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HUMAN DEVELOPMENT THRESHOLDS FOR INCLUSIVE MOBILE BANKING IN DEVELOPING COUNTRIES

Simplice A. Asongu² and Nicholas M. Odhiambo³

Abstract

This study assesses human development thresholds at which mobile banking mitigates poverty and inequality in 93 developing countries for the year 2011. Mobile banking entails: ‘mobile used to pay bills’ and ‘mobile used to receive/send money’, while the modifying policy indicator is the human development index (HDI). The empirical evidence is based on interactive quantile regressions. A summary of the findings shows that with increasing human development: (i) ‘mobiles used to pay bills’ contribute to reducing inequality in countries at the bottom and top ends of the inequality distribution, while (ii) ‘mobiles used to receive/send money’ have an appealing role in promoting inclusive development in all poverty distributions, with the exception of the top-end or 90th decile. The modifying thresholds of the HDI vary from 0.542 to 0.632 and 0.333 to 0.705 in inequality and poverty specifications, respectively. The relevance of the findings is discussed in light of the current transition from Millennium Development Goals to Sustainable Development Goals.

Key words: Mobile banking; Quality of growth; poverty; inequality

JEL Classification Code: G20; O40; I10; I20; I32

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Introduction

The market for mobile money is estimated to reach 1.3 billion USD by 2019 from about 655.8 million in 2014 (Caulderwood 2015). This represents considerable financial inclusive opportunities for the improvement of livelihoods and business development, especially for the social strata of the population that has been excluded from formal banking institutions. According to the narrative, the underlying advantages from mobile banking are more apparent in developing countries because, according to the Global Findex Inclusion Database, only 23% of adults living with less than 2USD/day have a bank account.

Mobile phones⁴ and mobile banking have been documented to provide a plethora of inclusive development benefits, notably: bridging the rural-urban divide (Qiang *et al.* 2011, 14-26; Chan and Jia 2011, 3-5), women empowerment (Maurer 2008; Ojo *et al.* 2012), promotion of financial inclusion (Kirui *et al.* 2013, 141; Singh 2012, 466; Asongu 2013a), mitigation of income-inequality (Asongu and Nwachukwu 2016a, 2016b), improvement of health services for the poor (Kline *et al.* 2013), enhancement of business opportunities (Ondiege 2010, 11; Mishra and Bisht 2013, 505), elimination of agricultural wastages through a reduction of demand-supply mismatches as well as demand- and supply-side constraints (Muto and Yamano 2009; Aker and Fafchamps 2010; Tchamyoun, 2017) and efficiency in the management of households (Al Surikhi 2012; Asongu 2015).

In light of the above, there have been growing calls for more research on the development outcomes of mobile phone applications (Mpogole *et al.* 2008, 71). Partly motivated by cautions that the mobile phone should not be automatically considered as a silver bullet of development (Asongu and De Moor 2015), the World Bank, in its continuous effort towards inclusive development has provided the research community with the first macroeconomic database on mobile banking (Mosheni-Cheraghloou 2013). This represents an opportunity to assess the role of mobile banking in inclusive development.

The motivation for assessing a 'mobile banking'-'inclusive development' nexus is at least twofold. First, with the transition from Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs), the policy debate has shifted from development to inclusive development (Asongu and Rangan 2016). Second, the imperative of the underlying policy debate has reemerged with the April 15th 2015 publication by the World Bank of World Development Indicators which has concluded that, poverty has not been decreasing in many regions of the world, especially in Africa (Asongu and Kodila-Tedika 2017).

⁴ The term 'mobile phones' is used interchangeably with 'cell phones' 'mobile telephony' and 'mobiles' throughout this paper.

As far as we have reviewed, the positioning of this line of inquiry steers clear of the inclusive development literature on the one hand and the mobile banking literature on the other hand. First, on the latter, the mobile banking literature which has been fundamentally based on surveyed microeconomic data for the most part has focused on mobile banking adoption intentions (Medhi *et al.* 2009; Gu *et al.* 2009; Daud *et al.* 2011; Akturan and Tezcan 2012; Kazi and Mannan 2013; Alsheikh and Bojei 2014; Cudjoe *et al.* 2015). We steer clear of this stream by: (i) focusing on macroeconomic data and (ii) broadening the scope from country-specific studies to 93 developing countries. Second, on the former, the available inclusive development literature has focused essentially on: gender inequality (Anyanwu 2013b, 2014b; Elu and Loubert, 2013; Balamoune-Lutz 2007; Balamoune-Lutz and McGillivray 2009), poverty correlates (Anyanwu 2013a, 2014a), reinventing development assistance for inclusive and sustainable development (Asongu 2016), measurements of inclusive development (Anand *et al.* 2013; Mlachila *et al.* 2017), recent advances in finance for inclusive development (Asongu and De Moor 2015) and debates between relative pro-poor (Dollar and Kraay 2003) versus absolute pro-poor (Ravallion and Chen 2003) growth. The last-two streams are closest to this study because we build on recent advances in finance by assessing the pro-poor character of mobile banking.

In order to provide more room for policy implications, we employ: (i) interactive (ii) quantile regressions (QR). Evidently, there is a twofold motivation for this empirical strategy. First, the intuition of the QR is that blanket policies may not be effective unless they are contingent on initial inclusive development levels and tailored differently across high-inclusiveness and low-inclusiveness countries. Second, we interact the mobile banking independent variables of interest with human development in order to further examine at what thresholds of human development mobile banking positively influences inclusive development. Inclusive development is measured by indicators of poverty and inequality while mobile banking entails: ‘*mobile phone usage for the payment of bills (% of adults)*’ and ‘*mobile phone usage for sending/receiving of money (% of adults)*’⁵.

The rest of the study is organized as follows. The ‘Theoretical highlights and literature review’ section provides theoretical underpinnings and reviews the relevant literature. In the ‘Data and methodology’ section, we discuss the measurement of variables and adopted

⁵ The positioning of the paper also departs from recent studies on the use of information and communication technology for doing business and economic development (Kuada, 2009, 2014, 2015; Tony and Kwan 2015; Afutu-Kotey *et al.* 2017; Bongomin *et al.* 2018; Gosavi 2017; Hubani and Wiese 2017; Isszhaku *et al.* 2017; Minkoua Nzie *et al.* 2017; Muthinja and Chipeta 2017).

empirical strategy. The empirical analysis and discussion of results are covered in the ‘Empirical results’ section while the ‘Concluding implications and future research directions’ section presents concluding remarks.

Theoretical highlights and literature review

Theoretical highlights

Motivations for the adoption of mobile phones/banking embody complex and multifaceted processes, notably: (i) an approach centered on customers by managers and system developers on formation belief as opposed to a direct influence of attitudes and (ii) essential characteristics such as combined considerations (utilitarian, customers’ behavioral, personal, social and psychological features). For the interest of brevity, we briefly highlight the three most dominant theories on users’ attitudes documented by Yousafzai et al. (2010, 1172), notably, the: theory of reasoned action (TRA), theory of planned behavior (TPB) and technology acceptance model (TAM).

First, the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen (1975), Ajzen and Fishbein (1980) and Bagozzi (1982) supposes that, before adopting a given attitude, customers are rational in their considerations of all possible implications that their actions may generate. As a well grounded theory, it focuses on drivers of consciously-intended attitudes and is intuitive, insightful and parsimonious in its ability to clarify attitudes.

Second, the Theory of Planned Behavior (TPB) developed by Ajzen (1991) complements the TRA by identifying a fundamental set-back, which is the lack of a difference between individuals who have conscious control from those who do not. According to the account, perceived behavioural control (PBC) or a third factor also influences behavioural intentions and actual behaviour, the first-two factors being attitudinal and normative factors. Therefore, the extension of the TRA by the TPB incorporates scenarios where-by customers have restricted situation control. In line with the underpinnings, three principal considerations influence human actions, namely: (i) behavioural beliefs on various possible results from a particular attitude and examination the corresponding results; (ii) “*normative beliefs about the normative expectations of others and the motivation to comply with these expectations*” (Yousafzai et al. 2010, 1175-1176) and (iii) control beliefs on resources by individuals, opportunities that possessed and unpossessed resources as well as foreseen obstacles towards materialising an anticipating attitude. From a holistic perspective: (i) behavioural beliefs yield outcomes in either favourable or unfavourable attitudes linked to the underlying behaviour; (ii)

‘normative beliefs’ engender social pressure or perceived subjective norm and (iii) ‘control beliefs’ yields perceived behavioural control.

Third, the Technology Acceptance Model (TAM) is spear-headed by Davis (1989). In accordance with Yousafzai *et al.* (2007a, 2007b), the TAM has been developed to be a solid and parsimonious model. The authors sustain that, the TAM: (i) adapts to the framework of the TRA and (ii) assumes that the adoption of a specific technology by an individual can be elucidated by his/her voluntary intentions to accept and use the given technology. Within this framework, intention is defined as the perception of the individual on the usefulness of the technology and attitude towards its usage.

The three underlying theories align with this study in the perspective that customers adopt mobile phones because of perceived gains in inclusive development underlying mobile applications like mobile banking. In what follows, we engage some of these perceived rewards in substantive detail.

Mobile phones/banking and inclusive development

In accordance with Asongu and De Moor (2015), the mobile revolution has influenced almost every fabric of society in developing countries: enhancing household and corporate management by constantly improving networks of interaction. These include, among others: upgraded business-to-business networks, improved systems of health care monitoring, better payment facilities for Small and Medium Size Enterprises (SMEs), education in terms of skills and training, household-to-household and household-to-business interactions, women empowerment and reduction of gaps in development between rural and urban areas. As far as we have reviewed, the available inclusive development literature on mobile phone/banking can be classified in three main streams, notably: improvement of health services, gender-gap reduction and mitigation of the rural/urban divide.

In the first stream on reducing the gender gap, evidence on the relevance of mobile phones in female empowerment has been substantially documented. Some mobile phone/banking channels via which female financial inclusion is facilitated have included: (i) enhanced coordination of household activities and women-managed SMEs (Asong and Nwachukwu 2016a) and (ii) multi-tasking, cost-reduction and education (Jonathan & Camilo 2008; Ondiege 2010; Al Surikhi 2012; Ondiege 2013). The literature in this stream is consistent with the need for good government policy to facilitate the inclusive benefits of mobile phones/banking, notably: (i) Maurer (2008), on the central role of policy in promoting and sustaining the gender inclusiveness of mobile services and (ii) Ojo *et al.* (2012), on the

utilization of mobile phones by Ghanaian women to improve their livelihoods. More country-specific strategies/approaches have been documented by Ondiege (2010, 11) and Bisht (2013, 505).

The second stream which has focused on mitigating the rural-urban gap can be discussed in three main currents, notably: reduction of demand- and supply-side constraints in agricultural productivity; issues about unemployment, production and distribution of food in rural communities and support of SMEs and cooperatives. (i) In accordance with the engaged literature, mobile phone applications are increasingly being employed in rural communities to reduce demand- and supply-side constraints (Muto and Yamano 2009; Aker and Fafchamps 2010). This mitigation has enhanced farmers' incomes, hence, improved their growth opportunities. In summary, the overarching issues tackled by this stream are mechanisms by which mobile phones have reduced supply- and demand-wastes through improved matching networks and practices. (ii) Challenges of employment on the one hand and food production and distribution on the other hand are increasingly being addressed by mobile phones/banking. Eloquent examples include Ghana in which a study has revealed that better market information by means of mobile banking/applications improves income for traders by about 10% (E-agriculture 2012, 6-9). (iii) Mobile banking is consolidating agricultural finance by supporting SMEs and cooperatives. Cases in point include, among others: financially-sustainable groups in Costa Rica (Perez *et al.* 2011, 316) and the Community Credit Enterprises (CCE) that is improving the sustainability of business models (Asongu and De Moor 2015).

In summary, the benefits of mobile phones are more apparent in the livelihoods of underprivileged citizens in rural areas (Warren 2007) because comparatively, more barriers to the acquisition of information and purchase of commodities are lifted. For instance, in India, the adoption of mobile banking is boosting financial inclusions (Singh 2012, 466) in rural areas, partly because despite efforts devoted by formal financial institutions to remain major players in inclusive finance, '*Telecommunication infrastructure growth especially mobile phone penetration has created an opportunity for providing financial inclusion*' (Mishra and Bisht 2013, 503).

In the third stream related to health services, mobile phones are increasingly serving in healthcare delivery and improvement of medical services, essentially because of mobile services/applications destined to enhance better quality and more affordable health care (West 2013). Therefore, geographical and income constraints are being facilitated with the continuous employment of mobile phone applications to improve health services. Channels through which health services are improved include: access to laboratory test, medical record and reference

material. It is in this light that mobile applications are increasingly being adapted for: better tailored feedbacks owing to improved self-monitoring (Bauer *et al.* 2010); enhanced treatment and observations of patients with tuberculosis (Hoffman *et al.* 2010) and clinical appointments (Da Costa *et al.* 2010). Communities in rural areas have been documented to be among the greatest beneficiaries of health-oriented mobile applications (Kliner *et al.* 2013), a position that is in line with the conclusions of Kirui *et al.* (2013) on the absolute pro-poor features of mobile phones/banking in these communities: ‘*We conclude that mobile phone-based money transfer services in rural areas help to resolve a market failure that farmers face; access to financial services*’ (141).

The three streams above are consistent with the World Bank’s position on the critical role of mobile phones/banking in rural and agricultural development (Qiang *et al.* 2011, 14-26). A view that is broadly supported by Chan and Jia (2011) on the inclusive benefits of the mobile telephony in facilitating access to finance ‘*mobile banking is an ideal choice for meeting the rural financial needs*’ (p. 3) due to increasing ‘*rates for bank transfers through mobile cell phones at commercial banks*’ (Table 2, 5).

Data and methodology

Data

We assess a sample of 93 developing countries with cross-sectional data: (i) a 2005-2011 average from Mlachila *et al.* (2017) and the year 2011 from Mosheni-Cheraghrou (2013). The dataset from the former consists of four non-overlapping intervals (1990-1994; 1995-1999; 2000-2004 and 2005-2011) while that of latter is only available for the year 2011. The dependent variable from Mlachila *et al.* (2017) consists of the inequality index and the poverty rate. Hence, the dataset is a cross-section for the year 2011 because of data availability constraints at the time of the study.

The mobile phone/banking variables are from Mosheni-Cheraghrou (2013). As far as we have reviewed, macroeconomic indicators for mobile banking are only available for the year 2011. The two main mobile banking indicators are: ‘*mobile phone usage for the payment of bills (% of adults)*’ and ‘*mobile phone usage for sending/receiving of money (% of adults)*’.

Consistent with recent inclusive development literature (Anand *et al.*, 2013; Asongu and Nwachukwu 2016c; Asongu and Rangan 2016), the adopted control variables include: *education spending, government stability, credit, inflation, foreign direct investment (FDI) and remittances*, while the modifying human development variable is the human development index (HDI). The definitions of the variables are provided in Appendix 1. But for inflation, we expect

the control variables to be positively related to inclusive development (or negatively related to poverty and inequality). The inflation sign cannot be established with certainty because while high inflation mitigates inclusive development, low and stable inflation is appealing for inequality reduction (Asongu 2013b). This is fundamentally because; chaotic inflation discourages the much needed investment for economic growth because investors have been documented to prefer less ambiguous strategies (Kelsey and Le Roux 2017a, 2017b).

The positive covariates to inclusive development have been substantially documented in the inclusive development literature (Dollar and Kraay 2003; Barro and Lee 2000; Calderon and Servén 2004; Levine 2005; Hausmann *et al.* 2007; IMF 2007; Mishra *et al.* 2011; Anand *et al.* 2012; Seneviratne and Sun 2013). We devote space to briefly discuss the corresponding literature. Consistent with the International Monetary Fund (IMF 2007) and Anand *et al.* (2013), macroeconomic stability, human capital and structural change are crucial drivers of inclusive development in developing countries. Structural change also embodies, globalisation (e.g. foreign direct investment: FDI), macroeconomic stability and human capital. Other documented structural and macroeconomic features needed for inclusive development entail: stable inflation and less negative output volatility (Barro and Lee 2010; Dollar and Kraay 2003), financial access (Levine, 2005), value chains enhancement (Hausmann *et al.* 2007; Anand *et al.* 2012), improvements in infrastructure (Calderon and Servén 2004; Seneviratne and Sun 2013) and modernization of production facilities (Mishra *et al.* 2011).

Appendix 2 presents the summary statistics while Appendix 3 reveals the correlation matrix. From the summary statistics we observe that: (i) the means are comparable and (ii) the variables show a substantial degree of variation, thus we can be confident that reasonable estimated nexuses would emerge. The objective of the correlation matrix is to mitigate potential concerns of multicollinearity and overparameterization. A multicollinearity concern is highlighted in bold: 0.865 for the two mobile banking indicators. We avoid employing them in the same specification.

Methodology

In line with the motivation provided in the introduction, we adopt Quantile regression (QR). The QR technique consists of examining the role of mobile banking in inclusive development throughout the conditional distributions of the dependent variable. That is, from high-‘inclusive development’ to low-‘inclusive development’ countries. The distribution is from high to low because poverty and inequality indicators are negative signals. The QR

provides estimates at multiple thresholds of the conditional distributions of inclusive development (Koenket and Hallock 2001; Tchamyou and Asongu 2017).

Previous studies such as Mlachila *et al.* (2017) have reported parameter estimates at the conditional mean of inclusive development. Whereas such mean impacts are important, we complement the underlying stream of studies by using QR to engage determinants throughout the conditional distribution of the dependent variable. For instance, while Ordinary Least Squares (OLS) is based on the assumption that error terms of the inclusive development indicator are normally distributed, this assumption does not hold for QR estimations. Accordingly, with the approach, parameter estimates are derived at multiple points of the conditional distributions of inclusive development (Koenker and Bassett 1978). The QR estimation strategy is increasingly being employed in development literature, inter alia in: finance, (Asongu 2014a), health (Asongu 2014b), corruption (Billger and Goel 2009; Okada and Samreth 2012; Asongu 2013c) and studies. In summary, the strategy enables an examination of the role of mobile banking with particular emphasis on best- and worst-performing developing countries in terms of inclusive development.

The θ^{th} quantile estimator of inclusive development is obtained by solving for the following optimization problem, which is presented without subscripts in Eq. (1) for the purpose of simplicity and readability.

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

Where $\theta \in (0,1)$. Contrary to OLS which is fundamentally based on minimizing the sum of squared residuals, with QR, the weighted sum of absolute deviations are minimised. For example the 10th decile or 25th quartiles (with $\theta=0.10$ or 0.25 respectively) by approximately weighing the residuals. The conditional quantile of inclusive development or y_i given x_i is:

$$Q_y(\theta / x_i) = x_i' \beta_\theta \quad (2)$$

Where unique slope parameters are modelled for each θ^{th} specific quantile. This formulation is analogous to $E(y / x) = x_i' \beta$ in the OLS slope where parameters are assessed only at the mean of the conditional distribution of inclusive development. For Eq. (2) the dependent variable y_i is either the poverty or inequality indicator while x_i contains: a constant term, *education spending, government stability, credit, inflation, foreign direct investment (FDI) and remittances.*

Since, the empirical technique adopted by this study involves interactive models; it is relevant to briefly engage some pitfalls of interactive estimations. As documented by Brambor *et al.* (2006), for the estimation to have economic meaning, the corresponding estimates from interactive models should be interpreted as conditional marginal effects. It follows that the modifying human development variable should be within the range provided by the summary statistics for marginal correlations to have economic meaning.

Empirical results

Table 1 and Table 2 present findings corresponding respectively to inequality and poverty. Whereas Panel A of all tables provide findings related to the ‘*mobile phone used to pay bills*’, Panel B is focused on the ‘*mobile phone used to send/receive money*’. For either table, we consistently notice that the QR estimates are different from the OLS estimates in terms of signs and significance. This further justifies the relevance of the QR strategy. Before we discuss table-specific findings, for the interest of clarity, it is relevant to briefly discuss three issues in order to enhance readability, notably: signals of the dependent variable, conditional distributions and thresholds for inclusive development. First, the inclusive development variables have negative signals, implying that higher values are unappealing. Second, low-ends of the distributions represent high-‘inclusive development’ and vice versa. Third, for mobile banking to boost inclusive development, negative thresholds are required of the modifying human development variable.

The following findings can be established from Table 1 on linkages between ‘mobile banking and inequality’. First, in Panel A, the interaction between the ‘mobile used to pay bills’ and the HDI is negatively correlated with inequality for: OLS, the 10th and the 90th deciles. The corresponding negative thresholds are within the HDI range (0.280 to 0.809) disclosed by the summary statistics, notably: (i) 0.613 (2.648/4.319) for OLS, (ii) 0.632 (2.302/3.638) for the 10th decile and (iii) 0.580 (3.033/5.221) for the 90th decile. It follows that relatively higher levels of human development are needed for the inclusive benefits of ‘mobiles used to pay bills’ at the bottom distribution of inequality compared to the top-end of the distribution. Second, in Panel A, the interaction between ‘mobile used to send/receive money’ and the HDI is negatively correlated with inequality for OLS and the 90th decile, with corresponding negative thresholds within the HDI range, notably: (i) 0.603 (0.581/0.963) for OLS and (ii) 0.542 (0.868/1.599) for the 90th decile.

Third, some of the significant control variables display the expected signs. (i) Government stability consistently has a negative relationship with inequality. (ii) Remittances

scantly reduce inequality at the bottom-end of the distribution. (iii) Inflation is negatively (positively) correlated with inequality at the low- (high-) end of the inequality distribution. Accordingly, whereas a ‘low and stable’ inflation is conducive for inclusive development, the effect may be more negative on the poor if initial levels of inequality are high. This ultimately results in higher (lower) levels of inequality in countries with higher (lower) initial levels of inequality. (iv) The fact that educational spending and private domestic credit increase inequality may derive from negative externalities of structural inequality, whereby policies tailored towards reducing inequality may only end-up fuelling inequality.

Table 1: Mobile banking, human development and Inequality

| Panel A: Mobile for Payment of Bills (Mobile.Pay) | | | | | |
|---|------|------|------|------|------|
| OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |

| | | | | | | |
|--|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Constant | 39.149*** (0.000) | 38.800*** (0.000) | 36.878*** (0.000) | 39.469*** (0.000) | 45.711*** (0.000) | 38.872*** (0.000) |
| Mobile.Pay | 2.648** (0.024) | 2.302*** (0.000) | 2.046 (0.349) | 1.140 (0.565) | 1.902 (0.485) | 3.033*** (0.001) |
| Mobile.Pay × HDI | -4.319** (0.023) | -3.638*** (0.000) | -3.189 (0.355) | -1.708 (0.540) | -3.089 (0.421) | -5.221*** (0.000) |
| Educational Spending | 12.684** (0.014) | -2.464 (0.400) | 9.395 (0.397) | 9.384 (0.442) | 15.306 (0.329) | 14.364** (0.028) |
| Government Stability | -1.255*** (0.001) | -0.464*** (0.000) | -1.083* (0.078) | -1.165 (0.205) | -1.171 (0.259) | -0.995*** (0.003) |
| Inflation | -0.262 (0.245) | -0.489*** (0.000) | -0.447 (0.395) | -0.074 (0.901) | -0.443 (0.429) | 0.516** (0.025) |
| Credit | 0.017 (0.684) | 0.013 (0.283) | 0.003 (0.956) | 0.018 (0.972) | -0.020 (0.853) | 0.076*** (0.006) |
| Foreign Direct Investment | -0.156 (0.474) | 0.002 (0.968) | -0.017 (0.966) | -0.244 (0.690) | -0.261 (0.629) | -0.088 (0.762) |
| Remittances | -0.231 (0.120) | -0.0420 (0.348) | -0.241 (0.261) | -0.307 (0.348) | -0.412 (0.333) | 0.150 (0.198) |
| R ² / Pseudo R ² | 0.240 | 0.1508 | 0.135 | 0.147 | 0.158 | 0.230 |
| Fisher | 3.78*** | | | | | |
| Observations | 67 | 67 | 67 | 67 | 67 | 67 |

Panel B: Mobile for sending and receiving money (Mobile.SR)

| | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |
|--|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Constant | 39.524*** (0.000) | 34.316*** (0.000) | 35.178*** (0.000) | 39.470*** (0.000) | 44.242*** (0.000) | 39.476*** (0.000) |
| Mobile.SR | 0.581* (0.078) | 0.281 (0.372) | 0.711 (0.432) | 0.481 (0.553) | 0.756 (0.371) | 0.868*** (0.005) |
| Mobile.SR × HDI | -0.963* (0.085) | -0.209 (0.685) | -1.037 (0.489) | -0.826 (0.586) | -1.486 (0.336) | -1.599*** (0.004) |
| Educational Spending | 11.202** (0.034) | 4.539 (0.555) | 11.017 (0.305) | 8.940 (0.419) | 14.145 (0.347) | 11.924** (0.013) |
| Government Stability | -1.224*** (0.001) | -0.755* (0.067) | -1.021* (0.091) | -1.063 (0.201) | -1.016 (0.354) | -0.989*** (0.002) |
| Inflation | -0.196 (0.409) | -0.282 (0.297) | -0.447 (0.361) | -0.086 (0.873) | -0.354 (0.544) | 0.752*** (0.000) |
| Credit | 0.015 (0.729) | 0.007 (0.882) | -0.003 (0.959) | 0.017 (0.972) | -0.020 (0.850) | 0.076*** (0.000) |
| Foreign Direct Investment | -0.205 (0.346) | -0.389 (0.119) | -0.069 (0.853) | -0.221 (0.684) | -0.153 (0.878) | -0.116 (0.610) |
| Remittances | -0.216* (0.087) | -0.058 (0.690) | -0.138 (0.500) | -0.292 (0.205) | -0.390 (0.266) | 0.108 (0.607) |
| R ² / Pseudo R ² | 0.208 | 0.137 | 0.127 | 0.152 | 0.149 | 0.188 |
| Fisher | 3.58*** | | | | | |
| Observations | 67 | 67 | 67 | 67 | 67 | 67 |

***, **, *: significance levels of 1%, 5% and 10% respectively. Lower quantiles (e.g., Q 0.1) signify nations where Inequality is least. OLS: Ordinary Least Squares. R² for OLS and Pseudo R² for Quantile Regressions. Mobile.Pay: Mobile for payment of bills. Mobile. SR: Mobile for Sending and Receiving in Money. HDI: Human Development Index. The HDI is not included in the interaction regression because of perfect multicollinearity.

The following findings can be established from Table 2 on linkages between ‘mobile banking and poverty’. First, in Panel A, the interaction between the ‘mobile used to pay bills’ and the HDI is negatively correlated with inequality for: OLS, the 25th quartile, the 50th quartile, and 75th quartile. The corresponding negative thresholds are within the HDI range (0.280 to

0.809) disclosed by the summary statistics, notably: (i) 0.642 (0.027/0.042) for OLS, (ii) 0.333 (0.001/0.003) at the 25th quartile, (iii) 0.705 (0.024/0.034) at the 50th quartile and (iv) 0.683 (0.041/0.060) at the 75th quartile. It follows that thresholds needed for the poverty mitigation benefits of ‘mobiles used to pay bills’ display an inverted U-shape from the 25th to the 75th quartile. Second, in Panel A, the interaction between the ‘mobile used to send/receive money’ and the HDI is negatively correlated with inequality for OLS and throughout the distributions (with the exception of the 90th decile), with corresponding negative thresholds within the HDI range, notably: (i) 0.600 (0.009/0.015) for OLS, (ii) 0.666 (0.004/0.006) for the 10th decile, (iii) 0.642 (0.009/0.014) for the 25th quartile, (iv) 0.666 (0.012/0.018) for the 50th quartile and (v) 0.600 (0.015/0.025) for the 75th quartile. The thresholds follow a wave-like pattern from the 25th to the 75th quartiles. Third, the consistent significant control variable displays expected signs. We notice that educational spending is negatively related to inequality and its insignificance in the highest quantile is consistent with the corresponding explanation provided in Table 1 for structural inequality.

Table 2: Mobile banking and Poverty

Panel A: Mobile for Payment of Bills (Mobile.Pay)

| | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |
|--|----------------------------|---------------------|-----------------------------|-----------------------------|-----------------------------|--------------------|
| Constant | 0.156*** (0.005) | 0.002 (0.007) | 0.024*** (0.000) | 0.103*** (0.000) | 0.293*** (0.000) | 0.247 (0.248) |
| Mobile.Pay | 0.027* (0.096) | 0.0002 (0.438) | 0.001** (0.028) | 0.024*** (0.000) | 0.041*** (0.005) | 0.016 (0.728) |
| Mobile.Pay × HDI | -0.042* (0.086) | -0.0003 (0.453) | -0.003** (0.019) | -0.034*** (0.000) | -0.060*** (0.004) | -0.028 (0.693) |
| Educational Spending | -0.171** (0.023) | -0.003 (0.033) | -0.023*** (0.000) | -0.108*** (0.000) | -0.301*** (0.003) | -0.306 (0.251) |
| Government Stability | -0.002 (0.531) | -0.00001 (0.829) | 0.00005 (0.802) | 0.0003 (0.758) | -0.002 (0.697) | 0.003 (0.821) |
| Inflation | 0.003 (0.345) | -0.00001 (0.807) | -0.0003* (0.074) | -0.0004 (0.382) | -0.0004 (0.899) | 0.012 (0.425) |
| Credit | -0.0002 (0.274) | -0.000 (0.849) | -0.00001 (0.492) | -0.00008 (0.231) | 0.00003 (0.929) | -0.0003 (0.753) |
| Foreign Direct Investment | 0.001 (0.484) | 0.00001 (0.738) | -0.0001 (0.452) | 0.0004 (0.511) | -0.0006 (0.863) | 0.007 (0.422) |
| Remittances | 0.0001 (0.917) | 0.000 (0.688) | 0.00004 (0.584) | -0.0003 (0.216) | 0.002 (0.264) | 0.0007 (0.879) |
| R ² / Pseudo R ² | 0.283 | 0.006 | 0.021 | 0.154 | 0.290 | 0.361 |
| Fisher | 3.21*** | | | | | |
| Observations | 73 | 73 | 73 | 73 | 73 | 73 |

Panel B: Mobile for sending and receiving money (Mobile.SR)

| | OLS | Q.10 | Q.25 | Q.50 | Q.75 | Q.90 |
|--|----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|--------------------|
| Constant | 0.155*** (0.005) | -0.001 (0.934) | 0.004** (0.036) | 0.093*** (0.000) | 0.274*** (0.000) | 0.262 (0.246) |
| Mobile.SR | 0.009** (0.029) | 0.004*** (0.000) | 0.009*** (0.000) | 0.012*** (0.000) | 0.015*** (0.000) | 0.005 (0.712) |
| Mobile.SR × HDI | -0.015** (0.028) | -0.006*** (0.002) | -0.014*** (0.000) | -0.018*** (0.000) | -0.025*** (0.001) | -0.010 (0.697) |
| Educational Spending | -0.175** (0.013) | 0.002 (0.885) | -0.001 (0.719) | -0.096*** (0.000) | -0.252*** (0.000) | -0.337 (0.174) |
| Government Stability | -0.001 (0.635) | 0.00004 (0.977) | -0.0001 (0.442) | -0.0007 (0.572) | -0.003 (0.443) | 0.005 (0.764) |
| Inflation | 0.003 (0.368) | -0.00007 (0.937) | -0.0001 (0.198) | -0.0005 (0.476) | -0.002 (0.328) | 0.013 (0.425) |
| Credit | -0.0002 (0.252) | -0.00001 (0.915) | -0.00001 (0.570) | -0.00004 (0.609) | -0.0001 (0.724) | -0.0002 (0.798) |
| Foreign Direct Investment | 0.001 (0.554) | -0.000 (0.991) | -0.0001 (0.204) | 0.0003 (0.575) | 0.0009 (0.718) | 0.005 (0.532) |
| Remittances | 0.0006 (0.639) | 0.000 (0.985) | -0.00002 (0.601) | -0.00003 (0.905) | 0.002 (0.163) | 0.001 (0.813) |
| R ² / Pseudo R ² | 0.288 | 0.0156 | 0.097 | 0.216 | 0.305 | 0.351 |
| Fisher | 4.20*** | | | | | |
| Observations | 73 | 73 | 73 | 73 | 73 | 73 |

***, **, *: significance levels of 1%, 5% and 10% respectively. Lower quantiles (e.g., Q 0.1) signify nations where Inequality is least. OLS: Ordinary Least Squares. R² for OLS and Pseudo R² for Quantile Regressions. Mobile.Pay: Mobile for payment of bills. Mobile. SR: Mobile for Sending and Receiving in Money. HDI: Human Development Index. The HDI is not included in the interaction regression because of perfect multicollinearity.

Concluding implications and future research directions

This study has assessed human development thresholds at which mobile banking mitigates poverty and inequality in 93 developing countries for the year 2011. Mobile banking entails: ‘mobile used to pay bills’ and ‘mobile used to receive/send money’ while the modifying policy indicator is the human development index (HDI). The empirical evidence is based on interactive quantile regressions. A summary of the findings shows that with increasing human development: (i) ‘mobiles used to pay bills’ contribute to reducing inequality in countries at the bottom and top ends of the inequality distribution while (ii) ‘mobiles used to receive/send money’ have an appealing role in promoting inclusive development in all poverty distributions, with the exception of the top end or 90th decile. The modifying thresholds of the HDI vary from 0.542 to 0.632 and 0.333 to 0.705 in inequality and poverty specifications, respectively.

While the above findings are consistent with previous literature on the inclusive benefits of mobile phones/banking (Ondiege 2010; Ojo *et al.* 2012; Al Surikhi 2012; Mishra and Bisht 2013; Asongu and Nwachukwu 2016a, 2016b), we have complemented this stream of the literature in a number of dimensions already discussed in the introduction, notably: macroeconomic evidence, a plethora of developing countries, distinction between high-‘inclusive development’ and low-‘inclusive development’ countries and the relevance of a policy variable of human development (HDI) in the underlying relationship.

Despite the important role of mobile banking in inclusive development, this nexus has not featured prominently in the SDGs agenda. Maybe this missing element could be traceable to the scarce literature with macroeconomic empirical evidence on the underlying relationship for a broad sample of developing countries. This gap has inspired some ongoing reports like ‘Vodafone SIM project’ (Asongu and De Moor 2015).

Consistent with the stylized facts presented in the introduction, the implications of the findings are most relevant to sub-Saharan African countries for at least a fourfold reason. First, relative to other developing countries in the sub-region have been documented to enjoy relatively higher levels of mobile banking (Mosheni-Cheraghloou 2013). Second, countries in the sub-region have also been documented to reflect burgeoning levels of mobile banking (Caulderwood 2015) and significant growth opportunities of mobile phone penetration because their markets are not yet saturated relative to those of other regions (Penard *et al.*, 2012). Third, the April 15th World Bank report on MDGs has shown that poverty has been decreasing in all regions of the world with the exception of SSA. Mobile banking provides great room for mitigating immiserizing growth in the sub-region because: (i) the sub-region has been experiencing growth resurgence since the mid-1990s (Fosu 2015, 44; Asongu and Nwachukwu

2016d) and (ii) is currently hosting 7 of the 10 fastest-growing economies in the world (Asongu and Rangan 2016).

Overall, for all sampled developing countries, we have found that the HDI can be used as a crucial policy variable in the role of mobile banking in mitigating poverty and inequality in developing countries. However, it is important to note that components of the HDI (education, income per capita and life expectancy) have different regional tendencies, which should be considered by policy makers. In order to provide more policy insights, future research can focus on: (i) providing a comparative regional analysis of the established nexuses and (ii) decomposing the HDI into its respective components to assess which elements are most relevant in driving inclusiveness. A caveat to the study is that, given the cross-sectional nature of the data, the established thresholds are based on correlations instead of causality. Hence, as more data become available; it would be worthwhile for future research to also assess if the established thresholds withstand empirical scrutiny within the framework of causality.

Appendices

Appendix 1: Definition of variables

| Variable(s) | Definition(s) | Source(s) |
|------------------------------|--|-------------------------------|
| Poverty | Poverty rate: Proportion (per cent) of the population living on one USD a day | Mlachila <i>et al.</i> (2017) |
| Inequality | GINI index of Inequality | |
| Mobiles for bills | Mobile phone used to pay bills (% of Adults) | Mosheni-Cheraghrou (2013) |
| Mobiles to receiving/sending | Mobile phone used to send/receive money (% of Adults) | |
| Educational Spending | “Public resources allocated to education spending, as percent of GDP” (p. 25) | Mlachila <i>et al.</i> (2017) |
| Government Stability | “Index ranging from 0 to 12 and measuring the ability of government to stay in office and to carry out its declared program(s). The higher the index, the more stable the government is” (p. 25). | Mlachila <i>et al.</i> (2017) |
| Inflation | Inflation rate based on the Consumer Price Index (CPI) | Mlachila <i>et al.</i> (2017) |
| Credit to private sector | “Domestic credit to private sector, namely credit offered by the banks to the private sector, as percent of GDP” (p. 25). | Mlachila <i>et al.</i> (2017) |
| Foreign Direct Investment | “Net Inflows of Foreign Direct Investments, as percent of GDP” (p. 25) | Mlachila <i>et al.</i> (2017) |
| Remittances | “Workers' remittances and compensation of employees (Percent of GDP), calculated as the sum of workers' remittances, compensation of employees and migrants' transfers” (p. 25). | Mlachila <i>et al.</i> (2017) |
| Human Development | “Geometric mean of normalized indices measuring achievements in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living” (p. 25) | Mlachila <i>et al.</i> (2017) |

Appendix 2: Summary Statistics

| | Mean | S. D | Minimum | Maximum | Obs |
|------------------------------------|--------|--------|---------|---------|-----|
| Poverty rate | 0.062 | 0.113 | 0.000 | 28.127 | 93 |
| Inequality | 41.844 | 8.339 | 28.127 | 65.27 | 78 |
| Mobile for Bills payment | 2.601 | 4.125 | 0.000 | 25.70 | 80 |
| Mobile for Sending/Receiving money | 4.802 | 9.615 | 0.000 | 60.50 | 80 |
| Educational Spending | 0.701 | 0.211 | 0.202 | 1.000 | 93 |
| Health Spending | 0.734 | 0.189 | 0.284 | 0.995 | 93 |
| Government Stability | 2.626 | 2.242 | -0.379 | 11.278 | 93 |
| Inflation (log) | 7.909 | 4.106 | 2.202 | 21.669 | 90 |
| Domestic Credit (log) | 39.730 | 34.036 | -14.660 | 169.251 | 90 |
| Foreign Direct Investment | 4.488 | 3.720 | 0.0007 | 20.869 | 92 |
| Remittances | 5.445 | 7.612 | 0.003 | 38.590 | 84 |
| Human Development Index | 0.580 | 0.152 | 0.280 | 0.809 | 93 |

S.D: Standard Deviation. Obs: Observations.

Appendix 3: Correlation Matrix

Control variables

| Mobile banking

| Inclusive development

| Educ | GovStab | Infl | Credit | FDI | Remit | HDI | MBills | MSR | Pov. | GINI | |
|-------|---------|-------|--------|--------|--------|--------|--------|--------------|--------|--------|---------|
| 1.000 | 0.235 | 0.263 | 0.392 | 0.005 | 0.143 | 0.216 | 0.207 | -0.006 | -0.267 | 0.312 | Educ |
| | 1.000 | 0.277 | 0.324 | -0.125 | -0.063 | -0.098 | 0.080 | -0.182 | -0.171 | -0.188 | GovStab |
| | | 1.000 | 0.199 | 0.171 | -0.059 | -0.138 | 0.300 | 0.130 | 0.129 | -0.019 | Infl |
| | | | 1.000 | -0.202 | 0.530 | 0.387 | 0.082 | -0.183 | -0.367 | -0.185 | Credit |
| | | | | 1.000 | -0.159 | 0.034 | -0.082 | 0.012 | 0.203 | 0.065 | FDI |
| | | | | | 1.000 | -0.045 | -0.080 | -0.172 | -0.130 | 0.145 | Remit |
| | | | | | | 1.000 | 0.088 | -0.136 | -0.638 | -0.024 | HDI |
| | | | | | | | 1.000 | 0.865 | 0.142 | 0.039 | MBills |
| | | | | | | | | 1.000 | 0.185 | 0.062 | MSR |
| | | | | | | | | | 1.000 | 0.223 | Pov. |
| | | | | | | | | | | 1.000 | GINI |
| | | | | | | | | | | | QGI |

Educ: Educational Spending. GovStab: Government Stability. Infl: Inflation. Credit: Domestic Credit. FDI: Foreign Direct Investment. Remit: Remittances. MBill: Mobile used for Paying Bills. MSR: Mobile used for Sending/Receiving Money. Pov: Poverty rate. GINI: Inequality Index.

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