and other infrastructures increase economic growth which in turn should have a downturn effect on poverty. This implies that government intervention that through increased expenditure in the education and healthcare sectors is imperative for poverty reduction. In Keynesian theory, high inflation, huge national debt, and unemployment are other macroeconomic determinants of poverty.

The cultural theory of poverty attributes the causes of poverty to societal imbalances in cultural values, norms and practices perpetrated by people. This implies that poverty is trans-generational through the acceptance of beliefs and systems (Bradshaw, 2006). Meanwhile, Marxian theory posits that economic growth is important for poverty reduction. Although it is not enough, because the extent to which economic growth reduces poverty depends on how it is measured, and the ability of the poor to absorb the pattern of growth (Skare & Druzeta, 2016). In addition, the monetary theory of poverty views income and consumption as the main variables of interest in any analysis of poverty. Increased level of income increases the purchasing power of the poor, grants them access to resources, thereby reducing the problem of inequality (Bhalla, 2002). According to this school of thought, welfare can be measured by the total consumption of individuals approximated by either expenditure or income. The theory also considers other variables such as education completion rates, but recommends such as instrumental, only to be used in increasing productivity and hence monetary incomes among people in poverty. The monetarist see government spending as having a significant supply-side effect but no demand-side function unless it triggers changes in monetary measures. They, however, inferred that monetary policy will have a direct effect on poverty while fiscal policy will have a circuitous effect on poverty (Maku et al., 2020)

2.2. Empirical Review

Literature has recorded divergent views on the effect of digitalization on poverty across countries. While some studies have examined the direct effect of digitalization on poverty reduction, few studies have examined the effect via different channels of poverty reduction. The first strand of literature examines studies on the direct effect of digitalization on poverty reduction. In examining the relationship between information and communication technologies (ICT) and poverty in 182 countries for the period between 2000 and 2013, Yilmazet al. (2018) employed four different ICT indicators (internet penetration, mobile phone subscription, personal computer, and fixed broadband subscription) against six poverty indicators. The study recorded significant relationship between ICT indicators and poverty indicators, while internet usage is found to have the strongest effect on all poverty indicators.

In examining the important role of ICTs in addressing poverty challenges in rural China, Gu et al. (2022) employed a unique three-wave panel dataset of household surveys, collected from seven officially recognized poor counties in rural China between 2012–2018. Results show that ICTs contributed positively to poverty reduction in the sampled counties. Regina and Nababan (2022) estimated the impact of digitalization on poverty reduction and economic growth for 34 provinces in Indonesia from 2015 to 2020. Using the Random Effect Model (REM) with an estimation technique of Two-Stage Least Square (2SLS), findings show that digitization has a significant effect on reducing poverty but exhibits a negative impact on economic growth.

In examining the causal relationship as well as the effect of ICT diffusion on poverty in Sub-Saharan African countries, Mateko (2022) employed a Panel Vector Autoregressive model and Generalised Method of Moments on a panel data set from 1989 to 2019. Empirical results showed that information and communication technology significantly contribute to poverty reduction. Similarly, a long-run relationship was found to exist between information and communication technology usage (fixed telephone, mobile telephone and internet usage), foreign direct investment, development aid, primary school enrollment, real GDP per capita, remittances, and private domestic credit. Evidence of bidirectional causality was recorded between information and communication technology and real gross domestic product per capita. The study concluded that an increase in the usage of information and communication technology will lead to reduction in poverty levels in SSA.

In another study for SSA countries, Asongu (2021) examined the joint effects of mobile phone technology, knowledge creation and diffusion on inclusive human development in 49 sub-Saharan African (SSA) countries for the period 2000–2012. The study employed Tobit regressions and results show that the net effects of interactions between the mobile phone, knowledge creation and diffusion variables are positive indicating that the combined effects of these variables improve inclusive human development in SSA countries.

Evans (2019) examined the effect of internet usage on economic well-being for 45 SSA countries for the period 1995–2015 using panel fully modified least square (FMOLS) and panel dynamic ordinary least square (DOLS), and within a panel causality analysis. The panel FMOLS and panel DOLS analyses show that internet usage has a significant and positive effect on economic well-being. The panel causality analysis shows that there is bi-directional causality between internet usage and economic well-being in the short and long run, meaning that internet usage plays significant roles in increasing economic well-being, and economic well-being also plays significant roles in the expansion of internet usage both in the short and long run.

Subramaniam et. al. (2020) investigated the contribution of digitalization to poverty alleviation using a sample of 37 developing countries between 2014 and 2016. The study showed that digitalization does not benefit the extremely poor in the countries studied.

The second strand of literature examines studies that have identified various mechanisms through which digitalization translates into poverty reduction. In a study for SSA countries, Awad

(2022) identified the various mechanisms through which ICT could translate into poverty reduction. The study employed a sample of 37 economies in the Sub-Saharan Africa (SSA) region during the period 2003–2019. Income distribution, ecological system, employment rate, per capita income, and institutional quality were the assumed mechanisms through which ICT may reduce poverty. The results of the two-step system GMM technique showed that while an increase in the per capita income and employment rate contributed positively to poverty reduction, improvement in the environmental quality increased the poverty rate. Findings from the causal analysis showed that ICT strengthened the negative impact of environmental degradation on poverty. However, the strengthened positive impact of ICT on poverty through employment and per capita income was greater than the negative influence through the environmental mechanism.

Ofori et al. (2021) also examined the effectiveness of ICT diffusion and financial development in reducing the severity and intensity of poverty in Sub-Saharan Africa (SSA) from 1980–2019. ICT diffusion was disentangled into three measures, ICT usage, ICT access and ICT skills. The study employed the dynamic system GMM and the panel corrected standard errors estimation techniques. Findings showed that to show that for financial access, ICT skills is more significant in reducing both the severity and intensity of poverty than ICT usage and access. The results further revealed that, though ICT skills reduce poverty, the effect is more pronounced in the presence of enhanced financial development.

In another related study, Alimi and Okunade (2020) also analysed the role of financial inclusion and ICT diffusion on poverty reduction across 27 Sub-Sahara African countries for the period of 2004 to 2017, while employing the pooled mean group (PMG), mean group (MG), and dynamic fixed effect (DFE) estimators. Based on the result of the pooled mean group estimator, financial inclusion reduce poverty in the long run but it exerts no impact on poverty reduction in the short run. Similarly, ICT diffusion exert a significant reduction in poverty in the short run but has no impact on poverty reduction in the long run.

Mushtaq (2019) assessed the role of ICT in poverty & inequality reduction by fostering financial inclusion, using panel dataset of sixty-two countries between 2001 and 2012. The study established a positive association of ICT diffusion with financial inclusion and a negative relationship with poverty and inequality. It was also established that ICT dimensions when used as instruments for financial inclusion accelerate economic growth and reduce poverty & inequality.

Sassi and Goaied (2013) examined the effect of financial development and Information and Communication Technology (ICT) on economic growth. in some MENA countries by investigating the interaction between financial development and ICT Diffusion on economic growth. Based on the system GMM estimators, findings showed a negative direct effect of financial development on economic growth and a positive and significant direct effect of ICT proxies on economic growth. The interaction between ICT penetration and financial development also has a positive effect on economic growth in the selected countries.

In another study for SSA countries, Mensah et al (2021) investigated the impact of institutional investments on poverty reduction in sub-Saharan Africa using panel data from 2000-2018. The study employed fixed effect and quantile regression models to investigate the relationship between institutional investment and poverty reduction. The results revealed that investment in education contributes significantly to the fight against poverty in the sub- region as compared to health investment. Also, investment in the energy sector also contributes significantly to the fight against poverty in the sub-region, while investment in security has no significant effect on poverty reduction.

Wang et al. (2021) also analysed the impact of health expenditure on the poverty trap in Sub-Saharan Africa by employing the Autoregressive Distributed Lag model. Findings showed that health expenditure had no significant influence on the poverty trap in the long run. However, health expenditure was recorded to have a significant effect on poverty reduction in the short term. Lechman and Popowska (2022) also established that digital technologies contribute to poverty reduction, through different channels of impact, like education, labor market, income and ICT-trade related activities. Using the sample of 40 developing countries between 1990 and 2019, logistic growth model, and panel regression modelling techniques were employed. The study concluded that ICT deployment, school enrolments, and increases in material wealth are significant drivers of poverty alleviation in developing economies. However, the impact of digitalization on poverty is neither direct nor immediate.

Kwilinski et al (2020) evaluated the effect of digitalization on people at risk of poverty and social exclusion in the countries of the European Union. Digital economy and society index were used as indicators of digitalization while correlation analysis was applied for inferential statistical analysis. Findings revealed that countries with a higher digitalization level have a lower percentage of poverty and lower social exclusion risk.

3. Research Methodology

3.1 Data Description and Sources

The dataset underpinning this study spans from 2000 – 2020 for 45 SSA countries. The data employed include household final consumption per capita used as a measure of poverty, mobile cellular subscriptions, individuals using the internet, government expenditure on education, current health expenditure per capita, domestic credit to private sector by banks, GDP per capita growth rate and unemployment. Data was sourced from World Development Indicators (WDI, 2022). The list of countries includes Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo Democratic Republic, Congo Republic, Cote D'Ivoire, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia,

Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia.

3.2 Model Specification

The study hinges on the Neoclassical theory of poverty, which considers poverty-determining factors that are beyond an individual's control, especially in the presence of market failures. These include lack of social and private assets, market failures that exclude the poor from credit markets, barriers to education immigrant status, poor health and advanced age amongst others. The role of digitalization in this framework is a stimulant through technological progress which increases productivity, economic growth and subsequently reduces poverty. Digitalization accelerates economic growth and reduces poverty by fostering innovation process, development and adoption (Alimi et al., 2020). Following Alimi and Okunade (2020) as well as Ofori et al. (2021), the baseline models employed in the study is specified as follows:

For education:

$$POV_{it} = \beta_1 POV_{i,t-1} + \beta_2 EDU_{it} + \beta_3 DIGI_{it} + \beta_4 EDU * DIGI_{it} + \beta_5 GDP_{it} + \beta_6 UNEM_{it} + \mu_{it} \quad (1)$$

For health:

$$POV_{it} = \beta_1 POV_{i,t-1} + \beta_2 HEALTH_{it} + \beta_3 DIGI_{it} + \beta_4 HEALTH * DIGI_{it} + \beta_5 GDP_{it} + \beta_6 UNEM_{it} + \mu_{it} \quad (2)$$

For Financial access:

$$POV_{it} = \beta_1 POV_{i,t-1} + \beta_2 FIN_{it} + \beta_3 DIGI_{it} + \beta_4 FIN * DIGI_{it} + \beta_5 GDP_{it} + \beta_6 UNEM_{it} + \mu_{it} \quad (3)$$

Where POV represents poverty and is measured using household consumption expenditure per capita, EDU is education measures by government expenditure on education, DIGI is digitalization measured by internet users and mobile phone subscriptions, GDP is gross domestic product per capita, UNEM is unemployment rate, HEALTH is measured by current healthcare expenditure per capita, FIN is financial access measured by domestic credit to private sector by banks**.**

3.3 Estimation Procedure

The study employs the panel OLS, Fixed effects (FE) and system generalized method of moments (GMM) estimation methods. The panel OLS combines the subscript of time series (*t*) and cross-sectional unit (*i*) to accommodate the properties of both time series and cross-section data. The study

further applied the generalized method of moments model, which can be used for dynamic panel data developed by Arellano and Bond (1991) and Blundell and Bond (1998). In dynamic panel data, the cause-and-effect relationship for underlying phenomena is generally dynamic over time (Ullah et al., 2017). In an attempt to measure this, dynamic panel data estimation techniques leverage lags of the dependent variables as explanatory factors. Lagged values of the dependent variables are therefore used as instruments to control this endogenous relationship. The GMM model, which is generally used for panel data, provides consistent results in the presence of different sources of endogeneity, namely "unobserved heterogeneity, simultaneity and dynamic endogeneity" (Wintoki, Linck, & Netter, 2012).

GMM estimators can be created using two types of transformation methods: first-difference transformation (one-step GMM) and second-order transformation (two-step GMM). The first-difference transformation (one-step GMM) does, however, have significant drawbacks. If a variable's most recent value is absent, the first-difference transformation (which subtracts a variable's past value from its current value) may result in the loss of too many observations (Roodman, 2009). Arellano and Bover (1995) advocated using a second order transformation to avoid data loss due to the internal transformation problem with the first-step GMM (two-step GMM).

The second-order transformation (two-step GMM) uses 'forward orthogonal deviations,' which implies that instead of deducting previous data from the present value of a variable, the two-step GMM model subtracts the average of all future available observations (Roodman, 2009). A two-step GMM model delivers more efficient and consistent estimates for the involved coefficients in the case of a balanced panel dataset (Arellano & Bover, 1995).

The study employed, therefore, employed the Generalized Method of Moments (GMM) technique because the technique is applicable in cases where the number of countries studied (N) is greater than the years of observation (T) i.e. (N>T). Similarly, the technique controls for endogeneity of regressors. However, the system GMM estimator is preferred to the difference estimator due to its reliability and efficiency. The two-step system GMM estimates is also more robust to heteroskedasticity and panel-specific autocorrelation than the one-system GMM (Akinbode et al., 2020). Post-estimation diagnoses for the GMM framework will include the test for serial correlation, using the Arellano and Bond (1991) test as well as the Hansen tests for instrument validation.

The study used the forward orthogonal deviations instead of first differences adopted by Roodman (2009a, b) which is an extension of Arellano and Bover (1995). According to Love and Zicchino (2006) and Baltagi (2008), the estimation method can control for cross-country dependence and check over identification and control the proliferation of instruments. The two-step approach is employed in the specification since it controls for heteroskedasticity as against the one-step that is consistent with homoskedasticity.

4. Results and Findings

4.1 Analysis of Preliminary Statistics

The descriptive statistics of the panel datasets is presented in Table 2

Table 2: Descriptive Statistics

	Poverty	Mobile Subscription	Internet Users	Health	GDP	Education	Financial Access	Unemployment
Mean	1.857	14.264	1.558	3.963	1.741	3.962	18.864	-635.639
Median	1.699	14.811	1.705	3.764	2.033	3.371	13.472	4.307
Maximum	46.955	18.855	4.126	6.531	19.457	13.219	104.846	119.468
Minimum	-42.255	7.628	-3.658	2.075	-36.777	0.466	0.449	-44044.69

All variables exhibit positive mean values with the exception of unemployment. A negative mean value of -635.639 for unemployment shows the high rate of unemployment in the region. The average poverty value of $1.857 in terms of household consumption per capita indicates a high prevalence of poverty in the region. Financial access mean value of 18.86% shows that only a small percentage of people in the region have access to domestic credit from banks. Mobile subscription users tend to be higher than the number of individuals using the internet. Similarly, government expenditure on health and education are abysmally low given the mean values recorded.

Table 3: Correlation Matrix

	Poverty	mobile sub	internet	health	GDP	Education	Financial access	Unemployment
Poverty	1							
Mobile sub	-0.089	1						
Internet	0.019	0.291	1					
Health	0.141	0.054	0.668	1				
GDP	0.427	-0.035	0.019	0.082	1			
Education	0.117	-0.102	0.195	0.404	0.031	1		
Financial Access	0.060	-0.005	0.449	0.636	0.066	0.308	1	
Unemployment	-0.027	-0.121	-0.222	-0.369	-0.691	-0.031	-0.601	1

All variables exhibit negative correlation with poverty with the exception of mobile subscription and unemployment. However, the correlation coefficients imply weak correlation with poverty.

4.2. Results of Panel Regression

4.2.1 Baseline Pooled, Fixed and Random Effects Regression

This subsection reports the results of pooled OLS, panel fixed effects and panel random effects which controls for unobserved country characteristics. The Hausman test statistics presented in the table reveal the appropriateness of the panel fixed and random effects. Tables 4, 5 and 6 present result for the different determinants of poverty employed in the study as well as their interactive effects with digitalization.

Table 4: Effect of digitalization and education on poverty reduction

	Dependent Variable: Poverty					
	POLS		Fixed effect		Random Effect	
	Internet Use (Digital Use)	Mobile Sub (Digital Access)	Internet Use (Digital Use)	Mobile sub (Digital access)	Internet Use (Digital Use)	Mobile Subs (Digital access)
C	0.693(0.215)	-2.527(0.541)	0.904(0.398)	-3.162(0.545)	-0.693(0.221)	-2.527(0.548)
Internet	0.075(0.697)		0.189(0.423)		0.075(0.710)	
Mobile	-----	0.149(0.601)		0.272(0.452)		0.149(0.607)
Education	0.389(0.002)	1.389(0.116)	0.038(0.884)	1.647(0.138)	0.389(0.003)	1.389(0.122)
Education x internet	0.389(0.175)		-0.0117(0.015)		-0.005(0.181)	
Education x mobile		-0.077(0.21)		-0.114(0.132)		-0.077(0.218)
Unemployment	-1.84e-05(0.752)	-5.99e-06(0.914)	-2.57e-05(0.764)	1.70e-05(0.838)	-1.84e-05	-5.99e-06(0.916)
GDP	0.693(0.002)	0.635(0.002)	0.614(0.002)	0.626(0.003)	0.693(0.002)	0.635(0.003)
Adj R2	0.221	0.226	0.198	0.199	0.221	0.226
F stat	32.157***	33.250***	4.232(***)	4.276***	32.157***	33.250***
Hausman					0.161	0.718
Countries	45	45	45	45	45	45
Obs	549	552	549	552	549	552

From the table shown above, the Hausman test indicates the appropriateness of the random effect model as against the fixed effect model. The POLS results show that education and GDP have a positively significant relationship with poverty. As such, an increase in government spending on education by one percent will increase consumption per capita by 0.389 percent and subsequently reduce poverty by the same magnitude, as consumption per capita is used as a measure of poverty. Similarly, a percentage increase in GDP per capita increases consumption per capita and, therefore, decreases poverty by 0.693 percent. The model shows that digital use proxy by internet users has no effect on poverty reduction. For the second model, POLS result shows that digital access (mobile subscriptions) has no significant direct effect on poverty reduction in SSA. Similarly, digital access (mobile subscriptions) has no significant interacting relationship with education in poverty reduction. However, GDP per capita has a significantly negative relationship with poverty reduction, as an increase in GDP per capita by one percent increases consumption per capita by 0.635 percent and subsequently reduces poverty. The random effect results for digital use (internet use) and digital access (mobile subscriptions) corroborate POLS results.

Table 5: Effect of Digitalization and Health on Poverty Reduction

	Dependent Variable: Poverty					
	POLS		Fixed effect		Random Effect	
	Internet Use	Mobile Sub	Internet Use	Mobile sub	Internet Use	Mobile Subs
C	-3.441(0.002)	-1.281(0.235)	-1.594(0.659)	0.283(0.951)	-3.441(0.003)	-1.281(0.235)
Internet	-0.441(0.048)		-0.422(0.219)		-0.441(0.050)	
Mobile	-----	-0.264(0.165)		-0.545(0.272)		-0.263(0.165)
Health	1.364(0.002)	1.349(0.021)	0.888(0363)	0.109(0.951)	1.364(0.002)	
Health x internet	-0.007(0.186)		-0.006(0.307)		-0.007(0.191)	
Health x mobile		-0.037(0.217)		0.037(0.703)		-0.037(0.217)
Unemployment	1.58e-05(0.833)	5.05e-05(0.006)	1.64e-06(0.988)	4.33e-05(0.368)	-1.58e-05(0.835)	5.05e-05(0.006)
GDP	0.568(0.003)	0.547(0.004)	0.565(0.002)	0.552(0.002)	0.568(0.002)	0.547(0.002)
Adj R2	0.139	0.126	0.118	0.105	0.139	0.127
F stat	23.108***	20.762***	3.116(***)	2.872***	23.108***	20.671***
Hausman					0.922	0.623
Countries	45	45	45	45	45	45
obs	681	682	681	682	681	682

The table shown above reports the direct and indirect effect of digitalization and health on poverty reduction in SSA countries. For digital use (internet use), POLS results show that internet use exhibits positive influence on poverty reduction in SSA countries. A percentage increase in internet use reduces consumption per capita by 0.441 percent and subsequently increases poverty. Conversely, health expenditure and GDP exhibit a reducing effect on poverty, as a percentage increase in these variables increases consumption per capita by 1.364 and 0.568 percent, respectively. The POLS results for digital access (mobile subscriptions) also reveal that health expenditure, unemployment and GDP per capita have reducing effect on poverty. A percentage increase in these variables, increase consumption per capita by 1.349, 0.00005 and 0.547 percent, respectively. However, digital access is seen not to have direct or indirect effects on poverty reduction in SSA countries in this model. The random effect results corroborate the POLS findings.

Table 6: Effect of Digitalization and Financial Access on Poverty reduction

	Dependent Variable: Poverty					
	POLS		Fixed effect		Random Effect	
	Internet Use	Mobile Sub	Internet Use	Mobile sub	Internet Use	Mobile Subs
C	1.037(0.057)	6.655(0.080)	0.662(0.509)	7.021(0.116)	1.037(0.058)	-2.527(0.548)
Internet	-0.145(0.478)		-0.453(0.189)		-0.145(0.478)	
Mobile	-----	-0.396(0.105)		-0.420(0.219)		0.149(0.607)
Financial Access	0.016(0.446)	-0.115(0.366)		-0.119(0.430)	0.016(0.446)	
Financial access x internet	-0.003(0.386)		-0.009(0.096)		-0.003(0.386)	
Financial access x mobile		0.008(0.348)		0.008(0.370)		
Unemployment	-1.94e-05(0.614)	3.44e-05(0.545)	-4.38e-05(0.477)	6.51e-05(0.249)	-1.94e-05(0.614)	-5.99e-06(0.916)
GDP	0.579(0.002)	0.554(0.003)	0.579(0.001)	0.569(0.001)	0.578(0.002)	0.635(0.003)
Adj R2	0.131	0.226	0.133	0.123	0.131	0.226
F stat	20.993***	33.250***	3.478(***)	3.285***	20.993***	33.250***
Hausman					0.412	0.718
Countries	45	45	45	45	45	45
obs	659	552	659	667	549	552

For the relationship between digitalization and financial access, POLS estimate for digital use (internet users) show that digitalization has no direct or indirect effect on poverty reduction. However, the model shows a positive influence of GDP on consumption per capita. Therefore, an increase in GDP per capita by one percent will reduce poverty by 0.579 percent. For digital access (mobile subscriptions), only GDP has a significant relationship with consumption per capita. An increase in GDP per capita by one percent will increase consumption per capita by 0.554 percent, thereby reducing poverty. Random effect estimates also corroborate POLS results.

	Dependent Variable: Poverty					
	System GMM 1(Education)		System GMM 2(Health)		System GMM 3 (Financial access)	
	Internet Use	Mobile Sub	Internet Use	Mobile sub	Internet Use	Mobile Subs
Poverty(-1)	1.037(0.057)	0.968(0.002)	0.918(0.001)	0.706(0.01)	0.943(0.009)	0.986(0.008)
Mobile sub		-0.155(0.003)		-0.207(0.002)		-0.163(0.440)
Internet use	0.116(0.949)		-0.201(0.002)		-0.688(0.002)	
education	0.083(0.889)	5.285(0.002)				
health			-0.018(0.308)	12.065(0.002)		
Fianacial access					0.178(0.003)	-0.113(0.607)
mobile x education	-----	-0.367(0.001)				
Internet x education	-0.020(0.699)					
Mobile x health				-0.342(0.001)		
internet x health			-0.918(0.001)			
mobile x fianacial access						0.009(0.596)
Internet x financial access					-0.002(0.007)	
Unemployment	-3.61e-05(0.949)	-0.0002(0.433)	0.001(0.545)	-0.001 (0.784)	-9.76e-05(0.524)	0.001(0.469)
GDP	0.696 (0.001)	0.669(0.003)	0.584(0.001)	0.554(0.001)	0.627(0.004)	0.652(0.002)
Net effect	0.114	-0.151	-0.326	7.000	0.175	0.020
AR(1)	0.002	0.012	0.002	0.003	0.003	0.058
AR(2)	0.233	0.276	0.207	0.208	0.290	0.447
Hansen	0.822	0.838	0.141	0.358	0.685	0.643
Instruments	37	37	37	37	37	37
Countries	45	45	45	45	45	45
obs	438	442	600	594	581	588

For education, system GMM results show that digital use (internet use), education, unemployment as well as the interaction of digital use and education do not exert significant influence on poverty reduction. However, GDP has a significantly negative influence on poverty as a percentage increase in GDP per capita increases consumption per capita by 0.69 percent thereby reducing poverty by the same magnitude. Still for education, digital access (mobile subscription) and its interaction with education positively affects poverty. This reflects in the negative relationship between these variables and consumption per capita. An increase in mobile subscription as well as its interaction with education by one percent will increase poverty by 0.155 and 0.367 percent, respectively. Meanwhile, education and GDP per capita exert significant and negative effects on poverty. For health, GMM results show that digital use (internet use) has a significantly positive direct and interactive effect with poverty in SSA. An increase in internet access as well as its interaction with health by one percent is seen to reduce consumption per capita by 0,201 and 0.918 percent respectively, while an increase in GDP per capita by one percent will reduce poverty by 0.584 percent. Still for health, digital access (mobile subscriptions) as well as its interaction with health have significant and positive influence on poverty by reducing consumption per capita. An increase in these variables by one percent will increase poverty by 0.027 and 0.342 percent, respectively. Health consumption expenditure and GDP per capita have significant and negative effect on poverty as they are seen to increase consumption per capita. For financial access, the table shows that digital use (internet use) and its interaction with financial access have positive effects on poverty as they are seen to reduce consumption per capita. A percentage increase in these variables will reduce consumption expenditure per capita by 0.688 and 0.002 percent respectively. Financial access and GDP exert significant and negative effects on poverty as they increase consumption per capita. For digital access (mobile subscription) and financial access, digital access as well as its interactive term with financial access do not significantly affect poverty in SSA countries.

The main findings from this model emerge from the "net effect", which reveals the effect of digitalization on poverty reduction when the interactive variables of education, health and financial access are included. The net effect from the various regression models with interactive digitalization

variables is calculated as: $\frac{\%\Delta\ in\ poverty}{\%\Delta in\ digital*determinants} = \beta_2 + \beta_4 DIGI\beta_{it}$

The net effects are given as 0.114, -0.326, and 0.175 for education, health and financial access respectively when evaluated at an average digitalization use(internet use) index of 1.558. Similarly, for digital access (mobile subscription), the net effect are given as -0.151, 7.00 and 0.020 for education, health and financial access respectively when evaluated at an average digitalization access (mobile subscription) index of 14.811.

5. Discussion and Conclusion

The study examined the direct and complementary effect of digitalization on poverty reduction measures in education, health and financial access for 45 SSA countries between 2000 and 2020. Data was sourced from World Development Indicators (WDI) database. POLS, Fixed Effect, Random effects regression as well as the two-step system GMM estimation techniques were employed in the study. Results from the two-step GMM showed that for education, digital use in terms of internet access has no direct or indirect effect on poverty in SSA. This can be justified by the fact that most SSA countries have not embraced digital teaching facilities due to the high cost of internet and other digital infrastructure in the region. Similarly, internet coverage gaps exist, particularly in rural areas. However, digital access measured by mobile subscription has a direct and indirect relationship with poverty. The relationship is positive for both sides, meaning that mobile subscription increases poverty in SSA countries. This largely owes to the high cost of mobile phones, particularly for people with lower income. The cost of using a mobile phone is about 5% of personal income in most SSA countries (GSMA report, 2015). For the health channel, internet use and mobile subscriptions directly and indirectly increases poverty in SSA. The same findings relate to the financial access channel of poverty reduction. All these findings show that digitalization has not contributed positively to poverty reduction in SSA countries. This owes largely to issues of affordability and lack of infrastructure that support digitalization, such as electricity. The study concludes that digitalization could only offer an opportunity for poverty reduction in SSA countries but is not a panacea for poverty reduction. The study, therefore, recommends that digital services should be provided at lower cost and that infrastructures supporting the use of digital services be made readily available in SSA countries.

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