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Financial Access Thresholds in Mitigating Market Power for Financial Inclusion

Financial access thresholds in mitigating market power for financial inclusion

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Abstract

The study assesses how financial access dynamics in terms of bank accounts and automated teller machines (ATMs) moderate the influence of market power on financial inclusion in terms mobile money innovations in developing countries. The empirical evidence is based on Tobit regressions. From the findings, bank concentration has a negative influence on mobile money accounts while such a negative influence is hedged by financial access dynamics of bank accounts and ATMs. Though the interactive influences are positive, the overall or net influences are negative and hence, financial access thresholds at which the overall negative influences on mobile money accounts are nullified are 95 percentage of adults who have an account in a formal financial institution and 100 ATMs per 100,000 people. Beyond these thresholds, bank concentration or market power no longer has a negative influence on mobile money accounts.

Keywords: Mobile money; technology diffusion; financial inclusion; inclusive innovation
JEL Classification: D10; D14; D31; D60; O30

1. Introduction

The premise of this study is founded on three main insights from the policy and scholarly literature, notably: (i) the importance of mobile money innovations in development outcomes; (ii) the relevance of financial inclusion in the post-2015 development agenda of sustainable development goals (SDGs) and (iii) gaps in the extant mobile money innovations literature. These three perspectives are substantiated in the same chronology as highlighted in subsequent paragraphs.

First, the advent of mobile money is having considerable positive development externalities in the world in general and in developing countries in particular. Of these favorable ramifications, the favorable incidences of the advantages represent a positive function of the degree of financial inclusion. To put this comparative relevance in more perspective, developing countries with a higher rate of the population excluded from formal banking activities are more likely to leverage on mobile banking activities to reach development targets in a plethora of economic sectors, *inter alia*: enhancement of agricultural productivity (Uduji & Okolo-Obasi, 2018a,b), improvement in health performance and amelioration of the mechanisms by which educational services are provided (Asongu & Boateng, 2018). The underlying positive development externalities are more worthwhile in the achievement of SDGs.

Second, the main issue surrounding financial inclusion is that the absence of financial inclusion can substantially impede prospects of achieving most SDGs. Accordingly, financial inclusion is relevant in the achievement of most SDGs for a multitude of reasons, though it is clearly articulated as the eigth of the seventeen goals. Accordingly, financial inclusion can prominently enable the achievement of most SDGs, *inter alia*: (i) SDG1 concerned with the eradication of poverty; (ii) SDG2 linked to ending of hunger, achievement of food security and the promotion of sustainable agriculture; (iii) SDG3 pertaining to well-being and health; (iv) SDG5 related to the achievement of women economic empowerment and gender equality; (v) SDG8 oriented towards the promotion of economic prosperity; (vi) SDG9 related to supporting innovation, infrastructure and the industry; (vii) SDG10 focused to the reduction of inequality and (viii) SDG17 as far as consolidating the implementation mechanism is concerned, especially as it pertains to the incidence of financial inclusion via enhanced moblisation of resources for consumption and investment purposes with the ultimate aim of spurring economic growth (Afutu-Kotey *et al*., 2017; Abor *et al*., 2018; Gosavi, 2018 ; Humbani & Wiese, 2018; Issahaku *et al*., 2018; Tchamyou *et al*., 2019a, 2019b; UNCDF, 2022; Abdulqadir & Asongu, 2022). In the light of this relevance of financial inclusion in achieving a plethora of SDGs, the present study focuses on the role of financial access dynamics (in terms of bank

accounts and ATMs)[1] in moderating the incidence of market power on financial inclusion for mobile innovation, not least, owing to an apparent gap in the extant literature.

Third, as far as we have reviewed, the extant contemporary literature on the role of mobile technology in development outcomes, has been concerned with, *inter alia*, understanding the importance of mobile banking in developing rural zones (Malaquias & Silva, 2020); disincentives to internet banking adoption (Arif *et al*., 2020); the relevance of technology in citizen-customer roles (Lammi & Pantzar, 2020); inequality, poverty and sustainable development ramifications linked to connections between financial inclusion and ICT(Hoque, 2020; Mushtaq & Bruneau, 2020), factors that determine the adoption of information technology (Alderete, 2020; Karakara & Osabuohien, 2019) and mobile money innovations (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021).

The closest studies to the present inquiry are Asongu *et al*. (2020, 2021) which have assessed mobile money innovations in development outcomes, highlighting concerns of multicollinearity that should be addressed in order to avoid misplaced policy implications. The present study departs from extant studies by focusing on how demand factors of mobile money innovations complement one another to influence mobile money innovations in terms of mobile money accounts, the mobile used to receive money and the mobile used to send money. Put in more perspective, the study assesses how financial access dynamics moderate market power in terms of bank concentration to influence mobile money innovations. The intuition and theory underlying the relevance of bank account ownership and ATMs in infleucing market power for financial access are discussed in Section 2.

The rest of the study is structured as follows. The theoretical undeprinings are discussed in Section 2 while Section 3 engages the data and methodology. The empirical results are covered in Section 4 while Section 5 concludes with implications and future research directions.

[1] Throughout the study, financial access dynamics are proxied by ATMs and bank account owernship. Hence, these are used interchangeably. Moreover, bank concentration and market power are also used interchangeably throughout the study.

2. Theoretical underpinnings

This secton discusses the intuition and theoretical insights into the relevance of ATMs and bank acconts in affecting banking sector competition so that financial inclusion is ultimately affected. Such an intuition is simply to follow, not least because the availability of more ATMs and more sources of bank accounts influence competition in the banking industry, given that abundance in supply is a characteristic of competition in the banking industry (Asongu & Odhiambo, 2019). Two main fundamental theoretical insights are worth revisiting to articulate the underlying nexuses, notably: (i) the Free Market Model (FMM) and (ii) the Theory of Information Asymmetry (TIA).

First, the TIA is founded on the perspective that concerns about adverse selection on the part of banks prior to the process of lending and moral hazard from borrowers, after the lending process, can be mitigated by establishing institutions that can share information between banks. The absence of competition in the banking industry is a function of market power detained by a few banks while with competition, less market power is apparent (Asongu & Biekpe, 2018). This is essentially because the presence high market power and absence for competiton can increase information asymmetry and limit financial access (especially by means of mobile money innovations). Hence, banking market power (used as the main channel in this study) affects financial inclusion contingent on financial access dynamics (i.e. bank account owernership and ATM penetration that are used as moderating variables in the present study). In essence, the ability to innovate in terms of mobile money innovations (i.e. employed as dependent variables in this study) is contingent on how competition is enhanced by means of decreasing market power in the banking industry. Financial access proxies such bank account ownership and ATMs are some instruments by which the attendant competition and market power in the banking industry can be stifled.

The underlying theoretical perspectives are consistent with the extant literature on the importance of introducing information sharing offices such as public credit registries and private credit bureaus in order to mitigate information asymmetry and market power on the one hand and on the other, improve financial access and innovations that further boost financial access (Kusi *et al*., 2017; Kusi & Opoku-Mensah, 2018; Asongu & Odhiambo, 2018a).

Second, with respect to the FMM, according to extant literature (Pradeep, 2011; Asongu & Odhiambo, 2022), the FMM perspective is a vital framework for the theoretical positioning of this study because financial inclusion by means of mobile money innovations is the outcome of the study. Accordingly, for financial inclusion to be promoted, some ramifications of the FMM should be curtailred especially with regard to financial exclusion. According to the underlying literature, financial exclusion can be exacerbated in situations or markets in which there is little oversight on banking sector deregulation. Following Pradeep (2011) and Asongu and

Odhiambo (2022), excessive deregulation can engender two possible outcomes. First of all, when a financial system is characterised by deregulation, entrenched polarizations between the financially-included and financially-excluded within society can be consolidated. Second, there is a possibility that financial exclusion can grow with enhanced deregulation. The main channel or bank concentration (i.e. market power) can also be a consequence of deregulation. It is important of articulate that market power within the remit of bank concentration (i.e. the main channel of this study), intuitively decreases competition and by extension, reduces financial inclusion. Moreover, financial access dynamics (i.e. the instruments of financial access used in this study), can intuitively boost competition for mobile money innovations that ultimately promote financial inclusion (i.e. employed as outcome variables in this study). From the underlying narrative, it is apparent that government regulation in the banking industry can also be fundamentally motivated by the need to boost competition within the industry in order to promote financial inclusion by means of greater opportunities of innovative banking for financial access.

In the light of the above, two testable hypotheses are assessed in the empirical section of this study:
Hypothesis 1: market power in terms of bank concentration is negatively related to financial inclusion in terms of mobile money innovations (i.e. mobile money accounts, the mobile used to send money and the mobile used to receive money).

Hypothesis 2: financial access dynamics (i.e. bank accounts and ATMs) decrease the negative influence of bank concentration on financial inclusion in terms of mobile money innovations (i.e. mobile money accounts, the mobile used to send money and the mobile used to receive money).

3. Data and methodology

3.1 Data

The data of the study come from contemporary mobile banking literature (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021). These consist of 2010 to 2014 averages from a plethora of sources, notably: (i) the World Bank's World Development Indicators (WDI); (ii) the World Bank's World Governance Indicators (WGI); (iii) the Global Financial Structure Database (GFSD); (iv) Waverman and Koutroumpis (2011) and (v) the Global System for Mobile Communications Association (GSMA). The data entail all countries in developing regions and continents (i.e. the Americas, Asia, the Middle East and Africa) for which data are available at the time of the study by Lashitew *et al*. (2019) which is the primary source of the data.

Consistent with the corresponding literature (Lashitew *et al*., 2019; Asongu et al., 2020, 2021), three main dependent variables are used in this study, notably: mobile money accounts, the mobile used to send money and the mobile used to receive money. In line with the motivation of the study as well as the narrative in the theoretical underpinnings section, two main instruments of financial access are employed, namely: (i) bank account ownership (as a % of the adult population) and (ii) the number of automated teller machines (ATMs). Still consistent with the motivation of the study and the corresponding theoretical insights in Section 2, market power or bank concentration is employed as the main mechanism by which financial access dynamics influence mobile money innovations. These variables which are demand-side mobile money innovations proxies are obtained from the GFSD.

In order to account for variable omission bias, three types of variables are involved in the conditioning information set, notably: (i) supply-side mobile money drivers such as mobile subscription, mobile connectivity performance and telecommunication sector regulation; (ii) macroeconomic indicators such as economic growh and the urbanisation rates and (iii) continental and regional fixed effects to control for the unobserved heterogeneity. Such fixed effects include: Africa, Asia, the Middle East and the Americas. It is relevant to note that the regions used in the study are for the purpose of controlling for the unobserved heterogeneity (i.e., a dimension of endogeneity). Appendix 1 provides the definitions and sources of the variables. Moreover, the choice of the variables is motivated by recent mobile phone, inclusive development and mobile baking literature, as clarified in the following paragraph.

The choice of corresponding variables is informed by: financial inclusion studies (Demirguc-Kunt & Klapper, 2012; Asongu & Asongu, 2018; Demirgüç-Kunt *et al*., 2015; Asongu & Odhiambo, 2018b); demand-side mobile money drivers (Muwanguzi & Musambira, 2009; Demirguc-Kunt *et al*., 2015; Van der Boor *et al*., 2014); supply-side mobile money determinants (Van der Boor *et al*., 2014; Mas & Morawczynski, 2009; Demirgüç-Kunt & Klapper, 2013; Gruber & Koutroumpis, 2013; Waverman & Koutroumpis, 2011; GSMA, 2018) and factors at the macroeconomic level

(World Bank, 2016; Murendo *et al*., 2018). The summary statistics are provided in Table 1 while Appendix 2 discloses the corresponding correlation matrix.

Table 1: Summary Statistics

Variables	Mean	S.D	Min	Max	Obs
Dependent variables					
Mobile accounts (%)	3.30	7.90	0.00	58.39	145
Sending money (%)	3.10	7.58	0.00	60.48	146
Receiving money (%)	4.47	9.58	0.00	66.65	146
Demand factors					
Account at formal fin. Institution (%)	45.72	31.73	0.40	99.74	147
ATM penetration	43.28	45.03	0.33	279.71	148
Banking sector concentration	71.94	20.70	9.49	100.00	143
Supply factors					
Unique mobile subscription rate	61.73	23.29	4.23	133.64	199
Mobile connectivity (performance)	11.92	14.69	0.04	67.19	147
Mobile connectivity (coverage)	62.18	27.29	8.88	99.60	147
Telecom regulation	0.41	0.17	0.00	0.74	128
Macro-level factors					
GDP per capita (PPP)	17,874	19,677	648	132,468	152
GDP growth	3.90	2.82	-4.92	11.10	153
Rule of Law	-0.09	1.01	-2.42	1.98	157
Urbanization (%)	58.22	22.85	8.81	100	155

Notes:- The average values for the dependent variables are calculated across all countries, including those in which mobile money services are not available.

3.2 Methodology

In the light of the motivation of the study and the sources of the data, the study adopts the Tobit estimation approach (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021). Beyond this premise of comparative studies, the adoption of a Tobit estimation approach is also in accordance with data behavior, not least, because the outcome variables have a limited range. Such a motivation based on data behavior is also consistent with the extant literature that has employed the Tobit regressions approach (Coccorese & Pellecchia, 2010; Ajide *et al*., 2019; Nchofoung *et al*., 2021; Nchofoung & Asongu, 2022).

Looking at Table 1 which discloses the summary statistics, it is apparent that the three dependent variables are situated within a specified range. Hence, by construction, all the

three indicators of mobile money innovation are adoption rates that are situated between 0 and 100% and hence, theoretically censored by 0% and 100%. The limited range is because the outcome variables are by definition and measurement expressed in terms of percentage and thus, are limited or censored between 0% and 100%. As argued by Amemiya (1984), when such a limited range is apparent, employing a standard Ordinary Least Squares (OLS) approach engenders estimated coefficients that are not consistent. Hence, the relevance of a non-linear double censored or a two-limit Tobit regression model that censores mobile money adoption rates on both sides of the corresponding distributions of the dependent variables.

In Equations (1) and (2) below, the standard Tobit procedure is provided in accordance with the extant literature (Tobin, 1958; Carson & Sun, 2007).

$$y_{i,t}^{*} = \alpha_0 + \beta X_{i,t} + \varepsilon_{i,t} \ , \qquad (1)$$

where $y_{i,t}^{*}$ is a latent response variable, $X_{i,t}$ is an observed $1\times k$ vector of explanatory variables and $\varepsilon_{i,t} \approx$ i.i.d. N(0, σ^2) and is independent of $X_{i,t}$. As opposed to observing $y_{i,t}^{*}$, we observe $y_{i,t}$:

$$y_{i,t} = \begin{cases} y_{i,t,}^{*} \ if \ y_{i,t}^{*} > \gamma \\ 0, \ if \ y_{i,t}^{*} \le \gamma, \end{cases} \qquad (2)$$

where γ is a non-stochastic constant. It follows that, the value of $y_{i,t}^{*}$ is missing when it is less than or equal to γ.

The assumptions surrounding the Tobit model are tailored such that, the residuals are distributed normally on the one hand and on the other, there is the presence of latent dependent variables that are not bounded as well as a linear function of the explanatory explanatory variables (Amemiya, 1984). In the regression output, two marginal impacts of the independent variables of interest are apparent: (i) one showing the marginal effects of the independent variables on the unobserved latent adoption rate and (ii) the other showing the censored, observed adoption rate. Consistent with contemporary Tobit regression studies, in repoting the findings, only the maginal effects related to the observed censored adoption rates are reported given that such reporting allows for a more robust interpretation (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021).

Given that the focus of the present study is to assess financial access thresholds at which the negative or unfavorable effect of market power is completely dampened, the corresponding threshold based on the interactive regressions is presented as follows in Equation (3), in the light of contemporary interactive regressions literature (Tchamyou et al., 2023).

$$\text{Financial Access Threshold} = \left| \frac{\text{Unconditional impact of market power}}{\text{Conditional or interactive impact of market power}} \right| \qquad (3)$$

4. Empirical results

4.1 Presentation of results

The empirical findings are disclosed in this section in Table 2 below. The table is divided into two main sections; with each providing insights into regressions related to bank concentration and financial access in terms of bank account and ATMs. The first-three specifications articulate nexuses between bank accounts and bank concentration while the last-three specicifcations are concerned with linkages between ATMs and bank concentration. For each financial access category, three specifications are apparent, respectively for mobile bank accounts, the mobile used to send money and the money used to receive money.

Of the three specifications in each category, only the regressions associated with mobile money accounts are significantly linked to bank concentration both from conditional (i.e. the interactive effect between bank concentration and financial access dynamics) and unconditional pespecitves (i.e. the isolated influence of bank concentration). In order to examine the overall incidence of financial access dynamics on bank concentration for mobile money innovations, net influences are computed. For instance, in the second column of Table 1, the net influence from the role of bank account in moderating banking sector concentration to influence mobile money accounts is negative or -0.049. The corresponding value is computed from the following equation -0.049 = ([0.001 × 45.72] + [-0.095]). In this computation, -0.095 is the unconditional effect of bank concentration, 0.001 is the corresponding interactive or conditional effect between bank concentration and bank accounts while 45.72 is the mean value of bank account subscriptions obtained from Table 1.

Table 2: Bank concentration, financial access and moibile money innovations

	Dependent variables: Mobile money accounts, Mobile used to send money & Mobile used to receive money					
	Bank accounts and Bank concentration			**ATM and Bank concentration**		
	Mobile money accounts	**Mobile used to send money**	**Mobile used to receive money**	**Mobile money accounts**	**Mobile used to send money**	**Mobile used to receive money**
Demand Factors						
Bank Accounts	**-0.122***	-0.044	-0.077	---	---	---
	(0.064)	(0.473)	(0.345)			
ATM penetration	---	---	---	**-0.131****	**-0.064***	**-0.085***
				(0.011)	**(0.074)**	**(0.050)**
Bank sector Con	**-0.095****	-0.028	-0.049	**-0.100****	-0.048	-0.070
	(0.018)	(0.538)	(0.390)	**(0.011)**	(0.246)	(0.150)

Bank Accounts × Bank sector Con	**0.001****	0.0005	0.0008	---	---	---
	(0.041)	(0.443)	(0.348)			
ATM penetration × Bank sector Con	---	---	---	**0.001****	0.0007	0.0009
				(0.019)	(0.158)	(0.117)
Supply Factors						
Unique Mobile Subscription. rate	0.004	0.028	0.017	0.009	0.030	0.023
	(0.842)	(0.254)	(0.543)	(0.657)	(0.220)	(0.423)
Mobile Connectivity Performance	0.0002	**-0.284*****	**-0.347*****	0.012	**-0.272*****	**-0.337*****
	(0.996)	**(0.003)**	**(0.002)**	(0.769)	**(0.001)**	**(0.000)**
Telecom Sector Regulation	4.197	-0.721	-0.678	**4.977****	-0.127	-0.156
	(0.105)	(0.797)	(0.839)	**(0.039)**	(0.967)	(0.966)
Macro-level factors						
GDP growth	**0.593*****	0.012	-0.162	**0.663*****	0.104	-0.021
	(0.002)	(0.957)	(0.595)	**(0.000)**	(0.667)	(0.946)
Urbanization	**-0.052***	0.010	0.029	-0.043	0.009	0.023
	(0.091)	(0.822)	(0.604)	(0.114)	(0.838)	(0.671)
Region dummies						
Africa	**7.643*****	2.684	**4.463***	**7.530*****	1.648	3.028
	(0.001)	(0.150)	**(0.061)**	**(0.000)**	(0.375)	(0.188)
Asia	**3.147***	-0.005	0.897	**2.696***	-0.976	-0.411
	(0.056)	(0.997)	(0.657)	**(0.086)**	(0.577)	(0.843)
Americas	**5.408*****	-1.719	-1.412	**5.098*****	**-2.650***	-2.605
	(0.004)	(0.270)	(0.431)	**(0.004)**	**(0.093)**	(0.145)
Middle East	**5.319****	-2.669	-1.537	**5.763*****	-2.229	-0.853
	(0.017)	(0.252)	(0.458)	**(0.008)**	(0.341)	(0.736)
Net Effects	-0.049	na	na	-0.056	na	na
Threholds	95	na	na	100	na	na
Observations	108	114	114	111	115	115

GDP: Gross Domestic Product. PPP: Purchasing Power Parity. *,**,***: significance levels of 10%, 5% and 1% respectively. The average value of bank accounts is 45.72 while the average of ATM penetration is 43.28. na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant.

The following findings can thus be established. (i) Finanical access dynamics of bank account subscriptions and ATM penetration moderate bank concentration to engender net negative influences on mobile money accounts. (ii) The corresponding net influences on the mobile used to send money and the mobile used to receive money are not significant. (iii) Most of the control variables are significant while the unexpected signs are traceable to concerns of multicollinearity that are overlooked in interactive regressions because overall or net effects are computed (Brambor *et al*., 2006).

Given the findings, the following are apparent in the light of the tested hypotheses.

Hypothesis 1 is valid because bank concentration has an unconditional negative influence on mobile money innovations, though the incidence is significant only for mobile money accounts and not for the mobile used to send money and the mobile used to receive money.

Hypothesis 2 is also valid because the financial access dynamics of bank accounts and ATMs moderate bank concentration in the light of the negative unconditional influences that are significant exclusively in mobile money accounts regressions.

It is important to note that while some negative unconditional influences are apparent to confirm *Hypothesis* 2, the corresponding overall influences are negative. This invites the question of what critical masses of financial access dynamics are needed to completely nullify the corresponding net negative overall incidences. This motivated the next section on financial access thresholds.

4.2 Finanical access thresholds

This section is important because it will enable the study to provide policy makers with actionable critical levels of financial access that should be considered if the overall incidence of bank concentration on financial inclusion in terms of mobile money innovations is to be changed from negative to positive. The computation is consistent with contemporary interactive regression literature on the importance of establishing policy thresholds in order to boost increase for policy making (Nchofoung *et al*., 2022; Nchofoung & Asongu, 2022).

In the second column of Table 1, the corresponding thresholds are: (i) 95 (0.095/0.001) percentage of adults who have an account at a formal financial institution and (ii) 100 (0.100/0.001) ATMs per 100,000 people. These thresholds are policy relevant not least, because they make economic sense given that they are within the statistical ranges (minimum to maximum values) disclosed in the summary statistics in Table 1.

From the established critical levels, more policy effort is needed in promoting bank account ownership among the adult population compared to the policies designed to favor the penetration of ATMs. This is essentially because the bank account ownership threshold is closer to its maximum policy limit in the summary statistics compared to the corresponding maximum policy limit of ATM penetration.

5. Concluding implications and future research directions

The study has assessed how financial access dynamics in terms of bank accounts and automated teller machines (ATMs) penetration moderate the influence of market power (i.e. bank concentration) on financial inclusion or mobile money innovations (i.e. mobile money accounts, the mobile used to receive money and the mobile used to send money) in developing countries (i.e, nations in Africa, Asia, the Americas and Middle East). The empirical evidence is based on Tobit regressions. From the findings, bank concentration has a negative influence on mobile money accounts while such a negative influence is hedged by financial access dynamics of bank accounts and ATMs. Though the interactive influences are positive, the overall or net influences are negative and hence, financial access thresholds at which the overall negative influences on mobile money accounts are nullified are: (i) 95 percentage of adults who have an account at a formal financial institution and (ii) 100 ATMs per 100,000 people. Beyond these thresholds, bank concentration or market power no longer has a negative influence on mobile money accounts.

The fact that the findings from regressions surrounding the mobile used to send money and the mobile used to receive money have the expected signs but are not significant, is evidence that more policy effort is needed in order for the population to go beyond having bank accounts, ATMs and mobile money accounts. Accordingly, more owners of bank accounts associated with mobile money accounts and ATMs need to use such privileges in sending and receiving money more.

Future studies can focus on assessing how mobile money innovation is related to specific SDGs. Moreover, it is also worthwhile to asses how information sharing offices which mitigate information asymmetry in the banking sector affect the established linkages. It is relevant to emphasize that the study is articulated to be understood in the light of the findings of Lashitew et al. (2019) who have shared their dataset. The source of the dataset is clarified in the data section. It follows that the findings should be understood in the perspective of a necessity in social sciences to replicate studies within different empirical frameworks. Hence, future studies should employ more updated data in order to provide more scholarly and policy insights into the issues.

Appendices

Appendix 1: Definitions and sources of variables

Variables	Descriptions	Sources
Dependent variables		

Mobile Accounts	Percentage of adults who have personally used mobile phone to pay bills, send or receive money in the past 12 months using a GSMA recognized mobile money service	Financial Inclusion Indices (Findex) database
Sending Money	Percentage of adults who used a mobile phone to send money in the past 12 months	
Receiving Money	Percentage of adults who used a mobile phone to receive money in the past 12 months	
Demand factors		
Account at formal financial institution	Percentage of adults who have an account at a formal financial institution	Global Financial Structure Database (GFSD)
ATM access	Number of ATMs per 100,000 people	
Banking sector concentration	The percentage share of the three largest commercial banks in total banking assets	
Supply factors		
Mobile phone penetration - Gross & unique subscription rates	Gross mobile subscription rates refer to the percentage of adults in a country with subscriptions to mobile phones based on data from WDI. We used additional data from GSMA (2014) to calculate unique mobile subscription rates by correcting for double SIM-card ownership, which differs between rural and urban areas. This correction is based on survey evidence that urban and rural users own 2.03 & 1.18 active SIM-cards respectively.	World Development Indicators (WDI), GSMA
Mobile connectivity quality	Measures the average speed of uploading and downloading data through mobile network in 2014 & 2015.	GSMA
Mobile connectivity coverage	Measures the weighted average of share of populations covered by 2 G, 3 G and 4 G mobile data networks (normalized to range between 0 and 100).	GSMA
Telecom regulation	Measures the regulatory quality of the telecom sector in terms of four major criteria: transparency, independence, resource availability, and enforcement capability of the regulator. The index is based on dozens of indicators taken from the International Telecommunication Union's regulatory database.	Waverman and Koutroumpis (2011)
Macro-level factors		

Rule of Law	A measure of the extent to which agents have confidence in and abide by the rules of society	WDI
GDP per capita	GDP per capita in purchasing power parity	WDI
GDP growth	The rate of total GDP growth	WDI
Urbanization rate	Percentage of population living in urban areas	WDI

Notes: Mobile Accounts is based on the second wave of the survey (2014) and Sending Money and Receiving Money are based on the first wave (2011). The variables telecom regulation is based on data for 2011. The two variables measuring mobile connectivity are based on average values for the years 2014 & 2015. For the remaining variables, averages are taken over the years 2010–2014 to smooth out potential year-to-year variations.

Appendix 2: Correlation matrix

	Mobile inclusion variables			Demand Factors			Supply Factors				Macro-level Factors				Region dummies			
	MMA	Send M	Receiv.M	BankAc	ATM Pen	BankSC	UMSr	MCP	MCC	TSR	GDPpc	GDPg	RL	Urban	Africa	Asia	Americas	Middle East
MMA	1.000																	
Send M	0.640	1.000																
Receiv.M	0.597	0.980	1.000															
Bank Ac	-0.292	-0.227	-0.266	1.000														
ATM Pen	-0.319	-0.248	-0.279	**0.708**	1.000													
BankSC	-0.079	-0.028	-0.026	0.051	-0.171	1.000												
UMSr	-0.237	-0.116	-0.142	0.411	0.305	-0.045	1.000											
MCP	-0.320	-0.272	-0.300	**0.821**	**0.779**	-0.053	0.270	1.000										
MCC	-0.385	-0.300	-0.323	**0.815**	**0.701**	-0.091	0.525	**0.780**	1.000									
TSR	-0.088	-0.070	-0.067	0.549	0.363	-0.008	0.237	0.466	0.473	1.000								
GDPpc	-0.420	-0.209	-0.228	**0.825**	**0.690**	-0.078	**0.644**	**0.729**	**0.872**	0.535	1.000							
GDPg	0.376	0.189	0.176	-0.532	-0.481	-0.058	-0.300	-0.477	-0.527	-0.433	-0.553	1.000						
RL	-0.271	-0.273	-0.308	**0.850**	**0.623**	0.040	0.374	**0.838**	**0.772**	**0.605**	**0.772**	-0.457	1.000					
Urban	-0.396	-0.212	-0.220	0.566	0.567	-0.051	0.364	0.598	0.731	0.349	**0.788**	-0.381	0.583	1.000				
Africa	0.533	0.415	0.444	-0.558	-0.519	0.123	-0.462	-0.487	**-0.681**	-0.288	**-0.683**	0.407	-0.418	-0.560	1.000			
Asia	-0.101	-0.076	-0.088	0.087	0.077	-0.009	-0.013	0.153	-0.006	-0.129	0.007	0.244	0.014	-0.075	-0.199	1.000		

Americas	-0.098	-0.116	-0.095	-0.176	-0.016	-0.004	0.092	-0.198	-0.029	0.001	0.045	0.025	-0.221	0.158	-0.268	-0.278	1.000	
Middle East	-0.086	-0.072	-0.082	-0.0001	0.047	0.019	-0.010	0.035	0.124	-0.131	0.140	0.040	0.017	0.237	-0.101	-0.105	-0.141	1.000

MMA: Mobile Money Accounts. Send M: Sending Money. Receiv M: Receiving Money. Bank Ac: Bank Accounts. ATM Pen: ATM Penetration. BankSC: Bank Sector Concentration. UMSr: Unique Mobile Subscription rate. MCP: Mobile Connectivity Performance. MCC: Mobile C onnectivity Coverage. TSR: Telecom Sector Regulation. GDPpc: Gross Domestic Product per capita in PPP (in logs). GDPg: GDP growth. RL: Rule of Law. Urban: Urbanization.

References

Abdulqadir, I. A., & Asongu, S. A. (2022). "The asymmetric effect of internet access on economic growth in sub-Saharan Africa", *Economic Analysis and Policy*, 73(March), pp. 44-61.

Abor, J. Y., Amidu, Y., & Issahaku, H., (2018). "Mobile Telephony, Financial Inclusion and Inclusive Growth", *Journal of African Business*, 18(4), pp. 430-453.

Afutu-Kotey, R. L., Gough, K. W., & Owusu, G., (2017). "Young Entrepreneurs in the Mobile Telephony Sector in Ghana: From Necessities to Aspirations", *Journal of African Business*, 18(4), pp. 476-491.

Ajide, K. B., Raheem, I. D., & Asongu, S. A., (2019). "Dollarization and the "Unbundling" of Globalization in sub-Saharan Africa", *Research in International Business and Finance*, 47 (January), pp. 398-409.

Alderete, M. V. (2020). "Examining the drivers of internet use among the poor: The case of Bahía Blanca city in Argentina", *Technology in Society*, 59(November), 101179.

Amemiya, T., (1984). "Tobit models: a survey". *Journal of Econometrics*, 24 (1–2), pp.3–61.

Arif, I., Aslam, W., & Hwang, Y. (2020). "Barriers in adoption of internet banking: A structural equation modeling - Neural network approach", *Technology in Society*, 61(May), 101231.

Asongu, S. A., & Asongu, N., (2018). "The comparative exploration of mobile money services in inclusive development", *International Journal of Social Economics*, 45(1), pp.124-139.

Asongu, S. A., & Biekpe N., (2018). "ICT, information asymmetry and market power in African banking industry", *Research in International Business and Finance*, 44(April), pp. 518-531.

Asongu, S. A., Biekpe, N., & Cassimon, D., (2020). "Understanding the greater diffusion of mobile money innovations in Africa", *Telecommunications Policy*, 44(8), September 2020, 102000.

Asongu, S. A., Biekpe, N., & Cassimon, D., (2021). "On the diffusion of mobile phone innovations for financial inclusion", *Technology in Society*, 65 (May), 101542.

Asongu, S. A., &Boateng, A., (2018). "Introduction to Special Issue: Mobile Technologies and Inclusive Development in Africa", *Journal of African Business*, 19(3), pp. 297-301.

Asongu, S. A., & Odhiambo, N. M., (2018a). "Information asymmetry, financialization, and financial access", *International Finance*, 21(3), pp. 297-315.

Asongu, S. A., & Odhiambo, N. M., (2018b). "Human development thresholds for inclusive mobile banking in developing countries", *African Journal of Science, Technology, Innovation and Development*, 10(6), pp. 735-744.

Asongu, S. A., & Odhiambo, N. M., (2019). "Size, efficiency, market power, and economies of scale in the African banking sector". *Financial Innovation*, 5(1), 4, pp. 1-22.
DOI: 10.1186/s40854-019-0120-x

Asongu, S. A., & Odhiambo, N. M., (2022). "The role of mobile characteristics on mobile money innovations", *Quality & Quantity*, 56(6), 4693-4710.

Brambor, T., Clark, W. M., & Golder, M. (2006). "Understanding Interaction Models: Improving Empirical Analyses", *Political Analysis*, 14 (1), pp. 63-82.

Carson, R. T., & Sun, Y., (2007)."The Tobit model with a non-zero threshold", *Econometrics Journal*, 10(3), pp. 488-502.

Coccorese, P., &Pellecchia, A., (2010). "Testing the 'Quiet Life' Hypothesis in the Italian Banking Industry", *Economic Notes by BancadeiPaschi di Siena SpA*, 39(3), pp. 173-202.

Demirgüc-Kunt, A., & Klapper, L., (2012). "Measuring Financial Inclusion: the Global FindexDatabase". *World Bank Policy Research Working Papers* No. WPS 6025, Washington.

Demirgüç-Kunt, A., Klapper, L., (2013). "Measuring financial inclusion: explaining variation in use of financial services across and within countries". *Brookings Papers on Economic Activity*, (1), pp. 279–340.

Demirgüç-Kunt, A., Klapper, L., & Van Oudheusden, P., (2015). "The Global Findex Database2014". *World Bank Policy Research Working Paper* No. 7255, Washington D.C.

Gosavi, A., (2018). "Can mobile money help firms mitigate the problem of access to finance in Eastern sub-Saharan Africa", *Journal of African Business*, 18(4), pp. 343-360.

GSMA, (2014). Mobile Money: State of the Industry Report 2014. GSMA.

GSMA, (2018). "The Mobile Economy 2018". https://www.gsmaintelligence.com (Accessed: 02/04/2020).

Gruber, H., &Koutroumpis, P., (2013). "Competition enhancing regulation and diffusion of innovation: the case of broadband networks". *Journal of Regulatory Economics*, 43 (2), pp. 168–195.

Hoque, M. R. (2020). "The impact of the ICT4D project on sustainable rural development using a capability approach: Evidence from Bangladesh", *Technology in Society*, 61(May), 101254.

Humbani, M., & Wiese, M., (2018). "A Cashless Society for All: Determining Consumers' Readiness to Adopt Mobile Payment Services", *Journal of African Business*, 18(4), pp. 409-429.

Issahaku, H., Abu, B. M., & Nkegbe, P. K., (2018). "Does the Use of Mobile Phones by Smallholder Maize Farmers Affect Productivity in Ghana?", *Journal of African Business*, 19 (3), pp. 302-322.

Karakara, A. A., & Osabuohien, E. S. (2019). "Households' ICT access and bank patronage in West Africa: Empirical insights from Burkina Faso and Ghana", *Technology in Society*, 56(February), 116-125.

Kusi, B. A., Agbloyor, E. K., Ansah-Adu, K., &Gyeke-Dako, A. (2017). "Bank credit risk and credit information sharing in Africa: Does credit information sharing institutions and context matter?" *Research in International Business and Finance*, 42(December), pp.1123- 1136.

Kusi, B. A., &Opoku- Mensah, M. (2018)."Does credit information sharing affect funding cost of banks? Evidence from African banks".*International Journal of Finance & Economics*, 23(1), pp. 19- 28.

Lammi, M., & Pantzar, M. (2020). "The data economy: How technological change has altered the role of the citizen-consumer", *Technology in Society*, 59(November), 101157.

Lashitew, A. A., van Tulder, R., &Liasse, Y., (2019). "Mobile phones for financial inclusion: What explains the diffusion of mobile money innovations?",*Research Policy*, 48(5), pp. 1201-1215.

Malaquias, R. F., & Silva, A. F. (2020). "Understanding the use of mobile banking in rural areas of Brazil",*Technology in Society*, 62, August 2020, 101260.

Mas, I., &Morawczynski, O., (2009). "Designing mobile money services lessons from M-Pesa". *Innovations*, 4(2), pp. 77–91.

Mushtaq, R., & Bruneau, C. (2020). "Microfinance, financial inclusion and ICT: Implications for poverty and inequality", *Technology in Society*, 59(November), 101154.

Muwanguzi, S., &Musambira, G., (2009). "The transformation of east Africa's economy usingmobile phone money transfer services: a comparative analysis of Kenya and Uganda's Experiences". *Journal of Creative Communications*, 4(2), pp. 131–146.

Murendo, C., Wollni, M., De Brauw, A., &Mugabi, N., (2018). "Social network effects on mobile money adoption in Uganda". *Journal of Development Studies*, 54(2), pp. 327-342.

Nchofoung, T. N., & Asongu, S. A., (2022a). "ICT for sustainable development: Global comparative evidence of globalisation thresholds". *Telecommunications Policy*, 46(5), 102296

Nchofoung, T. N., & Asongu, S. A., (2022b). "Effects of infrastructures on environmental quality contingent on trade openness and governance dynamics in Africa", *Renewable Energy*, 189(April), 152-163.

Nchofoung, T.N., Achuo, E.D. & Asongu, S. A., (2021). "Resource rents and inclusive human development in developing countries". *Resources Policy*, 74(4), 102382.

Nchofoung, T. N., Asongu, S. A., Kengdo, A. A. N., (2022). "Linear and non-linear effects of infrastructures on inclusive human development in Africa", *African Development Review*, 34(1), pp. 81-96.

Pradeep, K. B., (2011). "Financial Exclusion: A Theoretical Approach", *MPRA Paper* No. 89864, Munich.

Tchamyou, V. S., Asongu, S. A., &Odhiambo, N. M., (2019a). "The role of ICT in modulating the effect of education and lifelong learning on income inequality and economic growth in Africa", *African Development Review*, 31(3), pp. 261-274.

Tchamyou, V.S., Erreygers, G., & Cassimon, D., (2019b). "Inequality, ICT and Financial Access in Africa", *Technological Forecasting and Social Change*,139(February), pp. 169-184.

Tchamyou, V. S., Somé, J., & Asongu, S. A. (2023, December). The African Continental Free Trade Area and Financial Development for Female Labour Force Participation in Africa. In Forum for Social Economics (pp. 1-15). Routledge.

Tobin, J., (1958). "Estimation of relationships for limited dependent variables".*Econometrica* 26(1), pp. 24-36.

Uduji, J. I. & Okolo-Obasi, E. N., (2018a). "Adoption of improved crop varieties by involving farmers in the e-wallet programme in Nigeria". *Journal of Crop Improvement*, 32 (5), pp. 717-737.

Uduji, J.I. &Okolo-Obasi, E. N., (2018b). "Young rural women's participation in the e-wallet

programme and usage intensity of modern agricultural inputs in Nigeria", *Gender, Technology and Development*, 22(1), pp. 59-81.

UNCD (2022). "Financial Inclusion and SDGs", *United Nations Capital Development Fund.* https://www.uncdf.org/financial-inclusion-and-the-sdgs (Accessed: 22/03/2022).

Van der Boor, P., Oliveira, P., & Veloso, F., (2014). "Users as innovators in developing countries:the global sources of innovation and diffusion in mobile banking services". *Research Policy*, 43 (9), pp. 1594–1607.

Waverman, L., &Koutroumpis, P., (2011). "Benchmarking telecoms regulation – the telecoms regulatory governance index (TRGI)". *Telecommunications Policy*, 35(5), pp. 450–468.

World Bank(2016). Worldwide Governance Indicators. Retrieved from. http://data. worldbank.org/data-catalog/worldwide-governance-indicators (Accessed: 02/04/2020)