The Digital Divide in Developing Countries[1]

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Abstract

Poverty has been a critical issue for a long time and continues to affect developing countries in the era of booming digitalization. This study investigates the contribution of digitalization to poverty alleviation, confirming that it can promote economic growth. However, utilizing a sample of 37 developing countries in 2014 and 2016, this study observes that the extremely poor are deprived of their share of the benefits that digitalization can offer. Therefore, while strategies to further promote digitalization are critical to economic development, support systems or policies meant to bring those in extreme poverty into mainstream development are badly needed.

Key words: digitalization; poverty; developing countries

Introduction

At the moment, digital transformation is a significant trend, with almost all sectors experiencing transition.[2] Digital transformation is particularly crucial to the shift from the first industrial revolution to the recent fourth industrial revolution [Schwab, 2016]. In summary, the first industrial revolution focused on water and steam power to mechanize production, followed by the electric power-based second revolution and later by the electronic and information technology-based third revolution in the middle of the last century. Building on the third industrial revolu-

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[1] The editorial board received the article in August 2020.

[2] The most basic definition of digitalization refers to the use of digital technologies to generate income, value-producing opportunities, improve business processes and create a digital business environment [Rachinger et al., 2019]. Therefore, digitalization is the fundamental aspect of the digital transformation because it can affect society in terms of employment, incomes, inequality and health resource efficiency and eventually build a better future. Relatively close to digitalization, digitization refers to the transformation of analog to digital. For instance, Cisco has described digitization as the link between individuals, processes, information and data that provides information and knowledge that improves business outcomes [Schallmo, Williams, 2018].

tion, the fourth industrial revolution has emerged and is exponentially expanding. According to K. Schwab [2016], the fourth industrial revolution is characterized by a fusion of technologies that is blurring the line between the physical, digital and biological spheres, while disrupting almost every industry in every country.

This ongoing wave of digitalization is theoretically predicted to improve socio-economic status across countries, connecting people with services and jobs and building a better future. The use of digitally connected technologies, including the Internet, cloud computing, big data and fintech, by enterprises, government and consumers for digital storage, analysis and sharing of information promotes economic growth, productivity, innovation and employment. The World Bank [n. d., a] states that digital development components are now fully implemented across sectors such as transport, education, health, agriculture and public sector management and that activities across the sectors focus on five key elements: (a) digital infrastructure, (b) digital innovation and entrepreneurship, (c) digital financial services, (d) digital platform, digital literacy and skills. A combination of these five key elements helps to build strong and inclusive digital economies and ultimately results in successful digitalization. The e-agriculture project in Côte d'Ivoire, for example, made a significant contribution to increasing productivity for smallholder farmers and made it easier to disseminate essential information such as real-time crop prices [WB, n. d., a]. Digitalization in Myanmar helps the government to create the right regulatory environment and attract foreign investments, while creating jobs and improving the local IT industry. In addition, digitalization growth in Bangladesh is on the way to providing 30,000 or more jobs for Bangladeshi youth, increasing industry revenue by $200 million and making Bangladesh more competitive [WB, n. d., a].

According to António Guterres, the United Nations (UN) secretary-general, digitalization will support and facilitate the efforts to achieve the UN Sustainable Development Goals (SDGs) by 2030 [ITU, 2019]. The view is that the SGDs, with 17 pillars addressing issues of poverty, energy, environment, science and technology, partnership and urbanization, can be achieved partly and much faster through the adoption and implementation of digital technologies. This is because emerging technologies such as big data, artificial intelligence, robotics, blockchain, Internet of Things (IoT) and additive manufacturing can change all dimensions of global economies and societies, thereby promoting progress toward the achievement of the SDGs [Ibid.]. Industry 4.0 is defined as a new technology that manages and optimizes all aspects of manufacturing processes and supply chains and has the potential to drive improvement in fields ranging from education, public services, healthcare, infrastructure and energy [Morrar, Arman, Mousa, 2017; Nagy, 2018]. Returning to Schwab [2016], it is defined as how technologies like artificial intelligence, autonomous vehicles and the IoT are merging with humans' physical lives. More importantly, technological changes are exponentially taking place and altering the way individuals, firms and governments work. Eventually, this is expected to lead to a societal transformation similar to previous industrial revolutions. Although the implication of Industry 4.0 is mainly on the level of industrialization itself, Industry 4.0 also appears to have reduced the barrier of developing countries to innovation, giving every country the opportunity to improve the quality of life, eventually reducing inequality. Moreover, in line with the fourth SDG to provide equal and accessible quality education and foster opportunities for all for life-long learning, the digital education revolution (DER) will significantly improve global access to quality education. The DER is an initiative to change teaching and learning, to prepare students and to work in a digital environment, especially for schools in Australia [ANAO Audit Report, 2011].

While digitalization has made remarkable progress, developing countries are not currently on track to end extreme poverty. For example, although the share of the population living in extreme poverty decreased from 16% in 2010 to 10% in 2015, the pace of poverty reduction is

decelerating [UN DESA et al., 2019]. Meanwhile, the United Nations [2018] has estimated that 6% of the world's population will remain in extreme poverty by 2030. Poverty across South Asia has decreased, largely driven by strong economic growth and relative macroeconomic stability, but it remains the region with the largest proportion of poor people [UN, 2019]. Over 35% of the population in South Asia, calculated against their respective national poverty lines, lives in poverty in Bangladesh and Pakistan [UN DESA et al., 2019]. As shown in Fig. 1, more than half of the world's extremely poor live in Sub-Saharan Africa, followed by South Asia, East Asia and the Pacific, Europe and Central Asia, Latin America and the Caribbean, and the Middle East and North Africa. In East Asia and the Pacific, it is estimated that more than 100 million people are living on $1.90, $3.20 and $5.50 a day [Ibid.]. As the numbers of people living in poverty persist in all regions, the first pillar of the SDGs, which is to end poverty, has been a prolonged failure. This study specifically investigates whether digitalization is a curse or blessing to developing countries in regard to poverty alleviation.
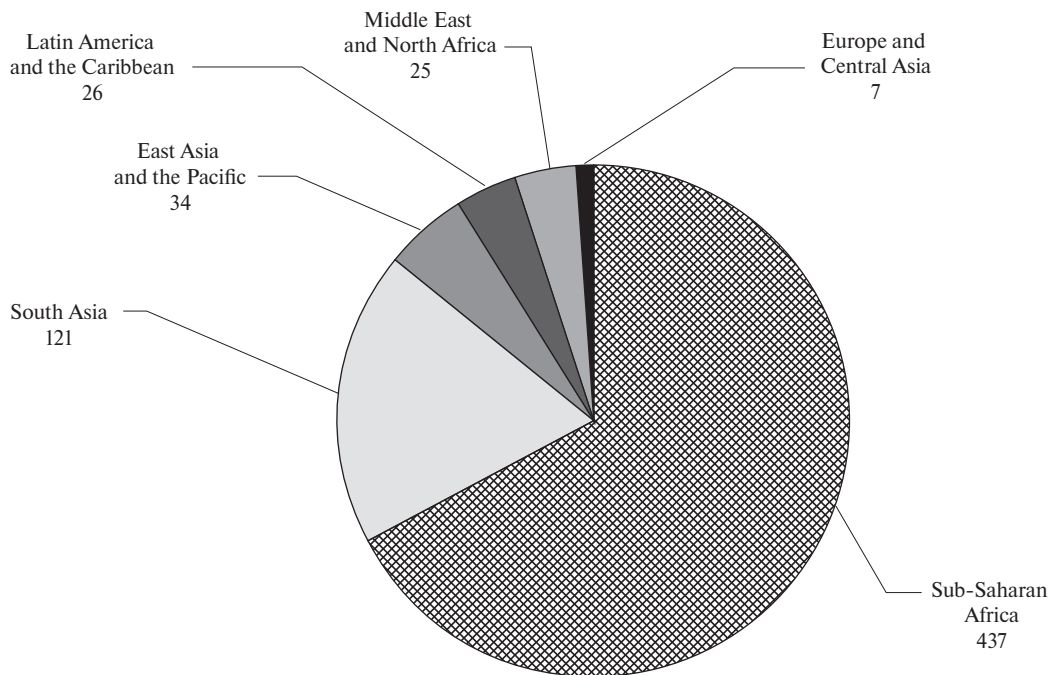

Fig. 1. Total Population Living in Extreme Poverty in 2018 (Millions)

Source: [WB, n. d., c].

Literature Review

The relationship between income, remittance, inflation, income inequality and poverty has been thoroughly investigated in past studies. Among crucial factors of poverty are income [Adams, 1991; Adams, Page, 2005; Batabyal, Chowdhury, 2015; Bugamelli, Paterno, 2009; Gupta, Pattillo, Wagh, 2009; Kalwij, Verschoor, 2007; Kuznets, 1955; Pasinetti, 1962; Shahbaz, 2010; Tiwari, Shahbaz, Islam, 2013], remittances [Adams, Cuecuecha, 2013; Adams, Page, 2005; Akobeng, 2016; Bang, Mitra, Wunnava, 2016; Barham, Boucher, 1998; Imai, Gaiha, Kaicker, 2014; Masron, Subramaniam, 2018; Milanovic, 1987; Shen, Docquier, Rapoport, 2010; Stark

and Taylor, 1989; Taylor, 1992], inflation [Akobeng, 2016; Alam, Paramati, 2016; Cardoso, 1992; Meo et al., 2018; Ravallion, 2001; Sehrawat, Giri, 2015; Seven, Coskun, 2016] and income inequality [Adams, 2004; Hazlewood, 1978; Leow, Tan, 2019; Neaime, Gaysset, 2018; Ravallion, 1997; Sehrawat, Giri, 2018].

The impact of income, which is reflected in the inverted U-shaped Kuznets theory on poverty, is a matter of great concern in past studies.[3] R.H. Adams [1991], R.H. Adams and J. Page [2005], S. Batabyal and A. Chowdhury [2015], M. Bugamelli and F. Paterno [2009], S. Gupta, C.A. Pattillo and S. Wagh [2009], A. Kalwij and A. Verschoor [2007], M. Shahbaz [2010], and A.K. Tiwari, M. Shahbaz and F. Islam [2013] find that higher growth means a greater reduction in poverty, so income plays a strong role in reducing the rate of poverty. The link between economic growth and poverty operates through two channels. First, there is the link whereby economic growth increases the income of the poor and therefore, increases their ability to pay for activities and goods that can improve their health and education. More spending or investment in health and education is also strongly associated with improvement in the standard of living. High economic growth also means a substantial increase in jobs and incomes for the poor, thereby helping to reduce the income gap and disparity between the rich and the poor. Ultimately, it helps reduce the incidence of poverty.

Remittances currently constitute the highest inflows of capital to developing countries, surpassing foreign direct investment and official aid [WB, n. d., c]. Given the volume of the inflows, remittances can also be considered as another crucial factor to accelerate the reduction of poverty in recipient countries. R.H. Adams and A. Cuecuecha [2013], Adams and Page [2005], E. Akobeng [2016], J.T. Bang, A. Mitra and P.V. Wunnava [2016], B. Barham and S. Boucher [1998], K.S. Imai, R. Gaiha and N. Kaicher [2014], T. A. Masron and Y. Subramaniam [2018], B. Milanovic [1987], I.L. Shen, Docquier and H. Rapoport [2010], O. Stark et al. [1989] and J.E. Taylor [1992] show that remittances can contribute to a reduction in the level of poverty. For instance, Adams and Cuecuecha [2013] show the probability that poor households in Ghana will fall by 17% and 97%, respectively, with internal and international remittances. Likewise, Gupta, Pattillo and Wagh [2009] study the effect of remittances on poverty in a sample consisting of 24 Sub-Saharan African countries and conclude that a 10% increase in the flow of remittances is associated with a 1% reduction in poverty. Among possible explanations is that an increase in the flow of remittances raises household incomes, allows households to acquire more assets and engage in business activity, which in turn improves the standard of living and reduces poverty. To the contrary, A. de la Fuente [2010], based on a study of Mexico, suggests that the share of remittance is not associated with reducing poverty due to the absenteeism of remittance flows to the most vulnerable households in a rural area.

Meanwhile, loss of the purchasing power of money can have huge implications for the poor, and one of the main sources of reduction in purchasing power is rapid inflation. Inflation can increase transaction costs, inhibit entrepreneurship and investment and impede economic growth, resulting in an increase in the poverty level. Akobeng [2016], E. Cardoso [1992], M. Chani et al. [2011], T.T. Chaudhry and A. Chaudhry [2008], T. Fujii [2013] and M. Meo et al. [2018] support the hypothesis that an increase in inflation raises the level of poverty. Moreover, M.S. Alam and S.R. Paramati [2016], M. Sehrawat and A.K. Giri [2015] and U. Seven and Y. Coskun [2016] report that inflation erodes cash holding values and reduces people's real incomes, which then widens the gap between the rich and the poor. Subsequently, high inflation may push the poor into the poverty trap.

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[3] Income inequality and poverty are slightly different. However, changes in the poverty level will certainly change income inequality and therefore, it is valid to replace income inequality with poverty. This conclusion is made despite the fact that the reverse causality, that is, that improvement in income inequality will also lead to reduction in poverty levels, may not necessarily be true.

There are studies that highlight the impact of income inequality on poverty, namely Adams [2004], A.K. Fosu [2015], A. Hazlewood [1978], House and Kellick [1981], H. Khemili and M. Belloumi [2018], K.W. Leow and E.C. Tan [2019], S. Neaime and I. Gaysset [2018], M. Ravallion [1997], M. Sehrawat and A.K. Giri [2018] and B. van Leeuwen and P. Földvári [2016]. These studies have typically produced homogenous findings of worsening poverty levels due to uneven income distribution. The uneven distribution of income creates fewer opportunities and resources for poor people to raise their standard of living, increasing poverty. Thus, the more unequal the income distribution, the worse off will be the poor.[4]

Digitalization has undergone rapid development and its applications have been in almost every sector and aspect of the economy. Digitalization has made the biggest contribution in terms of cost minimization and therefore has become vital for firms' survival and profitability as well as national productivity and income. L. Becchetti, D.A.L. Bedoya and L. Paganetto [2003], L. Becchetti and S.D. Giacomo [2007], I. Bertschek, D. Cerquera and G.J. Klein [2013], Š. Bojnec and L. Fertő [2012], F. Bollou and O. Ngwenyama [2008], A. Chatterjee [2020], S. Dewan and K.L. Kraemer [2000], H. Ishida [2015], M. Lio and M.C. Liu [2006], E.H. Nasab and M. Aghaei [2009], R.P. Pradhan, M.B. Arvin and N.R. Norman [2015], and R.P. Pradhan et al. [2018] argue that economic growth will accompany improvement in digitalization. Enhanced information and communication technologies (ICTs) will contribute to economic growth by improving productivity, reducing transaction costs, growing trade, generating innovation and development and rising employment and demand. For instance, G. Myovella, M. Karacuka and J. Haucap [2020] observe the positive contribution of digitalization on the economic growth of Organisation for Economic Co-operation and Development (OECD) countries but see a limited effect in the case of Sub-Saharan African countries. The general conclusion can be drawn from Myovella, Karacuka and Haucap [2020] that a country with limited digitalization progress may suffer deindustrialization or slow progression toward industrialization. Further, the use of technology can play a significant role in generating human and social development in terms of education, healthcare and access to modern infrastructures [Alderete, 2017; Assar, el Amrani, Watson, 2010; Gholami et al., 2010; Gudmundsdóttir, 2010; Katz et al., 2009; Koutroumpis, 2009; Spiezia, 2010]. The greater the access to technology, the greater the opportunities to gain higher learning, technical development, expertise and skills, thereby generating new jobs, increasing productivity and enhancing an equal distribution of income. Similarly, individuals without digital technology or only limited access may be left behind relative to those who are digitally knowledgeable and skilled. In fact, digitalization can be a critical factor in improving the quality of life and the future of individuals as well as poor countries.

Nevertheless, even if technology is becoming increasingly affordable and ubiquitous, it may not be helpful in creating economic opportunities for impoverished population groups.[5] Although the number of people living in extreme poverty has fallen, too many still struggle to meet their fundamental human needs. This may be due to the presence of the so-called digital divide, reflecting the fact that rich and educated people have better access to digital resources than poor people and seize most of the opportunities. The digital divide is, according to Wilson [2006], a state of inequality in access, distribution and use of information and communication technology among two or more populations. However, very few studies have explored the issue of the digital divide, with exception of studies such as those by B.E. Akanbi and C.O. Akanbi

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[4] Theoretically, we also believe that income inequality will bring dissatisfaction and potentially discourage productivity among the poor as they have a tendency to be deprived of opportunities which can allow them to escape from poverty. Income inequality may also refer to inequalities such as uneven distributions of electricity, infrastructure and education.

[5] The poor are deprived of opportunities due to lack of income, knowledge and economic ideas. Therefore, the strategies to assist them should be comprehensive and go beyond purely monetary assistance.

[2012] and K. Venkat [2001]. Venkat [2001], looking globally, and Akanbi and Akanbi [2012], looking at Nigeria, argue that high technology is irrelevant in combating poverty. In light of the inequality in access to digital technology, the consequences are that the technological gap is widening, people are not being lifted from poverty and fewer economic opportunities are available for the poor. This raises questions about the existence of the digital divide and its impact on poverty in developing countries. This study contributes to the literature by analyzing the effect of digitalization on poverty empirically, and also by using a developing country in the sample.

Empirical Model and Data

This study develops an empirical model that is consistent with the literature on the factors affecting poverty. It takes the following form:

$$POV = f(GDP, REM, INF, GINI), \qquad (1)$$

POV represents poverty and is a function of four variables: income per capita (*GDPC*), remittances (*REM*), inflation (*INF*) and income inequality (*GINI*). To examine the objective of this study, we include digitalization (*DIG*) in our model. Thereby *Eq.* (1) can be extended as follows:

$$POV = f(GDPC, REM, INF, GINI, DIG). \qquad (2)$$

The estimation model is transformed into logarithmic form and the econometric model can be expressed as follows:

$$LPOV_{it} = \alpha_0 + \alpha_1 LGDPC_{it} + \alpha_2 LREM_{it} + \alpha_3 LINF_{it} + \alpha_4 LGINI_{it} + \alpha_5 LDIG_{it} + \varepsilon_{it}. \qquad (3)$$

The prefix "ln" represents the natural logarithm, ε_{it} is the error term, $i = 1, ..., 35$ and $t = 2014$ and 2016 indicate the country and time, respectively. Accordingly, α_1 and α_2 are expected to be negative since higher economic growth and remittance flow tends to reduce the rate of poverty. The expected signs of α_3 and α_4 are positive, where an increase in inflation and inequality will result in a reduction in the standard of living and thereby increase the incidence of poverty. Finally, thesign corresponding to α_5 is expected to be negative if the technology gap is minimal or zero.

In this study, the two-stage least squares (2SLS) technique is used to cushion for a possible endogeneity problem. The 2SLS estimator is more precise and consistent than the ordinary least square (OLS) estimator because it is unbiased. This is because the OLS specification relies on the assumption that there is a zero correlation between ε and all of the explanatory variables. In other words, any time-invariant country-specific effect that affects poverty is not correlated with the explanatory variables. There are three conditions for the 2SLS estimator to work properly and provide results superior to the OLS. The first is that there must be at least as many instruments as potentially endogenous variables and preferably one extra. Having the same number of instruments as potentially endogenous variables is a necessary condition for model identification, but including at least one additional instrument makes it possible to perform an additional diagnostic test that is an important indicator of instrument validity. Second, the instrumental variable or variables must be strongly correlated with the potentially endogenous explanatory variable. Thereby, an F-test is performed of the null hypothesis that the coefficients on the instruments are jointly equal to zero in each of the first stage regressions. First-stage F-tests should be systematically reported whenever 2SLS is used. The last condition is that the instruments must be validly excludable from the second-stage regression, in the sense that they do not influence the dependent variable other than through the potentially endogenous variable.

Data

Data are collected for the period 2014 and 2016. The sample countries and the study period are selected on the basis of data availability. The sample countries are divided into six groups: (1) **Sub-Saharan Africa** (Angola, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Sudan, South Africa and Tanzania); (2) **Latin America and the Caribbean** (represented by Argentina, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru and Uruguay); (3) **Europe and Central Asia** (represented by Belarus, Bulgaria, Kazakhstan, Romania, the Russian Federation, Serbia, Turkey and Ukraine); (4) **East Asia and Pacific** (represented by Cambodia, China, Indonesia, Philippines, Korea and Thailand); (5) **Middle East and North Africa** (represented by Egypt and Israel) and (5) **South Asia** (India and Pakistan). The present study used various data sources to obtain the datasets on dependent and independent variables to developing countries as summarized in Table 1.

Table 1. List of Variables, Descriptions and Sources

Variable	Measurement		Source
Poverty (POV)	i.	Number of poor at $1.90 a day (2011 PPP)	World Bank [n. d., b]
	ii.	Number of poor at $3.20 a day (2011 PPP)	
	iii.	Number of poor at $5.50 a day (2011 PPP)	
Income (GDPC)	GDP per capita		
Income Inequality (GINI)	Gini index		
Remittances (REM)	Personal remittances		
Digitalization (DIG)	Digital Adoption Index		
Inflation (INF)	Change in consumer price index		

Results and Discussion

The summary of the variables employed in this study is presented in Table 2. As easily understood, the gap among the poor within $5.50 per day is the highest, followed by $3.30 per day and the lowest of $1.90 per day. In other words, there is a huge disparity among the poor as well as among countries. Regarding the DIG, some countries have a high level of achievement in digital adoption given the highest score is 0.74. Nevertheless, countries are lagging far behind with a minimum score of 0.38. On average, developing countries are relatively unsuccessful in implementing digital technology as the sample average is only 0.56, just barely above the average as the perfect implementation is set to be at 1.

For the correlation analysis, there is impressive preliminary evidence of a GDPC-DIG nexus from Table 3. High correlation may be translated into high GDPC if DIG is successfully developed. Overall, there is no serious multicollinearity issue as the highest correlation coefficient is represented by GDPC-DIG.

Moving on to the regression results using 2SLS, which are shown in Table 4, all explanatory variables are statistically significant determinants of poverty, and the signs correspond to previous studies. Prior to that, the model stability tests show that the residuals are normally distributed, indicating that the model is correctly modeled and reliable. Regarding the relation-

ship between the variables, the findings indicate that economic growth has a negative and statistically significant effect on poverty. For example, the magnitude of the coefficients of 0.6226, 0.3123 and 0.4034 imply that a 1% increase in the GDPC reduces the level of poverty at $1.90, $3.20 and $5.50 a day by 0.62%, 0.31% and 0.40%, respectively. Hence, economic growth is seen to be the key cause of decelerating poverty or even raising living standards for people. This finding offers a general observation that higher income alone does not offer any assistance to the poor. Inappropriate and unfavourable development strategies, while they may improve the country's income, deprive the poor of similar opportunities and enjoyment.

Table 2. Descriptive Statistics

	Mean	**Std. Dev.**	**Min**	**Max**
POV_1.90	2.00	1.17	0.05	10.85
POV_3.20	3.00	2.99	0.05	13.10
POV_5.50	8.28	7.57	0.10	28.80
GDPC	7.04	3.03	1.15	1.39
GINI	38.87	7.75	19.85	51.25
DIG	0.56	0.09	0.38	0.74
REM	3.59	4.59	0.08	18.65

Note: All poverty indicators are in millions, GDPC is in thousands.

Table 3. Correlation Analysis

	LPOV_1.90	*LPOV_3.20*	*LPOV_5.50*	*LGDPC*	*LGINI*	*LDIG*	*LREM*
LPOV_1.90	1.00						
LPOV_3.20	0.77	1.00					
LPOV_5.50	0.51	0.93	1.00				
LGDPC	−0.3	−0.53	−0.56	1.00			
LGINI	0.35	0.27	0.2	0.00	1.00		
LDIG	0.24	0.61	0.67	0.80	0.00	1.00	
LREM	0.46	0.48	0.43	−0.61	0.11	−0.44	1.00

Regarding remittance flows, the result implies that remittance significantly causes changes in poverty at 1 and 5%. Effectively, a 1% increase in the inflow of remittances leads to a reduction in poverty by around 0.04% to 0.16%. This finding is somewhat consistent with those of Adams and Cuecuecha [2013], Adams and Page [2005], Akobeng [2016], Bang, Mitra and Wunnava [2016], Barham and Boucher [1998], Imai et al. [2014], Masron and Subramaniam [2018] and Shen, Docquier and Rapoport [2010]. This empirical evidence tends to show that remittances flows may be viewed as a way to reduce levels of poverty among poor people in developing countries because remittances earnings increase economic opportunities such as investment, spending, jobs and saving, and transform poor peoples' lives for the better.

The results for the effect of inflation on the various levels of poor, namely at $1.90, $3.20 and $5.50 a day seem to be similar in terms of sign and significant level. As expected, inflation has a positive and significant impact on poverty, implying that inflation will worsen poverty of all types. Inflation will reduce the purchasing power of the limited amounts of money earned by the poor. A similar conclusion has been documented in Akobeng [2016], Chani et al. [2011],

Chaudhry and Chaudhry [2008], Fujii [2013] and Meo et al. [2018], who find that that inflation reduces people's buying power and lowers real incomes, leading to a growing number of individuals falling below the poverty line.

Table 4. Regression Analysis I − Full Sample

	DV = LPOV_ $1.90 a day	*DV = LPOV_ $3.20 a day*	*DV = LPOV_ $5.50a day*
C	12.7724*** [2.58]	15.7335*** [2.60]	7.1685*** [4.26]
LGDPC	−0.6226* [−1.82]	−0.3123** [−2.27]	−0.4034*** [−2.39]
LREM	−0.1548** [−2.16]	−0.0366* [−1.94]	−0.1649** [−2.29]
LINF	0.1416* [1.93]	0.0335* [2.18]	0.0251** [2.20]
LGINI	1.4805*** [4.37]	2.5642*** [6.22]	3.0066*** [4.22]
LDIG	1.4656* [1.97]	−3.2663* [−1.92]	−2.3357*** [−4.48]
	Model Criteria		
Adj-R²	0.8157	0.7613	0.6872
F-stat	15.94*** (0.00)	15.31*** (0.00)	11.43 (0.00)
Normality	0.83 (0.56)	1.49 (0.15)	2.08 (0.60)

Note: Asterisks *, ** and*** denote 10%, 5% and 1% level of significance, respectively. Figures in [ ] stand for *t-statistic* and in () denote *p-value*. Normality test is based on Jarque-Bera test.

For income inequality, the results clearly show that the impact of income inequality is statistically significant for all three levels of poverty. Increasing inequality increases financial instability and reduces the likelihood that economic and social policies will foster human and economic development. This finding corroborates the results reported in recent studies by Fosu [2015], Khemili and Belloumi [2018], Leow and Tan [2019], Neaime and Gaysset [2018], Sehrawat and Giri [2018] and van Leeuwen and Földvári [2016]. This is because a more inequitable income distribution offers the poor fewer opportunities or ways of improving their living standards, highlighting the critical issue that strategies to increase incomes may only benefit the middle-class upward and not the poor. Even if the strategies effectively lower income inequality, in the absence of appropriate pro-poor strategies they may be just another development process that leaves the poor even poorer.[6] Therefore, an increase in poverty is usually associated with a rise in income inequality.

Considering the role of digitalization, the results for the level of poor living on $1.90 a day are very dissimilar to those for the level of poor living $3.20 and $5.50 a day. Changes in digitalization have a positive and significant impact on the poverty level of $1.90 for the poor,

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[6] This is in one way associated with inflation. Higher income earned by the rich will allow them to demand more, pushing prices up and reducing critically the real value of money owned by the poor. Inflation will affect the rich only marginally. In the extreme case, where the middle class is also excluded from the strategies, income inequality may rise as some middle-class people may fall into poverty.

which implies that digitalization cannot lift the extremely poor from poverty. This finding is compatible with Venkat's global study [2001] and Akanbi and Akanbi's study on Nigeria [2012]. The poor who live on less than $1.90 a day are unable to meet basic needs, job capabilities or education requirements, have limited access to economic and social infrastructure and therefore no exposure to technology and digital connectivity.[7] According to A. Armbrecht [2016], more than four billion people still do not have Internet access, mostly in developing countries, which means over half of the world's people are missing out on the life-changing benefits of digitalization. Thus, digitalization does not significantly impact a country's ability to end poverty, which is becoming an increasingly important priority for developing countries. While digitalization is not a solution for people living in extreme poverty, the advantages of digitalization do benefit the poor in developing countries, especially those living on $3.20 and $5.50 a day. Digitalization will speed poverty reduction as new job and market opportunities grow, improve access to education and better health care and promote the widespread use of new technologies of communication and manufacturing. High Internet use, mobile applications and drones and satellites make communication and information transmission easier and improve the capacity of poor people to raise their income and participate in community development. For instance, in 2007, the Food and Agriculture Organization (FAO) launched a practice e-farming as a platform for people from around the world to exchange information, ideas and resources on the use of technology for sustainable agriculture and rural development in order to improve the livelihoods of poor individuals and communities in rural areas. Therefore, digital innovation and the use of technology create enormous opportunities and reduce the obstacles and challenges to ending poverty, especially for poor people living on $3.20 and $5.50 a day.

Even still, as digitalization offers ways to lift people who live on $3.20 and $5.50 a day out of poverty, there still exists a digital divide. Poor people with higher incomes are more likely to have better access to digital resources than poor people living in extreme poverty. Limited access to technology restricts digital skills, socio-economic development and education and thus perpetuates poverty among the extremely poor. Inadequate access to technology, according to M. Madden et al. [2012], will prevent children from gaining and strengthening the digital skills that are vital to the economy today in low-income school districts. Hence, the rapidly increasing disparities in technology use and accessibility among the poor widen not just the digital gap, but also widen the poverty and socio-economic disparities of the poor in developing countries. Digitization is a curse for poor people living on $1.90 a day, while likely a blessing for the poor living on $3.20 and $5.50 a day.

Given the above discussion, this study also looks at whether the findings are sensitive to the income inequality variable. As poverty is merely the other side of the coin, a similar effect of digitalization on income inequality is expected given the neglected extremely poor in the countries. At this stage, the analysis shows that digitalization continues to deepen the digital divide and is unsuccessful in bringing poverty reductions to developing countries as shown in Table 5. Therefore, advances in digital connectivity and technology offer unparalleled opportunities and incentives to improve poor people's living conditions, affecting income inequality positively.

Additionally, a robustness check is performed by estimating the model for each period, namely 2014 and 2016 (see Table 6) as well as adding regional-dummies (see Table 7). Table 6 presents the estimation results for the individual time period. The results given in Table 6 clearly illustrate that estimates are close to those reported in Table 5. The estimated coefficient of income, remittances, income inequality and inflation are similar across panels. More specifically, the evidence from the entire panel reveals that the coefficient of digitalization in the level

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[7] This may be worsened by the fact that most poor people live in areas where an Internet connection is either inadequate or completely absent.

of poverty at \$1.90 is positive and statistically significant. By contrast, digitalization is found to affect negatively and significantly the level of poverty at \$3.20 and \$5.50. Thus, the results show that the digital divide does exist and is worsening poverty among the extremely poor.

Table 5. Regression Analysis II − Full Sample

	DV = LGINI
C	6.7951[11.80]***
LGDPC	0.1810[2.18]**
LGDPC²	−1.0513[−2.27]***
LREM	−0.0344[−1.84]*
LINF	0.0706[−1.79]*
LDIG	0.0489[2.12]**
	Model Criteria
Adj-R²	0.8840
F-statistic	44.40(0.00)***
Normality	0.11(0.85)

Note: Asterisks *, ** and*** denotes 10%, 5% and 1% level of significance, respectively. Figures in [ ] stand for *t-statistic* and in () denote *p-value*. Normality test is based on Jarque-Bera test.

Table 6. Regression Analysis for Individual Periods

	DV = LGINI		**DV = LPOV_ \$1.90 a day**		**DV = LPOV_ \$3.20 a day**		**DV = LPOV_ \$5.50a day**	
	2014	2016	2014	2016	2014	2016	2014	2016
C	5.3072*** [7.92]	6.7560*** [3.98]	0.6616** [2.11]	4.9147*** [2.73]	6.6416*** [8.12]	13.2410*** [2.94]	4.2684*** [8.77]	7.1722*** [5.16]
LGDPC	0.0681** [2.10]	0.1774** [2.23]	−1.0581*** [−2.41]	−0.6382* [−1.84]	−0.5156** [−2.11]	−0.0152* [−2.03]	−0.6030** [−2.37]	−0.0895** [−2.18]
LGDPC²	−0.5227*** [−3.20]	−1.0768** [−2.35]	−	−	−	−	−	−
LREM	−0.0251* [−1.83]	−0.05368 [−1.92]	−0.2178** [−2.14]	−0.0905*** [−2.68]	−0.1239* [−1.94]	−0.1908** [−2.29]	−0.0392** [−2.22]	−0.1562** [−2.27]
LINF	0.0447* [1.96]	0.0124** [2.24]	0.6641** [2.10]	0.100*** [2.50]	0.0417** [2.31]	0.1901* [1.87]	0.0354*** [3.28]	0.1702* [1.87]
LGINI	−	−	2.6486*** [2.98]	2.5515*** [3.36]	2.8526*** [3.53]	3.0352*** [4.01]	2.8444*** [4.22]	2.0983*** [3.16]
LDIG	0.0779** [2.20]	0.04805** [2.11]	0.0700 [1.36]	0.8979* [1.81]	−2.3107* [1.90]	−3.4263* [−1.81]	−1.1485** [−2.18]	−2.5677*** [−2.51]
	Model Criteria							
Adj-R²	0.7980	0.9069	0.6588	0.6929	0.6886	0.6865	0.6305	0.6265
F-stat	24.47*** (0.00)	39.94*** (0.00)	54.06*** (0.00)	63.17*** (0.00)	72.97*** (0.00)	74.44*** (0.00)	65.21*** (0.00)	60.37*** (0.00)
Normality	0.26 (0.12)	0.49 (0.11)	0.25 (0.14)	0.57 (0.33)	0.27 (0.62)	0.35 (0.85)	0.27 (0.55)	0.16 (0.28)

Note: Asterisks *, ** and *** denote 10%, 5% and 1% level of significance, respectively. Figures in [ ] stand for *t-statistic* and in () denote *p-value*. Normality test is based on Jarque-Bera test.

Table 7. Regression Analysis for Regional Dummies

	DV = LIE	*DV = LPOV_ $1.90 a day*	*DV = LPOV_ $3.20 a day*	*DV = LPOV_ $5.50a day*
C	7.8629*** [4.09]	12.2853*** [2.44]	8.8489*** [3.53]	3.8001 [5.13]
LGDPC	0.1515* [1.81]	−0.8246*** [−2.38]	−0.9374** [−2.27]	−0.9639** [−2.14]
LGDPC²	−1.1181*** [−2.34]	−	−	−
LREM	−0.0702* [−1.85]	−0.1657* [−1.96]	−0.0453* [−2.05]	−0.1081* [−1.95]
LINF	0.1521** [2.16]	0.0420** [2.18]	0.3078** [2.34]	0.5002* [1.93]
LGINI	−	5.0301*** [7.14]	4.8808*** [5.00]	2.9238*** [4.05]
LDE	0.2088** [2.35]	0.8543* [1.92]	−1.1241*** [−3.80]	−0.5824*** [3.38]
Dummy Europe and Central Asia	−0.1844* [−1.95]	−0.1463** [−2.22]	−0.6363* [−1.85]	−0.9816** [−2.22]
Dummy_ Latin America and the Caribbean	−0.2269** [−2.36]	−0.330** [−2.30]	−1.0072*** [−2.53]	−1.2068* [−1.72]
Dummy_ South Asia	−0.5736*** [−3.96]	0.3668* [−1.99]	−3.6018*** [−3.10]	−2.7406** [−2.17]
Dummy_ Sub-Saharan Africa	−0.4677*** [−2.76]	0.2042** [2.34]	−0.7065* [−1.97]	−1.2366*** [2.61]
Dummy_ East Asia and Pacific	−0.0865* [−1.95]	−0.9074*** [−2.50]	−1.5877** [−2.37]	−1.6751** [−2.36]
Dummy_ Middle East and North Africa	−0.3899 [−2.18]	−0.0468* [2.07]	0.1363** [2.19]	−0.3939*** [−2.51]
	Model Criteria			
Adj-R²	0.4090	0.8536	0.8668	0.7606
F-stat	22.15*** (0.02)	139.99*** (0.00)	195.29*** (0.00)	101.66*** (0.00)
Normality	0.70 (0.22)	0.82 (0.32)	0.51 (0.26)	0.55 (0.39)

Note: Asterisks *, ** and *** denote 10%, 5% and 1% level of significance, respectively. Figures in [ ] stand for *t-statistic* and in () denote *p-value*. Normality test is based on Jarque-Bera test.

As a final robustness check, analyses were performed by incorporating regional dummies and the results are provided in Table 7. These results are quantitatively similar to those reported in Tables 5 and 6. More specifically, the coefficients associated with digitalization are statistically significant and negatively affect poverty, except for the level of poor living on $1.90 a day. For instance, the positive coefficient shows that a 1% increase in the level of digitalization in developing countries increases poverty by 0.8543%. That is bad news because there still exist people who are living in extreme poverty around the developing countries. Although digital

use has taken place largely in developing countries, the issue of the digital divide is serious and demands immediate attention.

Conclusion

Given the ongoing existence of poverty and income inequality in most developing countries, this study examined whether the rapid development of digitalization may have contributed to this issue. Collecting information from 37 developing countries in 2014 and 2016, this study confirms the negative hypothesis that digitalization is not really helpful to the extremely poor in these countries. As part of the possible policy implications, while promoting digitalization will certainly be good for the economic development of the countries, complementary strategies are needed to support the extremely poor to share the benefits of economic digitalization. The findings suggest that developing countries need to scale up efforts to give people the necessary technology-related knowledge, financial resources and broadband technological facilities to support, if not the current generation, the next generation of poor people. For instance, policy-makers and practitioners may enhance efforts to tackle ongoing inequalities in skills and knowledge by formulating education policies to improve the development and availability of digital learning for vulnerable groups regardless of gender, race or disability. Further, governments need to scale up policies and guidelines for digital development projects in accordance with the national developmental aims to eradicate poverty. These will help to close the digital gap and ensure the benefits of digitalization can be reaped by people who live in extreme poverty as well.

The experience of Bill Gates, founder of Microsoft, is instructive. He has contributed a great deal of his wealth back to society by establishing the Bill and Belinda Gates Foundation.[8] This kind of corporate social responsibility must be encouraged among technopreneurs once they have become successful in their businesses.

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[8] https://www.gatesfoundation.org.

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