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The Role of Mobile Money Innovations in the Effect of Inequality on Poverty and Severity of Poverty in Sub-Saharan Africa

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Abstract
This study investigates the role of mobile money innovations in the incidence of income inequality on poverty and severity of poverty in 42 sub-Saharan African countries over the period 1980 to 2019. Mobile money innovations are understood as the mobile used to send money and the mobile used to pay bills online while income inequality is measured with the Gini index. Poverty is measured as the poverty headcount ratio while the severity of poverty is generated as the squared of the poverty gap index. The empirical evidence is based on interactive Quantile regressions. The following main findings are established. (i) Income inequality unconditionally reduces poverty and the severity of poverty though the significance is not throughout the conditional distributions of poverty and the severity of poverty. (ii) Mobile money innovations significantly moderate the positive incidence of income inequality on poverty and the severity of poverty in some quantiles. (iii) Positive net effects are apparent exclusively in the poverty regressions. (iv) Given the negative conditional effects, policy thresholds or minimum mobile money innovation levels needed to completely nullify the positive incidence of income inequality on poverty are provided: 27.666 (% age 15+) and 24.000 (% age 15+) of the mobile used to send money in the 50th and 75th quantiles, respectively and 16.272 (% age 15+) and 13.666 (% age 15+) of the mobile used to pay bills online in the 10th and 50th quantiles, respectively. Policy implications are discussed with respect of SDG1 on poverty reduction and SDG10 on inequality mitigation.

Keywords Mobile phones · Financial inclusion · Poverty · Inequality · Africa

JEL Classification G20 · O40 · I10 · I20 · I32

1 Introduction

The concern of how mobile money innovations affect the incidence of inequality on poverty and the severity of poverty in sub-Saharan Africa (SSA) is motivated from scholarly and policy standpoints. These three main fronts are substantiated in the paragraphs that follow.

First, on the policy front, financial inclusion from mobile money innovations has been documented to be fundamental in the reduction of inequality and poverty, not least, because the mobile phone and associated innovations have been documented to be fundamental in driving inclusive development in developing countries in general and African countries in particular (Asongu & Tchamyou, 2020; Uduji et al., 2019a, b). Moreover, financial inclusion has also been established to be central in the achievement of most post-2015 goals surrounding the sustainable development agenda of the United Nations (UNCDF, 2022). In line with the narrative, financial inclusion provides room for the achievement of multiple SDGs, notably: (i) SDG1 which is focused on poverty eradication; (ii) SDG2 related to achieving security in food, ending hunger and sustainable agriculture promotion; (iii) SDG3 linked to health and wealth; (iv) SDG5 oriented towards gender equality and the empowerment of women; (v) SDG8 on the drive towards economic growth; (vi) SDG9 connected to promoting infrastructure, supporting innovation and consolidating the industry; (vii) SDG10 concerned with inequality eradication and (viii) SDG17 focused on boosting the implementation channel, especially

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within the remit of understanding how financial inclusion is connected to the mobilization of resources for sustainable investment and consumption that ultimately boost economic prosperity (Abdulqadir & Asongu, 2022; Agyei et al., 2022; Owusu et al., 2020; UNCDF, 2022). This positioning of this study directly focuses on SDG1 (i.e. poverty reduction) and SDG10 (i.e. inequality mitigation) by assessing how mobile money innovations modulate the incidence of inequality on poverty, not least, because of an apparent gap in the extant literature.

Second, on the scholarly front, the extant literature on nexuses between financial inclusion, mobile banking, poverty and inequality has focused on *inter alia*: (i) the nexus between financial inclusion and inclusive development (Carrado & Carrado, 2017; Meniago & Asongu, 2018; Pal et al., 2020; Qasim & Abu-Shanab, 2016; Sarma & Pais, 2011); (ii) the linkage between information technology and inclusive development (Asongu & Asongu, 2018; Asongu & Odhiambo, 2019); (iii) the connection between financial access and information technology (Bongomin et al., 2018; Gosavi, 2018; Peruta, 2017); (iv) nexuses underlying financial access, information technology and inclusive development (Abor et al., 2018; Yousefi, 2011); (v) linkages between information technology, financial inclusion, inequality and poverty (Adams & Akobeng, 2021; Asongu et al., 2021b; Ekeocha & Iheonu, 2021) and (vi) digital transformation for sustainable societies in the twenty-first century (Bacon et al., 2023; David-West et al., 2021; Dhar & Bose, 2023; Margherita & Braccini, 2023; Pappas et al., 2023; Vassilakopoulou & Hustad, 2023; Vimalkumar et al., 2021). The attendant five strands are expanded in the same chronology as highlighted in Section 2.1.

Of the extant literature, the closest study to the present study is Asongu et al. (2021b) which has assessed nexuses between financial institutions, poverty and the severity of poverty in SSA to conclude that: (i) financial institutions efficiency (depth) consistently mitigate the poverty headcount (severity of poverty) and (ii) financial institutions access consistently reduce the severity of poverty and poverty with the decreasing impact improving with growing levels of poverty throughout the conditional distribution of the severity of poverty and in top quantiles of the poverty distribution.

The positioning of the present study departs from the underlying study in that, financial institutions are not the main channel on the one hand and on the other, inequality and mobile money innovation used in the present study are not the independent variables in the underlying study. Moreover, the underlying study is modeled as a linear additive model which provides less room for policy implications compared to the current non-linear empirical strategy adopted in the study. Accordingly, thresholds of mobile money innovations that modulate the positive incidence of inequality on poverty are provided in order for policy makers to have actionable critical masses of mobile money innovations that can be acted upon in order to achieve the targeted objectives of mitigating poverty and the severity of poverty.

In the light of the above, the research question being considered in the present study is the following: what is the role of mobile money innovations in the effect of inequality on poverty and severity of poverty in SSA?

The remainder of the study is organized as follows. The theoretical underpinnings and related literature are discussed in Section 2 while the data and methodology are covered in Section 3. The empirical findings are disclosed in Section 4 while Section 5 concludes with implications and future research directions.

2 Theoretical Underpinnings and Related Literature

2.1 Empirical Literature

Following Tchamyou et al. (2019) on the importance financial inclusion and information technology in reducing income inequality, the empirical literature can be discussed in five main strands, notably: (i) the linkage between financial inclusion and inclusive development; (ii) the connection between information technology and inclusive development; (iii) the nexus between financial access and information technology; (iv) linkages underlying financial access, information technology and inclusive development and (v) nexuses between information technology, inequality and poverty. To these underlying five strands, a sixth strand on the importance of digital transformation for societies that is consistent with contemporary information systems frontier literature is added. The attendant six strands are expanded in the same chronology as highlighted.

In the first strand on the linkage between financial inclusion and inclusive development, Sarma and Pais (2011) have empirically assessed the nexus between financial inclusion and economic development by putting into perspective country-specific features that are connected to financial inclusion. They have established that for a specific nation, human development and financial inclusion levels are negatively related. Corrado and Corrado (2017) have examined the role of inclusive finance in inclusive growth to establish that inclusive finance, *inter alia*: improves the depth of financial services; (ii) provides consumption plans as well as long-term investment prospects; (iii) enables businesses and households to be protected against shocks of adverse nature and (iv) gives people avenues through which to better exploit socio-economic frontiers. Meniago and Asongu (2018) have explored the nexus between finance and inequality to

conclude that financial intermediation efficiency reduces inequality.

Concerning the second strand on the nexus between information technology and inclusive development, Asongu and Asongu (2018) have assessed correlates between quality of growth, poverty, inequality and mobile banking in developing countries to establish that the usage of mobile phones to pay bills is positively linked to inclusive growth in low-middle income countries while the corresponding nexus is negative in Latin America nations. In Central and Eastern Europe as well as in Asia and the Pacific, a negative association is apparent between poverty and the mobile phone used to send/receive money. Asongu and Odhiambo (2019) have examined correlations between mobile banking and inclusive development to show that above some critical thresholds of mobile banking, mobile banking decreases inequality and increases inclusive growth in top quantiles of the inclusive development distribution.

In the third strand on the linkage between financial access and information technology, Peruta (2017) has employed a cluster analysis within a macroeconomic framework in the assessment of whether mobile money services are more adopted in areas where formal banking services are low. Bongomin et al. (2008) have examined the moderating incidence of social networks in the nexus between the use of mobile money and financial inclusion to establish a moderating impact of social network that is significant in the connection between mobile money and financial inclusion. As opposed to previous literature, the findings do not support the position that financial inclusion is promoted by the use of mobile money. Gosavi (2018) has examined if mobile money is relevant in helping firms mitigate constraints to financial access and shown that companies using mobile money services have an advantage in terms of access to finance by means of loans. Moreover, firms using such mobile money services are comparatively more productive.

Looking at the fourth strand on linkages underlying financial access, information technology and inclusion development, Yousefi (2011) has established that the impact of economic prosperity on ICT is contingent on income groups. The author has established that ICT is significantly relevant in driving economic growth in upper-middle income and high income countries while the opposite effect is apparent in lower-middle income countries. The findings are broadly confirmed in SSA countries by Abdulqadir and Asongu (2022) who use a non-linear technique to show that internet drives economic growth when a certain internet penetration threshold is reached. At the microeconomic level, Abor et al. (2018) conclude that mobile phone penetration and financial inclusion considerably reduce the likelihood for a household to be poor.

In the fifth strand on linkages between information technology, inequality and poverty, Asongu et al. (2021b) have assessed nexuses between financial institutions, poverty and the severity of poverty to conclude from a broad perspective that, financial institutions reduce poverty and the severity of poverty. Ekeocha and Iheonu (2021) have investigated linkages between household-level poverty, consumption poverty thresholds, quality of lives and income inequality in sub-Saharan Africa to broadly establish that poverty increases inequality. Adams and Akobeng (2021) have concluded that ICT directly mitigates inequality while Ofori et al. (2021) have established that ICT reduces poverty.

In the sixth strand, Pal et al. (2020) have focused on the incidence of mobile payment technology on human and sustainable-centric development while David-West et al. (2021) are concerned with the diffusion of innovation especially as it pertains to financial inclusion and mobile utility. Qasim and Abu-Shanab (2016) focus on drivers of acceptance of mobile payment especially in relation to network externalities while Vimalkumar et al. (2021) are concerned with exploring mobile phone adoption within the remit of multi-level digital divide. Pappas et al. (2023) focus on responsible digital transformation for sustainable societies, Margherita and Braccini (2023) are concerned with flexible manufacturing for sustainable organization value creation within the remit of contemporary industrial technologies, Bacon et al. (2023) lay emphasis on the combinatory nature surrounding conditions of knowledge transfer while Dhar and Bose (2023) focus on the role of perceived benefits and social capital in the attachment of corporate users to social networking sites.

In the light of the motivation of the study discussed in the introduction as well as the narratives in the underlying Section 2, two main hypotheses below that are consistent with the attendant literature are investigated.

Hypothesis 1: inequality drives poverty and the severity of poverty

Hypothesis 2: mobile money innovations dampen the positive incidence of inequality on poverty and the severity of poverty

2.2 Theoretical Underpinnings

Consistent with contemporary literature on nexuses between financial inclusion, mobile banking, poverty and inequality (Acha-Anyi et al., 2020; Asongu & Odhiambo, 2018, 2019), the theoretical premise for the linkages assessed in this study are in line with the models underlying the adoption of new technology. According to Yousafzai et al. (2010), some of the models surrounding the adoption of new technology include, the: theory of reasoned action (TRA), technology acceptance model (TAM) and theory of planned behavior (TPB). A common feature underlying these theories is the fact that mobile phone adoption involves a process that is

both multifaceted and complex, entailing: (i) a procedure from developers and managers of information systems that is based on the formation of the customer's belief as opposed to the influence of attitude by the customer and (ii) relevant features that embody considerations of composite nature such as the social, psychological, behavioral and utilitarian dimensions of the customer.

First of all, as argued by Yousafzai et al. (2010), and posited in the corresponding literature (Ajzen & Fishbein, 1980; Bagozzi, 1982; Fishbein & Ajzen, 1975), the TRA is for the most part based on the premise that the rationality of customers is apparent, especially when it has to do with the consideration of the externalities of their actions. Second, within the remit of the TPB proposed by Ajzen (1991) as an extension of the TRA, emphasis is placed on the lack of apparent variations between customers who are growingly conscious of the need to keep their actions in check, compared to customers who do not manifest such awareness. Third, as argued by Davis (1989), the TAM acknowledges that the adoption of a given technology is a process whereby a customer can be assessed for the most part in the light of the his/her voluntary intention to accept and then utilize the corresponding mobile technology.

In the light of the above theoretical insights, the discussed theories are in line with the positioning of this study because customers (present and potential) adopt mobile phones with the purpose of benefiting from inclusive human development externalities such as poverty and inequality mitigation associated with such adoption of mobile money innovations. Moreover, we argue in this study that such anticipated benefits can be contingent on existing levels of poverty and severity of poverty such that customers with high existing levels of poverty and severity of poverty benefit differently compared to customers with low existing levels of poverty and severity of poverty.

3 Data and Methodology

3.1 Data

This research focuses on data from 42 SSA countries for the period 1980–2019. These are countries for which data are available at the time of the study.[1] As shown in Appendix Table 3, the data are obtained from three main sources, namely: (i) the World Bank's World Development Indicators (WDI); (ii) the Global Financial Development Database and (iii) the Global Findex database. In accordance with the corresponding literature that has used the same dataset (Asongu et al., 2021b, c; Ofori et al., 2021), the following poverty measures are used: (i) the poverty headcount ratio at national poverty lines (% of population) to proxy for poverty and (ii) the severity of poverty generated as the squared of the poverty gap index. Accordingly, the severity of poverty measures the degree of inequality among the poor by putting more emphasis on the position of the poorest.

The measure of income inequality adopted in this study is the Gini index, in accordance with contemporary income inequality literature (Tchamyou, 2019, 2021) while mobile money innovations are measured in terms of the mobile phone used to send money and the mobile phone used to pay bills online, in accordance with contemporary mobile money innovations literature (Asongu et al., 2020, 2021a). In essence, the Gini coefficient is a measurement of the income distribution of a country's residents; the mobile used to send money is the percentage of respondents who report using a mobile phone to send money in the past 12 months (% age 15 +) while the mobile used to pay bills is the percentage of respondents who report using a mobile phone to pay bills in the past 12 months (% age 15 +).

To account for variable omission bias, the following ten variables are involved in the conditioning information set, namely: financial institutions depth, financial institutions access, financial institutions efficiency, inflation, foreign aid, government expenditure, GDP growth, foreign direct investment, remittances and trade openness. The choice of the control variables is motivated by contemporary inclusive development literature (Asongu & le Roux, 2019; Asongu & Nting, 2022; Bae et al., 2012; Beck et al., 2007; Ofori et al., 2021; Tchamyou, 2020; Tchamyou et al., 2019).

The Financial Institutions Depth (FID) index, "compiles data on bank credit to the private sector, pension fund assets, mutual fund assets, and insurance premiums (life and non-life) as percentages of GDP"; the Financial Institutions Access (FIA) index comprises data on the number of bank branches and the number of automatic teller machines (ATMs) per 100,000 adults" while the Financial Institutions Efficiency (FIE) index, "compiles data on the banking sector's net interest margin, the lending–deposits spread, the ratios of non-interest income to total income and overhead costs to total assets, and the returns on assets and equity". Inflation is consumer prices (measured as annual %), foreign aid is Net Official Development Assistance received (% of GNI or Gross National Income), government expenditure reflects general government final consumption expenditure (% of GDP); economic growth is GDP growth (annual %); foreign investment is measured

[1] The 42 countries are: "*Angola; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; Congo Democratic Republic; Congo Republic; Cote d'Ivoire; Ethiopia; Gabon; Gambia, The; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; South Africa; Sudan; Tanzania; Togo; Uganda and Zambia*".

with foreign direct investment, net inflows (% of GDP); remittances is remittances inflows (% of GDP) and trade reflects the sum of exports and imports of goods and services measured as a share of GDP.

According to the attendant literature, some variables are expected to increase poverty, notably: (i) inflation because it is associated with a reduction of purchasing power (Chani et al., 2011); (ii) foreign aid which has been established to be detrimental to inclusive development (Asongu, 2014) and (iii) foreign direct investment has been documented to increase exclusive growth (Yaseen & Mishal, 2017). (iv) Meniago and Asongu (2018) have argued that remittances are negatively associated with inclusive development because majority of those migrating abroad are from rich households which can afford the expensive cost of visa processes. (v) As for financial institutions dynamics, they are anticipated to reduce poverty because financial dynamics of access, depth and efficiency have been broadly established to promote inclusive human development (Tchamyou et al., 2019). (vi) Moreover, government expenditure, economic prosperity within the remit of GDP growth and trade openness are associated with more prospects of inclusive development in terms of poverty reduction (Tahir et al., 2014).

It is however also important to highlight that, owing to the non-linear empirical exercise being considered in the study, interactive regressions can engender concerns of multicollinearity such that, some of the selected variables in the conditioning information set do not emerge from the regression output with the expected signs. It is for this reason that, as documented by Brambor et al. (2006) on the pitfalls of interactive regressions, multicollinearity is overlooked through the computation of net effects and/or thresholds. Hence, with such computations, the estimated coefficients are not interpreted as in linear additive models. This narrative is consistent with contemporary interactive regressions literature (Nchofoung & Asongu, 2022a; Nchofoung et al., 2021).

The definitions of variables and corresponding sources are disclosed in Appendix Table 3, while Appendix Table 4 presents the summary statistics which is related in the computation of net effects and/or thresholds. Accordingly, the computation of net effects in interactive regressions requires the use of mean or average values of the moderating or policy variables. Moreover, when the policy thresholds or thresholds for complementary policies are computed, in order for the attendant thresholds to have policy relevance and make economic sense, they should be within the statistical range (minimum to maximum values). Appendix Table 5 shows the correlation matrix which is provided for insights into concerns of multicollinearity discussed in the previous paragraph.

3.2 Methodology

Building on the narrative in the introduction, especially as it pertains to assessing the investigated nexuses throughout the conditional distributions of poverty and the severity of poverty, a quantile regressions (QR) approach is adopted because it enables the study to articulate countries with various initial levels of poverty and the severity of poverty. Accordingly, the QR approach is appropriate when the objective of the study, *inter alia*, is to articulate various levels of poverty and the severity of poverty. In essence, the selected technique is relevant when nexuses are to be established throughout the conditional distribution of the outcome variables (Asongu, 2017; Asongu et al., 2021c; Billger & Goel, 2009; Tchamyou & Asongu, 2017).

It is also relevant to emphasize that, compared to the ordinary least squares (OLS) approach which is founded on the premise that error terms are normally distributed, in the QR approach, such an assumption of normally distribution of error terms is not taken into account. This is essentially because; estimation on the bases of such an assumption can engender biases in estimated coefficients. The perspective that in QR, estimated parameters throughout the conditional distribution of the outcome variable are not based on normally distributed error terms is consistent with contemporary and non-contemporary literature on the subject (Boateng et al., 2018; Koenker & Bassett, 1978; Koenker & Hallock, 2001).

Given the outcome variable employed in this study, in the light of the narrative above, the θ^{th} quantile estimator of poverty is derived by solving for the optimization problem in Eq. (1), which is disclosed without subscripts for presentation simplicity.

$$\min_{\beta \in R^k} \left[\sum_{i \in \{i: y_i \geq x_i'\beta\}} \theta \left| y_i - x_i'\beta \right| + \sum_{i \in \{i: y_i < x_i'\beta\}} (1-\theta) \left| y_i - x_i'\beta \right| \right], \tag{1}$$

where $\theta \in (0, 1)$. Compared to OLS that is based on the minimization of the total of squared residuals, the procedure for quantile regressions is such that the sum of absolute deviations for all quantiles is considered. In order to put this narrative into perspective, the 10^{th} and 90^{th} quantiles (corresponding respectively to θ=0.10 or 0.90) are minimised by approximately weighing the attendant residuals. It follows that the conditional quantile of poverty or the severity of poverty or y_i given x_i is:

$$Q_y(\theta / x_i) = x_i'\beta_\theta \tag{2}$$

where for the corresponding θ th quantile to be determined, parameters with unique slopes are estimated. The attendant formulation is parallel to $E(y/x) = x_i'\beta$ in the OLS slope for which parameters are examined exclusively at the

conditional distribution of the severity of poverty and/or poverty.

In the light of the above, in Eq. (2), the dependent variable y_i is the indicator for the severity of poverty or poverty while x_i contains a constant term, *the Gini index, the mobile phone used to send money, the mobile phone used to pay bills online, financial institutions depth, financial institutions access, financial institutions efficiency, inflation, foreign aid, government expenditure, GDP growth, foreign direct investment, remittances* and *trade openness*.

4 Empirical Results

4.1 Presentation of Results

The empirical findings are disclosed in this section in Tables 1 and 2. Table 1 focuses on nexuses among, the mobile used to send money, inequality, poverty and severity of poverty while Table 2 is concerned with linkages between the mobile used to pay bills online, inequality, poverty and severity of poverty. The relevance of adopting the QR estimation approach is confirmed from the perspective that, in terms of significance, signs and the magnitude of signs, the estimated coefficients of OLS are distinct from those of QR when compared throughout the conditional distribution of the poverty and severity of poverty outcomes variables.

In each of the tables, the left-hand side provides findings related to the poverty headcount while the corresponding right-hand side shows findings on the severity of poverty. In order to assess the incidence of mobile money innovation in the effect of income inequality on poverty, net effects are computed in accordance with the extant contemporary literature focusing on interactive regressions (Nchofoung & Asongu, 2022a; Nchofoung et al., 2021). As an illustrative example, in the second column of Table 1 focusing on the OLS regressions, the net effect on poverty headcount is 0.040. In other words, 0.040 is the overall impact from the role of the mobile phone used to send money in modulating the effect of income inequality on poverty headcount. The net effect is arrived at from the following equation: 0.040 = ([-0.003 × 10.280] + [0.071]). In this computation, 10.280 is the mean value of the mobile used to send money, -0.003 is the conditional or interactive effect from the association between income inequality and the mobile used to send money in the effect on poverty while 0.071 is the unconditional effect of income inequality on poverty.

The following findings can be established in Tables 1 and 2: (i) Income inequality unconditionally reduces poverty for the most part, while the corresponding conditional or interactive effect is largely positive in both poverty and severity of poverty regressions. However, regressions in which both the unconditional effects and corresponding conditional effects are significant to enable the computation of net effects are only apparent from both tables in regressions focusing on poverty. (ii) The underlying tendency of a positive unconditional effect of income inequality and a corresponding negative conditional or interactive effect are apparent exclusively in the median and 75th quantile of the poverty distribution in Table 1 and in the 10th quantile and the median of the poverty distribution in Table 2. The corresponding net effects are consistently positive. (iii) Most of the control variables are significant with the expected signs (i.e. in line with the narrative in the data section).

(v) Looking at the tested hypotheses, *Hypothesis* 1 is valid in the 10th, 50th, 75th quantiles for the poverty headcount and the 50th quantile for severity of poverty in Table 1 while in Table 2, *Hypothesis 1* is valid in the 10th and 50th quantiles of the poverty headcount and in the 50th and 90th quantiles of the severity of poverty. On the other hand, *Hypothesis* 2 is valid in the 50th and 75th quantiles for poverty regressions in Table 1 while in Tables 2, the validity of *Hypothesis 2* is apparent in 10th, 50th and top quantiles of the poverty distribution. It follows that the validity of *Hypothesis 2* is not apparent in the severity of poverty regressions in both tables. In the light of the fact that the corresponding conditional effects are consistently negative while the net effects are consistently positive, there are some thresholds of mobile money innovations at which the unconditional incidence of inequality on poverty is completely nullified.

4.2 Discussion

This section is relevant because it provides insights into how policy makers can leverage on computed policy thresholds in order to influence the main channel to a desired outcome which is poverty in the context of the study. Accordingly, the corresponding main channel is income inequality while the policy or moderating variables are the mobile money dynamics (i.e. mobile money innovations in terms of the mobile used to send money and the mobile used to pay bills online). Accordingly, given that the conditional or interactive effects are negative while the unconditional effects of inequality are consistently positive, there are minimum or critical levels at which the mobile money dynamics completely dampen the positive effect of income inequality on poverty.

In the light of the above, still consistent with the illustrative example used in the previous section, in the second column of Table 1, the mobile phone used to send money threshold at which the net effect of income inequality changes from positive to negative is 23.666 (0.071/003) (% age 15 +). Hence, when the penetration of the mobile phone used to send money is above 23.666 (% age 15 +), the net effect of income inequality on poverty changes from positive to negative. For instances: (i) at 23.666 (% age 15 +)

Table 1 Mobile phones used to send money, inequality and poverty

	Poverty headcount						Severity of poverty					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
Constant	**54.883*****	**40.982*****	**44.988*****	**51.149*****	**64.184*****	**75.101*****	**13.874*****	**–1.667*****	**–2.255****	**4.317***	**15.796*****	**35.710*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.006)**	**(0.043)**	**(0.054)**	**(0.000)**	**(0.004)**
Gini	**0.071*****	**0.078*****	0.039	**0.083*****	**0.048***	–0.018	**0.105*****	0.0005	0.022	**0.056****	0.070	0.255
	(0.001)	**(0.003)**	(0.266)	**(0.000)**	**(0.087)**	(0.670)	**(0.001)**	(0.941)	(0.714)	**(0.049)**	(0.197)	(0.114)
Mobsen	0.025	–0.122	–0.127	0.075	–0.041	0.080	–0.044	0.018	0.0004	0.016	–0.087	–0.105
	(0.725)	(0.134)	(0.246)	(0.305)	(0.632)	(0.538)	(0.767)	(0.445)	(0.595)	(0.850)	(0.602)	(0.832)
Gini × Mobsen	**–0.003*****	–0.003	–0.0003	**–0.003****	**–0.002***	–0.003	0.001	0.0002	0.0004	–0.0005	–0.0009	0.005
	(0.006)	(0.009)	(0.872)	**(0.017)**	**(0.072)**	(0.161)	(0.667)	(0.513)	(0.595)	(0.710)	(0.737)	(0.518)
FinInDepth	**18.438*****	**11.970*****	–3.176	**25.585*****	**30.809*****	**19.133*****	**–16.780*****	1.395	**–3.316****	**–10.867*****	**–14.955****	**–31.634***
	(0.000)	**(0.000)**	(0.433)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.118)	**(0.041)**	**(0.001)**	**(0.016)**	**(0.084)**
FinInAccess	**–16.705*****	**–46.395*****	–3.779	**–7.937****	**–15.717*****	**–19.485*****	**–43.015*****	**–10.368*****	**–17.269*****	**–22.524*****	**–34.998*****	**–67.361*****
	(0.000)	**(0.000)**	(0.438)	**(0.015)**	**(0.000)**	**(0.001)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.002)**
FinInEffic	**–19.487*****	**–12.973*****	**–10.700*****	**–21.114*****	**–27.928*****	**–18.919*****	–3.659	**3.797*****	**10.147*****	**11.804*****	6.269	**–21.712***
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.350)	**(0.000)**	**(0.000)**	**(0.000)**	(0.150)	**(0.092)**
Inflation	**0.001*****	**0.001****	0.001	**0.001****	0.0009	0.0003	**0.002*****	**0.002*****	**0.002*****	**0.001*****	**0.008*****	0.002
	(0.000)	**(0.019)**	(0.141)	**(0.049)**	(0.172)	(0.710)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.006)**	**(0.000)**	(0.534)
Foreign aid	**0.398*****	**0.519*****	**0.470*****	**0.408*****	**0.314*****	**0.213*****	0.009	**0.035*****	**0.102*****	**0.161*****	**0.377*****	–0.075
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.829)	**(0.001)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.724)
Gov. Exp	0.014	0.012	0.005	0.009	**0.030***	0.003	–0.006	0.006	**0.019****	**0.029***	–0.007	0.029
	(0.239)	(0.393)	(0.792)	(0.463)	**(0.061)**	(0.887)	(0.679)	(0.135)	**(0.019)**	**(0.072)**	(0.799)	(0.746)
GDPg	**–0.206*****	–0.118	**–0.268*****	**–0.205*****	–0.117	–0.178	–0.113	–0.005	**–0.137*****	**–0.135***	–0.245	–0.235
	(0.007)	(0.112)	**(0.008)**	**(0.002)**	(0.141)	(0.137)	(0.318)	(0.813)	**(0.001)**	**(0.095)**	(0.110)	(0.604)
FDI	**0.113****	**0.170*****	**0.190****	0.009	–0.011	0.067	–0.046	0.028	0.054	0.063	–0.089	–0.351
	(0.028)	**(0.007)**	**(0.025)**	(0.867)	(0.865)	(0.507)	(0.551)	(0.128)	(0.108)	(0.350)	(0.490)	(0.359)
Remit	**0.068*****	**0.116*****	**0.101*****	0.014	–0.032	–0.033	**–0.093*****	**0.032*****	**0.021***	0.031	–0.047	**–0.290****
	(0.000)	**(0.000)**	**(0.001)**	(0.492)	(0.179)	(0.358)	**(0.000)**	**(0.000)**	**(0.080)**	(0.210)	(0.313)	**(0.037)**
Trade	**–0.064*****	**–0.094*****	**–0.079*****	**–0.023****	0.005	**–0.040***	**0.065****	0.008	0.003	**–0.033*****	0.013	**0.252*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.043)**	(0.665)	**(0.054)**	**(0.013)**	(0.019)	(0.642)	**(0.016)**	(0.616)	**(0.001)**
Net Effects	0.040	na	na	0.052	0.027	na	na	na	na	na	na	na
Thresholds	23.666	na	na	27.666	24.000	na	na	na	na	na	na	na
R^2/Pseudo R^2	0.302	0.279	0.162	0.198	0.204	0.101	0.116	0.032	0.074	0.090	0.099	0.144
Fisher	**60.18*****						**30.05*****					
Observations	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680

*,**,***: significance levels of 10%, 5% and 1% respectively. *OLS* Ordinary Least Squares. R^2 for OLS and Pseudo R^2 for quantile regression. Lower quantiles (e.g., Q 0.1) signify nations where poverty headcount and severity of poverty are least. Gini: Income Inequality. *MobSend* Mobile phones used to send money. *FinInDepth* Financial Institutions Depth. *FinInAcc* Financial Institutions Access. *FinInEffic*: Financial Institutions Efficiency. *Gov. Exp* Government Expenditure. *GDPg* Gross Domestic Product growth. *FDI* Foreign Direct Investment. *Remit* remittances. The mean value of the mobile used to send money is 10.280. *na* not applicable because at least one estimated coefficient needed for the computation of the net effect and/or threshold is not significant

Source: Authors

The bold values represent significant estimated coefficients and the Fisher statistics

Table 2 Mobile used to pay bills online, inequality and poverty

	Poverty headcount						Severity of poverty					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
Constant	**53.130*** **	**32.119*** **	**43.541*** **	**48.290*** **	**61.807*** **	**74.588*** **	**13.302*** **	**–1.644*** **	**–2.795*** **	3.502	**16.925*** **	**33.599*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.004)**	**(0.005)**	(0.103)	**(0.000)**	**(0.001)**
Gini	**0.069*** **	**0.179*** **	0.042	**0.082*** **	0.048	–0.014	**0.110*** **	0.001	0.024	**0.060** **	0.068	**0.259** **
	(0.001)	**(0.000)**	(0.156)	**(0.000)**	(0.118)	(0.642)	**(0.000)**	(0.846)	(0.053)	**(0.024)**	(0.149)	**(0.043)**
Mobpay	**0.306** **	**0.828*** **	0.112	**0.285***	0.146	0.357	0.021	0.037	0.081	0.145	–0.061	–0.027
	(0.022)	**(0.000)**	(0.598)	**(0.057)**	(0.499)	(0.117)	(0.931)	(0.468)	(0.357)	(0.446)	(0.856)	(0.976)
Gini × Mobpay	**–0.006*** **	**–0.011*** **	–0.001	**–0.006** **	**–0.009** **	**–0.009** **	0.002	0.001	0.001	–0.002	0.008	0.013
	(0.004)	**(0.000)**	(0.742)	**(0.019)**	**(0.019)**	**(0.023)**	(0.644)	(0.159)	(0.457)	(0.414)	(0.154)	(0.409)
FinInDepth	**16.963*** **	**13.276*** **	–5.480	**23.331*** **	**32.396*** **	**19.786*** **	**–17.306*** **	1.147	**–3.360** **	**–11.352*** **	**–19.110*** **	**–32.600** **
	(0.000)	**(0.000)**	(0.135)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.192)	**(0.027)**	**(0.001)**	**(0.001)**	**(0.035)**
FinInAccess	**–16.081*** **	**–62.844*** **	–6.225	**–7.339** **	**–16.723*** **	**–19.955*** **	**–42.397*** **	**–8.910*** **	**–16.394*** **	**–22.690*** **	**–26.695*** **	**–66.565*** **
	(0.000)	**(0.000)**	(0.158)	**(0.017)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
FinInEffic	**–18.513*** **	**–10.605*** **	**–9.919*** **	**–18.561*** **	**–27.822*** **	**–17.872*** **	**–3.572**	**3.459*** **	**9.975*** **	**12.398*** **	5.863	**–18.597***
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.363)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.145)	**(0.086)**
Inflation	**0.001*** **	**0.001** **	0.001	**0.001** **	0.0009	0.0003	**0.002*** **	**0.002*** **	**0.002*** **	**0.001*** **	**0.008*** **	0.005
	(0.000)	**(0.019)**	(0.101)	**(0.035)**	(0.228)	(0.669)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.006)**	**(0.000)**	(0.120)
Foreign aid	**0.386*** **	**0.325*** **	**0.471*** **	**0.406*** **	**0.360*** **	**0.208*** **	0.003	**0.033*** **	**0.094*** **	**0.165*** **	**0.239*** **	–0.044
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.939)	**(0.001)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.805)
Gov. Exp	0.011	0.002	0.007	0.006	0.019	–0.001	–0.005	0.001	**0.019** **	**0.027***	–0.008	0.007
	(0.294)	(0.869)	(0.698)	(0.619)	(0.291)	(0.933)	(0.714)	(0.652)	**(0.011)**	**(0.095)**	(0.756)	(0.925)
GDPg	**–0.225*** **	**–0.279*** **	**–0.302*** **	**–0.197*** **	–0.137	**–0.174***	–0.118	0.006	**–0.117*** **	**–0.143***	–0.227	–0.241
	(0.004)	**(0.000)**	**(0.001)**	**(0.002)**	(0.135)	**(0.071)**	(0.302)	(0.758)	**(0.002)**	**(0.077)**	(0.110)	(0.529)
FDI	**0.118** **	**0.101***	**0.184** **	0.029	–0.029	0.083	–0.041	**0.041** **	**0.063*** **	0.061	–0.042	–0.338
	(0.024)	**(0.098)**	**(0.016)**	(0.583)	(0.705)	(0.304)	(0.588)	**(0.023)**	**(0.045)**	(0.369)	(0.725)	(0.294)
Remit	**0.068*** **	**0.094*** **	**0.094*** **	0.017	–0.026	–0.029	**–0.101*** **	**0.031*** **	**0.023** **	0.030	–0.051	**–0.306** **
	(0.000)	**(0.000)**	**(0.001)**	(0.377)	(0.346)	(0.328)	**(0.000)**	**(0.000)**	**(0.047)**	(0.230)	(0.242)	**(0.010)**
Trade	**–0.059*** **	**–0.070*** **	**–0.073*** **	–0.008	0.022	**–0.041** **	**0.065** **	**0.008** **	0.006	**–0.029** **	–0.024	**0.244*** **
	(0.000)	**(0.000)**	**(0.000)**	(0.421)	(0.148)	**(0.012)**	**(0.014)**	**(0.026)**	(0.339)	**(0.036)**	(0.308)	**(0.000)**
Net Effects	0.046	0.138	na	0.059	na	na	na	na	na	na	na	na
Thresholds	11.500	16.272	na	13.666	na	na	na	na	na	na	na	na
R^2/Pseudo R^2	0.282	0.250	0.154	0.192	0.191	0.099	0.117	0.035	0.078	0.091	0.098	0.150
Fisher	**56.33*** **						**30.92*** **					
Observations	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680	1680

*,**,***: significance levels of 10%, 5% and 1% respectively. *OLS* Ordinary Least Squares. R^2 for OLS and Pseudo R^2 for quantile regression. Lower quantiles (e.g., Q 0.1) signify nations where poverty headcount is least. *Gini* Income Inequality. *MobApp* Mobile used to pay bills online. *FinInDepth* Financial Institutions Depth. *FinInAcc* Financial Institutions Access. *FinInEffic* Financial Institutions Efficiency. *Gov. Exp* Government Expenditure. *GDPg* Gross Domestic Product growth. *FDI* Foreign Direct Investment. *Remit* remittances. The mean value of the mobile used to pay bills online is 3.718. *na* not applicable because at least one estimated coefficient needed for the computation of the net effect and/or threshold is not significant

Source: Authors

The bold values represent significant estimated coefficients and the Fisher statistics

of the mobile phone used to send money, the net effect of income inequality on poverty is zero or 0.000 = ([-0.003 × 23.666] + [0.071]). (ii) Above the 23.666 penetration threshold, say, 25.000 (% age 15 +) of the mobile phone used to send money, the net effect becomes -0.004 = ([-0 .003 × 25.000] + [0.071]). Hence, policy makers should work towards ensuring that the penetration levels of mobile money innovations are above the projected thresholds in order for income inequality to no longer increase poverty. The computation is in line with contemporary interactive regressions literature on the importance of leveraging on mechanisms and policy variables to provide empirical findings with more actionable policy-making tools (Nchofoung & Asongu, 2022b; Nchofoung et al., 2022).

For the corresponding thresholds provided in Tables 1 and 2 to make policy sense and have economic meaning, they must be within the statistical limits disclosed in the summary statistics. In other words, the policy thresholds should be situated between the minimum and maximum levels provided in the summary statistics. Taking the same example above into consideration, the 23.666 threshold is within policy range and makes statistical sense because it is situated between 0.000 (i.e. minimum) and 50.122 (i.e. maximum) of the mobile used to send money in Appendix Table 4 of the summary statistics.

The computation is thresholds is consistent with contemporary interactive regressions literature especially as it pertains, *inter alia*, the relevance of globalization thresholds in the incidence of information technology on sustainable development (Nchofoung & Asongu, 2022b); human capital and financial development thresholds in the nexus between infrastructure development and industrialization (Nkemgha et al., 2023) and governance policy thresholds in the linkage between economic openness and inclusive green growth (Ofori & Figari, 2023).

Consistent with Asongu and Odhiambo (2023), the findings can be further discussed in relation to the attendant literature with respect to below and above the computed policy thresholds. Below the mobile money policy thresholds, the findings are consistent with a strand of literature, documenting the insignificance and/or unfavorable incidence of mobile money innovations and financial technologies on inclusive development, notably, some of the financially excluded not leveraging on financial technologies to improve their socio-economic conditions (Cheah et al., 2021; Chen et al., 2021; Molinier & Quan, 2019). Accordingly, some poorer fractions of the population may prefer to rely on traditional modes of financial transactions when mobile money innovations are below the established thresholds in this study (Cheah et al., 2021). Hence, some excluded fractions of the population can be more willing to remain in the status quo and hence, not adopt financial innovations (Demirguc-Kunt et al., 2018), especially in situations where traditional constraints are apparent (Kofman & Payne, 2021).

Conversely, the fact that above the mobile money innovation thresholds, mobile money is relevant in reducing the positive incidence of inequality on poverty, is consistent with another strand of literature on the importance of financial technologies in inclusive development (Asongu & Odhiambo, 2023; Yeyouomo et al., 2023), *notably*: Suri and Jack (2016) who have shown that financial technologies reduce household poverty as well as corresponding literature on the importance of financial technologies in reducing socio-economic exclusion (Loko & Yang, 2022; Moufakkir & Mohammed, 2020; Sahay et al., 2020; Sioson & Kim, 2019; Yeyouomo et al., 2023).

4.3 Implications to Theory

The invalidity of *Hypothesis* 2 below some mobile money innovation thresholds improves the theoretical underpinnings of the study in the perspective that, the technology acceptance theories motivating this study are valid only when some critical levels of technology have been attained in an economy. This is essentially because below the critical levels of corresponding technologies, the technologies are not relevant in achieving the objective for which the customers adopted them. It follows that the theory of reasoned action (TRA), technology acceptance model (TAM) and theory of planned behavior (TPB) discussed in Section 2.2 are contingent on extant levels of information technology penetration.

Moreover, the invalidity of *Hypothesis* 2 below the mobile money innovation thresholds, could also be traceable to a premise that the poor may always want to maintain certain traditional values or a status quo until the underlying technologies have become very popular, with proven success in improving the socio-economic conditions of those who adopt them (Cheah et al., 2021; Chen et al., 2021). It also worthwhile note that the technological acceptance, planned behavior and reasoned action theories that motivate the adoption of mobile money innovations in view of mitigating the incidence of inequality on poverty, may not hold below some mobile money innovations thresholds because, below such thresholds, innovations in mobile money are still clouded by issues related to information asymmetry that need to be addressed in order for the poor to properly leverage on mobile money innovations below the attendant thresholds of mobile money innovations.

4.4 Implications to Practice

In terms of policy implications, three main insights are worth noting. (i) Within the framework of an interactive regression, when policy thresholds or threshold for

complementary policies are computed and provided to policy makers, these attendant thresholds directly reflect actionable critical masses of the policy variables that can be acted upon by policy makers on the main channel in order to influence the outcome variable in a desired direction. For instance, above the established critical masses of mobile money innovations, at the corresponding quantiles, poverty can be mitigated through the inequality channel. (ii) By providing mobile money innovations policy thresholds at which the positive incidence of income inequality on poverty is mitigated, the study has direct implications for SDG10 (i.e. inequality reduction) and SDG1 (i.e. poverty mitigation). (iii) The computed thresholds are not substantially close to the corresponding maximum levels in the summary statistics, which is an indication that the policy thresholds can be achieved without exceptional policy effort.

4.5 Limitations and Future Research Directions

One main shortcoming of the study is that quantile regressions enable the understanding of global nexuses and incidences. Hence, other country-centric studies are relevant within the remit of corresponding robust country-oriented time series empirical strategies, in order to provide policy makers with more country-specific policy implications. Moreover, as clarified in the theoretical implications of the study, the caveat that below some mobile money thresholds, information asymmetry can cloud the relevance of mobile money innovations in the incidence of inequality on poverty could be addressed in future research by further interacting mobile innovations with proxies for reducing information asymmetry. Future research can also focus on assessing other mechanisms and policy variables that mitigate poverty in order to improve conditions for the achievement of SDG1 on extreme poverty reduction. Moreover, reconsidering the analysis and focusing on other SDGs is relevant for policy makers, not least, because in the light of the narratives in this study, financial inclusion is associated with most SDGs.

5 Conclusion

This study has investigated the role of mobile money innovations in the incidence of income inequality on poverty and severity of poverty in 42 sub-Saharan African countries over the period 1980 to 2019. Mobile money innovations are understood as the mobile used to send money and the mobile used to pay bills online while income inequality is measured with the Gini index. Poverty is measured as the poverty headcount ratio while the severity of poverty is generated as the squared of the poverty gap index. The empirical evidence is based on interactive Quantile regressions. The relevance of employing QR is twofold: on the one hand, assessing the investigated nexuses throughout the conditional distribution of poverty limits the prospects of blanket policies from regression models based on mean values of the outcome variable. Hence, the specification is tailored such that the effectiveness of fighting poverty and the severity of poverty is contingent on initial levels of poverty and the severity of poverty. One the other hand, the incidence of inequality on poverty is tailored within an interactive framework such that critical masses of mobile money innovations are provided at which the incidence on inequality on poverty changes from positive to negative.

The following main findings are established. (i) Income inequality unconditionally reduces poverty and the severity of poverty though the significance is not throughout the conditional distributions of poverty and the severity of poverty. (ii) Mobile money innovations significantly moderate the positive incidence of income inequality on poverty and the severity of poverty in some quantiles. (iii) Positive net effects are apparent exclusively in the poverty regressions. (iv) Given the negative conditional effects, policy thresholds or minimum mobile money innovation levels needed to completely nullify the positive incidence of income inequality on poverty are provided: 27.666 (% age 15+) and 24.000 (% age 15+) of the mobile used to send money in the 50th and 75th quantiles, respectively and 16.272 (% age 15+) and 13.666 (% age 15+) of the mobile used to pay bills online in the 10th and 50th quantiles, respectively. Implications for theory and policy have been discussed. Caveats have been acknowledged and future research directions suggested.

Appendix

Table 3 Definitions and sources of variables

Variables	Definitions	Sources
Poverty Headcount	Poverty headcount ratio at national poverty lines (% of population)	WDI (World Bank)
Severity of poverty	"Poverty severity, which measures the degree of inequality among the poor by putting more weight on the position of the poorest". Squared of poverty gap index	Generated
Income Inequality (Gini)	"The Gini coefficient is a measurement of the income distribution of a country's residents"	WDI (World Bank)
Mobile Send	The percentage of respondents who report using a mobile phone to send money in the past 12 months (% age 15 +)	GFDD (World Bank)
Mobile Payment	The percentage of respondents who report using a mobile phone to pay bills in the past 12 months (% age 15 +)	GFDD (World Bank)
Financial Institutions Depth Index	"*The Financial Institutions Depth (FID) Index, which compiles data on bank credit to the private sector, pension fund assets, mutual fund assets, and insurance premiums (life and non-life) as percentages of GDP*"	Findex (World Bank)
Financial Institutions Access Index	"*The Financial Institutions Access (FIA) Index, which compiles data on the number of bank branches and the number of automatic teller machines (ATMs) per 100,000 adults*"	Findex (World Bank)
Financial Institutions Efficiency Index	"*The Financial Institutions Efficiency (FIE) Index, which compiles data on the banking sector's net interest margin, the lending–deposits spread, the ratios of non-interest income to total income and overhead costs to total assets, and the returns on assets and equity*"	Findex (World Bank)
Inflation	Inflation, consumer prices (annual %)	WDI (World Bank)
Foreign Aid	Net Official Development Assistance received (% of GNI)	WDI (World Bank)
Government Expenditure	General government final consumption expenditure (% of GDP)	WDI (World Bank)
Economic growth	GDP growth (annual %)	WDI (World Bank)
Foreign Investment	Foreign direct investment, net inflows (% of GDP)	WDI (World Bank)
Remittances	Remittance inflows (%GDP)	WDI (World Bank)
Trade	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product	WDI (World Bank)

GDP Gross Domestic Product. *GNI* Gross National Income. *WDI* World Development Indicators. *IMF* International Monetary Fund. *GFDD* Global Financial Development Database

Source: Authors

Table 4 Summary statistics

	Mean	S.D	Min	Max	Obs
Poverty Headcount	48.215	14.055	7.900	73.200	1680
Severity of Poverty	16.529	22.480	0.000	169.299	1681
Inequality (Gini)	53.250	19.829	0.000	86.832	1680
Mobile Send	10.280	13.011	0.000	50.122	1680
Mobile Payment	3.718	5.154	0.000	37.104	1680
Financial Institutions Depth	0.097	0.147	0.000	0.880	1680
Financial Institutions Access	0.077	0.128	0.000	0.880	1680
Financial Institutions Efficiency	0.494	0.199	0.000	0.990	1680
Inflation	32.026	593.191	–13.056	23773.13	1680
Foreign Aid	11.345	11.527	–0.250	94.946	1680
Government Expenditure	5.353	25.868	–17.463	565.538	1680
GDP growth	3.635	5.173	–50.248	35.224	1680
Foreign Direct Investment	2.938	6.456	–28.624	103.337	1680
Remittances	4.385	17.842	0.000	235.924	1680
Trade Openness	67.240	35.588	6.320	311.354	1680

SD Standard Deviation. *Min* Minimum. *Max* Maximum

Source: Authors

Table 5 Correlation matrix (uniform sample size: 1680)

	PovHC	SoPov	Gini	Mobsen	Mobpay	FID	FIA	FIE
PovHC	1.000							
SoPov	0.071	1.000						
Gini	0.120	0.139	1.000					
Mobsen	–0.069	0.016	–0.051	1.000				
Mobpay	0.080	0.034	–0.035	0.873	1.000			
FID	–0.069	–0.207	0.001	0.024	0.056	1.000		
FIA	–0.264	–0.283	–0.156	–0.081	–0.100	0.412	1.000	
FIE	–0.338	–0.146	–0.034	–0.089	–0.087	0.312	0.305	1.000
Infl	0.055	0.066	0.012	–0.017	–0.017	–0.025	–0.022	0.001
NODA	0.375	0.084	0.097	0.083	0.117	–0.251	–0.164	–0.246
Gov	–0.044	–0.023	0.017	0.016	0.001	0.036	0.018	0.073
GDPg	–0.111	–0.036	0.005	0.043	0.044	0.001	0.029	0.069
FDI	0.004	–0.050	–0.094	–0.031	–0.040	0.058	0.196	–0.010
Remit	0.082	–0.046	0.044	0.037	0.180	0.111	–0.013	–0.052
Trade	–0.146	–0.054	–0.040	–0.062	–0.005	0.255	0.380	0.005

	Infl	NODA	Gov	GDPg	FDI	Remit	Trade
PovHC							
SoPov							
Gini							
Mobsen							
Mobpay							
FID							
FIA							
FIE							
Infl	1.000						
NODA	–0.013	1.000					
Gov	–0.095	–0.092	1.000				
GDPg	–0.062	–0.017	0.146	1.000			
FDI	–0.017	0.069	0.031	0.081	1.000		
Remit	–0.009	0.034	0.088	0.031	0.014	1.000	
Trade	–0.028	–0.056	0.083	0.059	0.308	0.305	1.000

PovHC Poverty Headcount. *SoPov* Severity of Poverty. *Gini* the Gini Coefficient. *Mobsen* Mobile phones used to send money. *Mobpay* Mobile used to pay bills online. *FID* Financial Institutions Depth. *FIA* Financial Institutions Access. *FIE* Financial Institutions Efficiency. *Infl* Inflation. *NODA* Foreign Aid. *Gov* Government Expenditure. *GDPg* Gross Domestic Product growth. *FDI* Foreign Direct Investment. *Remit* remittances

Source: Authors

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Data Availability The data for this research are available upon request.

Declarations

Ethical Approval This article does not contain any studies with human participants or animals performed by the authors.

Conflict of Interest The authors declare that they have no conflict of interest.

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