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Telecommunications regulation, mobile money innovations and financial inclusion

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Abstract

This study assesses how corporate telecommunication (telecom) policies follow telecom sector regulation in mobile money innovation for financial inclusion in developing countries.

Telecom policies are understood in terms of mobile subscriptions, mobile connectivity coverage and mobile connectivity performance while mobile money innovations represent mobile money accounts, the mobile used to send money and the mobile used to receive money. The empirical evidence is based on Tobit regressions. Telecom sector regulation positively influences mobile money innovations. From net influences, mobile subscriptions and connectivity policies moderate telecom sector regulation to positively influence mobile money innovations; exclusively within the remit of mobile money accounts because the corresponding net influences on the mobile used to send money and the mobile used to receive money are negative. The interactive influences are consistently negative and hence, thresholds for complementary policies are provided in order to maintain the positive influence of telecom sector regulation on mobile money innovations. This study has complemented the extant literature by assessing how corporate telecommunication policies follow telecommunication sector regulation in mobile money innovations for financial inclusion.

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

1. Introduction

The situation of this study within the context of extant literature on how corporate telecommunication (telecom) policies follow telecom sector regulation in mobile money innovations for financial inclusion in developing countries build on two principal motivations, notably: (i) the importance of financial inclusion in development outcomes especially in the light of sustainable development goals and (ii) gaps in the extant literature. These two points are substantiated below

First, there is a growing body of evidence in the policy, theoretical and empirical literatue in support of the premise that digital financial inclusion can spur more progress towards the achievement of sustainable development goals (SDGs) as well as provide avenues for the creation of a long-lasting socio-economc impact for millions of people in the world (United Nations, 2018; Tchamyou, 2019). According to the narrative, financial inclusion is related to a plethora of SDGs, *inter alia*: (i) SDG1 linked to poverty eradication; (ii) SDG2 connected to the end of hunger, boosting of sustainable agriculture and realization of food security; (iii) SDG3 related to health and well-being; (iv) SDG5 connected to promoting gender equality and women empowerment; (v) SDG8 linked to economic growth promotion; (vi) SDG9 linked to boosting the industry, innovation and infrastructure; (vii) SDG10 concerned with inequality reduction and (vii) SDG17 focusing on boosting the implementation channels, especially as it concerns the role of financial inclusion through better investment, consumption and resources mobilization with the ultimate purpose of promoting economic growth (Afutu-Kotey *et al*., 2017; Uduji & Okolo-Obasi, 2018a, 2018b; Abor *et al*., 2018; Asongu & Boateng, 2018; Gosavi, 2018; Issahaku *et al*., 2018; Humbani & Wiese, 2018; Tchamyou *et al*., 2019a, 2019b; Abdulqadir & Asongu, 2022; UNCDF, 2022). Given the underlying importance of financial inclusion in achieving a plethora of SDGs, the present study focuses on the role of mobile phone usage/subscriptions and mobile connectivity dynamics in the influence of telecom sector regulation on mobile money innovations, not least, owing to an apparent gap in the extant literature[1].

Second, as far as we know, the extant literature on the importance of mobile phones in outcomes of economic development has substantially focused on, amongst others, insights into the relevance of banking through the mobile phone, especially in view of facilitateing the a bridge in the rural-urban divide (Malaquias & Silva, 2020); banking related to the internet and corresponding disincentives (Arif *et al*., 2020); the importance of technology in the nexus

[1] Mobile connectivity dynamic represent mobile connectivity coverage and mobile connectivity performance.

between the customers and citizens (Lammi & Pantzar, 2020); poverty, inequality and sustainable development externalities associated with information technology and finncial inclusion (Mushtaq & Bruneau, 2020; Hoque, 2020); characteristics of information technology adoption (Karakara & Osabuohien, 2019; Alderete, 2020) and innovations in mobile telecom for financial inclusion purpose (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a).

Of the highlighted studies, the closest strand to the present paper are works fom Asongu *et al*. (2020, 2021a, 2021b). Accordingly, Asongu *et al*. (2020, 2021b) have revisited Lashitew *et al*. (2019) by putting emphasis on a concern of multcollineartity that is overlooked. The present study extends the underlying body of literature by assessing how some supply-side mobile money drivers moderate the incidence of telecom sector regulation on mobile money innovations. In other words, the main objective of the study is to investigate how supply-side mobile mobile drivers moderate the incidence of telecom sector regulation on mobile money innovation dynamics such as mobile money accounts, the mobile used to send money and the mobile used to receive money. The intuition and theory suupporting the the underlying nexuses are provided in Section 2.

Another distinguishing feature of this study with respect to the closest studies in the literature (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a) is that the attendant literature on which the present study is motivated is fundamentally based on linear additive models which provide less room for policy implications. Accordingly, the present study builds on a non-linear model understood within the framework of interactive regressions in order to provide space for more policy implications. Hence, it is for the purpose of providing more room for policy implications that the specifications in the empirical section are tailored such that mobile phone usage/subscriptions and connectivity dynamics (i.e. mobile coveragage and performance) moderate the incidence of telecom sector regulation on mobile money innovation dynamics (i.e. mobile money accounts, the mobile used to send money and the mobile used for receive money). The policy relevance of the non-linear empirical stategy is apparent from the thresholds for complementary policies that are provided in the empirical results section. Moreover, by employing mobile phone usage and connectivity dynamics as modulating variables, the present study also departs from Asongu *et al*. (2021b) which has examined how the rule of law moderates mobile money factors for mobile money innovations.

The rest of the study is organised as follows. The intuition and theoretical underpinnings for the study are discussed in Section 2. Section 3 covers the data and methodology while the empirical results are presented in Section 4. Section 5 concludes with future research directions.

2. Intuition, theoretical underpinnings and testatable hypotheses

This section is discussed in three main strands, notably: the intuition for the study, the theoretical underpinnings supporting the attendant intuition and testable hypotheses. These strands are expaned in the same chronology as highlighted.

First, the intuiton for this study is simply to follow. Accordingly, corporations respond to telecom sector regulation in their decisions to innovate in terms of mobile money innovations. Hence, consistent with intuition, the decision to innovate by corporations is contingent on the existing telecom sector regulation. In others words, corporate policies that are destined to improve mobile phone subscriptions, mobile phone connectivity coverage and mobile phone connectivity performance (i.e. with the ultimate aim of innovating mobile banking activities) are contingent on the existing telecom regulations. On the premise of this intuition, the empirical strategy is tailored such that mobile phone usage and connectivity dynamics moderate the incidence of telecom sector regulation on mobile money innovations.

Second, consistent with the regulations literature (Blind, 2012; Blind *et al*., 2017), regulations for the most part are formulated and implemented by the government to shape and influence the market environment as well as the behavior of actors operating in the corresponding environment. According to the narrative, there is a difference between regulation which is fundamentally a top-down approach and formal standards which are typically the results of market-oriented processes (Büthe & Mattli, 2011). As apparent form Gupta and Lad (1983), the difference can be understood in terms of "direct governmental regulation" versus "industry self-regulation". In essence, the difference can also be viewed in terms of formal standards that are set by corporations versus regulations emanating from the government. Accordingly, we argue in the study that the adoption of formal standards which is voluntary on the part of corporations is contingent on the regulations established by the government. In other words, corporate telecom sector policies and strategies are contingent on government-driven telecom sector regulation. Moreover, such corporate telecom policies could be tailored to promote mobile subscriptions, mobile connectivity performance and mobile connectivity converage, in view of ultimately improving opportunities for mobile money innovations. The attendant narrative is consistent with the title of this study which is: how corporate telecom policies follow telecom sector regulation in mobile money innovations for financial inclusion.

The above narratives are broadly consistent non-contemporary corporate regulations literature (Stigler, 1971; Laffont & Tirole, 1991), not least, because as elucidated by Blind and Mangelsdorf (2016), government institutions responsible for setting regulations can be

employed to explain firms' policies and strategies: this is consistent with the notion of corporate telecom policies following government regulations, as employed in the problem statement of this study. Such responsive corporate policies can be employed to create market entry barriers (Salop & Scheffman, 1987; Swann, 2000; De Vries, 2006; Rysman & Simcoe, 2008; Berger *et al*., 2012), which is consistent with this study because *inter alia*, improvement in mobile connectivity and mobile converage (used in this study as instruments or modulating variables) by corporations can be done with the ultimate aim to limiting access to new companies entering the telecom sector. Moreover, as argued by Swann (2000) and Blind (2016), formal standards that are not mandatory which set up by corporations in response to regulations in place, can influence technological infrastructure within a specific market. In this study such influence is understood in terms of mobile money innovations such as mobile money accounts, the mobile used to send money and the mobile used to receive money, which are employed as outcomes variables. Within the specific remit of telecommunications and in particular, Global System for Mobile communication (GSM) usage, alliance networks and corporate strategies surrounding corporate standards and policies, the intuition and theoretical underpinnings of this study are consistent with the arguments of Bekkers *et al*. (2002) in relation to the market structure and Blind *et al*. (2017) with respect to the standardization process.

Third, it is worthwhile to clarify the notion of telecom regulation as understood in this study before stating the corresponding testable hypotheses in this strand. In terms of conceptual clarification, as apparent in Appendix 1 on the definitions of variables, regulation in the telecom sector is understood from four major criteria, notably: independence, transparency, enforcement and resource availability. These are factors that are more likely to favour competiton and hence, it is anticipated that such characteristics should increase innovation of mobile phones in terms of mobile money innovations. This leads the study to the statement of the following hypothesis:

Hypothesis 1: Telecom sector regulation posively influences mobile money innovations (i.e. mobile money accounts, the mobile used to send money and the mobile used to receive money).

In accordance with the discussion in this section, when telecom sector regulation is tailored to improve competition, corporate telecom policies are induced to tailor their strategies and operations towards improving the usage and effectiveness of their telecom services. It follows that corporate policies tailored to favor mobile subscriptions, mobile connectivity coverage and

mobile connectivity performance (i.e. mobile usage and connectivity dynamics) interact with telecom sector regulation to further boost mobile money innovations in terms of mobile money accounts, the mobile used to send money and the mobile used to receive money. The underpinning leads to the following hypothesis:

Hypothesis 2: Mobile usage and connectivity policies (i.e. coverage and performance) moderate telecom sector regulation to positively influence 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

The data employed for the purpose of assessing the testatable hypotheses are consistent with the attendant contemporary literature that has investigated problem statements that are tailored towards providing better insights into the understanding of mobile mobile innovations, notably: Lashitew *et al*. (2019), Asongu *et al*. (2020, 2021a). The corresponding data entail averages of 2010 and 2014 which are obtained from a multitude of sources, namely: (i) World Development Indicators (WDI) of the World Bank; (ii) World Governance Indicators (WGI) of the World Bank; (iii) the Global Financial Structure Database (GFSD); (iv) the Global System for Mobile Communications Association (GSMA) and (v) Waverman and Koutroumpis (2011). The data consist of all countries for which data were apparent at the time of study by Lashitew *et al*. (2019). Hence, the temporal and geographical scopes of the data are contingent on Lashitew *et al*. (2019) which is the primary source of the data. The developing continents and regions included in the study are Africa, the Middle East, Asia and the Americas.

Consistent with three of the closest studies motivating this study (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a), three main outcome variables are used in order to proxy for mobile money innovations, namely: mobile money accounts, the mobile used to send money and the mobile used to receive money.

In accordance with the introduction, contrary to the corresponding literature (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a), which is based on linear additive models, this study exclusively considers supply-side money mobile drivers as the main independent variables of interest, notably: telecom sector regulation, mobile subscriptions, mobile connectivity performance and mobile connectivity coverage. These independent variables of interest constitute the main channel (i.e. telecom sector regulation) and instruments of corporate telecom policies such as mobile phone subscriptions, mobile connectivity coverage and mobile connectivity performance. The full definitions of variables are provided in Appendix 1.

In order to control for the omission of variables that are likely to biase the estimated coefficients if not considered, a set of control variables is taken into account. These include demand-side mobile money drivers, macroeconomic factors and continental/regional fixed effects in order to account for the unobsevered heterogeneity. First, the demand-side mobile money drivers included are: automated teller machines (ATMs) penetration and banking sector sector concentration. The macroeconomic variables included are the economic growth and urbanization rates while the fixed effects are dummies for the following continents and regions: Africa, Asia, the Americas and the Middle East. The underlying demand-side variables, macroeconomic indicators and fixed effects are documented in the attendant literature (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a). The choices of the underlying variables are substantiated in more detail below.

The extant empirical literature motivating the choice of variables in the preceding paragraph is as follows: (i) mobile money drivers from the demand side (Muwanguzi & Musambira, 2009; Van der Boor *et al*., 2014; Demirguc-Kunt *et al*., 2015); studies focusing on financial inclusion (Demirguc-Kunt & Klapper, 2012; Demirgüç-Kunt *et al*., 2015; Asongu & Asongu, 2018; Asongu & Odhiambo, 2018a, 2018b); supply-side drivers of mobile money (Van der Boor *et al*., 2014; Mas & Morawczynski, 2009; Demirgüç-Kunt & Klapper, 2013; Gruber & Koutroumpis, 2013; Waverman & Koutroumpis, 2011; GSMA, 2018) and macroeconomic indicators (Murendo *et al*., 2018; World Bank, 2016; Asongu & Odhiambo, 2022). The correspoding summary staitistics and correlation matrix of the variables are provided in Appendix 2 and Appendix 3, respectively.

3.2 Methodology

In line with the elements of the motivation in the introduction and the corresponding narrative in Section 2 pertaining to the theoretical underpinnings, the empirical strategy adopted to investigate the problem statement is the Tobit regression model, which has also been used by recent studies employing the same data set while investigating determinants of mobile money innovations (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a). Even beyond the remit of the attendant comparative emphasis, it is worthwhile to also emphasize that the adopted empirical strategy is consistent with data behavior, not least because, the three dependent variables employed are situated within a specified range. This justification of the choice of the empirical strategy that is contingent on consistency with data behavior is in accordance with

contemporary literature that has also employed the Tobit regressions strategy (Nchofoung & Asongu, 2022; Nchofoung *et al*., 2021; Ajide *et al*., 2019; Coccorese & Pellecchia, 2010).

In the light of the above, the consistency between the choice of the empirical strategy and the data behavior is in Appendix 2 from which, it is apparent that all three outcome variables are situated within a range of 0% to 100%. It follows that the construction of the variables is in line with the choice of an empirical strategy that is bound to censore the attendant outcome variables on both sides of the conditional distributions. In essence, as argued in non-contemporauy (Amemiya, 1984) and contemporary literature focused on the problem statement (Asongu *et al*., 2021b), the Tobit empirical strategy censores all the adopted mobile money outcomes on both sides of the conditional distributions. When such limited range in the outcome variables is apparent, estimation by Ordinary Least Squares (OLS) can engender inefficient estimated coefficients.

Given the insights above, the standard Tobit procedure is spelt in Equations (1) and (2) below, in line with the corrrespondng 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.

It is worthwhile to emphasize that the underlying assumptions on which the Tobit approach are premised are such that on the one hand, the residuals are normally distributed and on the other, the latent outcome variables and the corresponding linear function of the independent variables that are present are not bounded (Amemiya, 1984). In the regression outcomes, two influences of the explanatory variables are apparent: (i) one displaying the marginal influences for the independent variables on the adoption latent rate that is unobserved and (ii) another reflecting the observed and censored rate of adoption. In accordance with the attendant Tobit regressions literature on the subject (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a), in the reporting of findings in Section 4, only the marginal influences linked to the observed adoption censored rate are reported for the purpose of robustness (Lashitew *et al*., 2019; Asongu *et al*., 2020, 2021a) .

4. Empirical results

4.1 Presentation of results

This section discloses the empirical findings that are provided in Table 1. The results are presented in three main sections, each corresponding to three specifications, respectively for mobile money accounts, the mobile used to send money and the mobile used to receive money. The first set of specifications focuses on the nexuses among telecom sector regulation, mobile connectivity performance and mobile money innovations, the second is on telecom sector regulation, mobile subscription and mobile money innovations while the third focuses on linkages among telecom sector regulation, mobile connectivity coverage and mobile money innovartions.

In all the nine specifications, it is apparent that both the unconditional or isolated incidences of telecom sector regulation and the interactive influences are overwhelmingly significant. This is evidence that the corresponding net influences can be computed and thus both *Hypothesis* 1 and *Hypthesis* 2 can evidently be assessed based on the unconditional influences of telecom sector estimates and net/overall influences, respectively. Accordingly, net influences are computed for the assessment of *Hypothesis* 2 because in interactive regressions, both the conditional and unconditional influences should be involved in order to assess the overall incidence of the modulating variables on the main channel for an effect on the outcome variables (Tchamyou, 2019). Hence, net influences are computed to assess Hypothesis 2. For instance, in the second column of Table 1, the net influence of mobile connectivity performance on telecom sector regulation to affect mobile money accounts is positive or 4.719= ([-0.325 × 11.920] + [8.593]). In the corresponding computation, 8.593 represents the unconditional incidence of telecom sector regulation, -0.325 denotes the conditional influence from the interaction between telecom sector regulation and mobile connectivity performance while 11.920 is the value of mobile connectivity performance, as apparent in the summary statistics of Appendix 2.

Given the above clarification, the following findings are apparent. (i) The unconditional influence of telecom sector regulation on the outcomes variables is consistently positive throughout the specifications. (ii) The conditional influences from the interactions between telecom sector regulation and the modulating mobile usage and connectivity dynamic variables are consistently negative. (iii) While net influences are consistently positive when mobile money accounts are employed as the outcome variable, the corresponding net influences are consistently negative when the mobile used to send money and the money used to receive money are employed as outcome variables. (iv) Most of the control variables are significant,

especially for regressions focusing on mobile money accounts. However, given that multicollinearity is overlooked in interactive regressions, emphasis is placed on significance as apposed to whether the estimated signs are expected or not. This argument is consistent with Brambor *et al*. (2006) on understanding interactive regressions, especially in informing the basis that the unexpected signs could be the result of multicollinearity. This is the reason that net influences (involving both the conditional and unconditional influences) are taken into account in this study. This leads us to assessing the validity the tested hypotheses.

Hypothesis 1 is valid given that the unconditional influences of telecom sector regulation on the outcome variables are consistently positive. It follows that telecom sector regulation positively influences mobile money innovations in terms of mobile money accounts, the mobile used to receive money and the mobile used to send money.

Hypothesis 2 is valid for mobile money accounts and not for the mobile used to send money and the mobile used to receive money on the premise of net positive influences that are computed in order to assess the role of mobile phone subscription and connectivity dynamics in the influence of telecom sector regulation on mobile money innovations. It follows that, mobile usage and connectivity policies (i.e. coverage and performance) moderate telecom sector regulation to positively influence mobile money innovations; exclusively within the remit of mobile money accounts because the corresponding net influences on the mobile used to send money and the mobile used to receive money are negative. A possible explanation is that mobile usage and connectivity dynamics have to be improved such that beyond the establishment of mobile money accounts, such mobile money accounts are used to send money and receive money more significantly. More insights into this direction are provided in Section 4.3 below.

Table 1: Telecom regulation, mobile subscription, mobile connectivity performance and financial inclusion

	Dependent variables: Mobile money accounts, Mobile used to send money & Mobile used to receive money								
	Telecom regulation and mobile connectivity performance			**Telecom regulation and mobile subscription**			**Telecom regulation and mobile connectivity coverage**		
	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**	**Mobile money accounts**	**Mobile used to send money**	**Mobile used to receive money**
Supply Factors									
Telecom Regulation (TR)	**8.593*****	**7.033***	**9.558****	**19.343*****	**15.897****	**17.102***	**16.025*****	**16.241****	**21.369****
	(0.008)	**(0.070)**	**(0.040)**	**(0.004)**	**(0.047)**	**(0.065)**	**(0.001)**	**(0.034)**	**(0.018)**
Mobile Con. Perf. (MCP)	**0.202****	0.065	0.105	---	---	---	---	---	---
	(0.035)	(0.590)	(0.431)						

Mobile Subscription (MS)	---	---	---	**0.090****	**0.128****	**0.129****	---	---	---
				(0.014)	**(0.018)**	**(0.038)**			
Mobile Connectivity Coverage (MCC)	---	---	---	---	---	---	**0.106*****	**0.077***	**0.104****
							(0.002)	**(0.079)**	**(0.036)**
TR × MCP	**-0.325****	**-0.814****	**-1.080*****	---	---	---	---	---	---
	(0.038)	**(0.014)**	**(0.005)**						
TR × MS	---	---	---	**-0.234****	**-0.282****	**-0.308****	---	---	---
				(0.027)	**(0.027)**	**(0.041)**			
TR × MCC							**-0.197*****	**-0.311*****	**-0.401*****
							(0.009)	**(0.006)**	**(0.002)**
Demand Factors									
ATM Penetration	**-0.027***	-0.023	-0.031	-0.016	**-0.051****	**-0.061****	**-0.020***	**-0.040****	**-0.049****
	(0.058)	(0.233)	(0.177)	(0.105)	**(0.024)**	**(0.022)**	**(0.065)**	**(0.045)**	**(0.046)**
Banking Sector Con	**-0.055****	-0.018	-0.029	**-0.048****	-0.030	**-0.045***	**-0.044****	-0.024	-0.035
	(0.026)	(0.484)	(0.327)	**(0.036)**	(0.181)	**(0.095)**	**(0.044)**	(0.293)	(0.180)
Macro-level Factors									
GDP growth	**0.715*****	0.086	-0.022	**0.740*****	0.270	0.179	**0.725*****	0.202	0.129
	(0.000)	(0.714)	(0.942)	**(0.000)**	(0.303)	(0.579)	**(0.000)**	(0.414)	(0.678)
Urbanization	-0.041	0.016	0.029	-0.042	-0.020	-0.015	**-0.049***	0.004	0.011
	(0.117)	(0.708)	(0.592)	(0.114)	(0.627)	(0.763)	**(0.087)**	(0.918)	(0.847)
Region dummies									
Africa	**7.749*****	0.467	1.591	**7.342*****	2.509	**4.336***	**8.034*****	1.112	2.585
	(0.000)	(0.768)	(0.407)	**(0.000)**	(0.155)	**(0.069)**	**(0.000)**	(0.516)	(0.234)
Asia	**3.046***	-2.224	-2.114	2.793	-1.234	-0.490	**3.186***	-2.112	-1.858
	(0.070)	(0.141)	(0.221)	(0.107)	(0.392)	(0.781)	**(0.069)**	(0.171)	(0.313)
Americas	**5.422*****	**-3.659****	**-3.879****	**4.723*****	-0.643	0.177	**5.064*****	-1.709	-1.253
	(0.005)	**(0.022)**	**(0.029)**	**(0.005)**	(0.600)	(0.907)	**(0.005)**	(0.262)	(0.483)
Middle East	**5.438****	-3.469	-2.647	**6.269*****	-1.396	0.407	**5.185****	-3.848	-2.942
	(0.011)	(0.178)	(0.339)	**(0.005)**	(0.519)	(0.864)	**(0.018)**	(0.136)	(0.266)
Net Effects	4.719	-2.670	-3.315	4.898	-1.510	-1.910	3.775	-3.097	-3.565
Thresholds	26.440	8.640	8.850	82.662	56.372	55.526	81.345	52.222	53.289
Observations	111	115	115	112	116	116	111	115	115

GDP: Gross Domestic Product. PPP: Purchasing Power Parity. *,**,***: significance levels of 10%, 5% and 1% respectively. The mean value of mobile subscription rate is 61.73, the mean value of mobile connectivity performance is 11.92 while the mean value of mobile connectivity coverage is 62.18. na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant.
Source: Author

Still considering the evidence on *Hypothesis* 2, it is apparent that the interactive influences are consistently negative which is an indication that in the light of the corresponding positive unconditional influences of telecom sector regulation, there are certain thresholds of mobile usage and connectivity dynamics at which, compelementary policies are needed to maintain the positive influence of telecom sector regulation on mobile money innovations. This motivates the next section on thresholds for complementary policies.

4.2 Threhsolds for complementary policies

This section is relevant given that policy makers can be provided with thresholds for complementary policies. These are critical masses of the modulating variables that when reached, complementary policies should be put in place in order to maintain the positive influence of telecom sector regulation on mobile money innovations. Such computations are

consistent with the contemporary literature on policy thresholds (Nchofoung & Asongu, 2022; Nchofoung *et al*., 2022) as well as thresholds for complementary policies (Asongu & Odhiambo, 2020, 2021).

To put the above into more perpective, in the second column of Table 1, the threshold for complementary policy is 26.440 (8.593/0.325). Hence, at 26.440 weighted average of share of populations covered by 2G, 3G and 4G mobile data networks (normalized to range between 0 and 100), complementary policies are needed in order to maintain the positive influence of telecom sector regulation on mobile money accounts. To put this into perspective, when mobile connectivity coverage is 26.440, the net influence is zero or 0= ([-0.325 × 26.440] + [8.593]). Hence, above the threshold of 26.440, the net influence on the outcome variable becomes negative. Therefore, above the threshold, complementary policies are needed to maintain the positive influence of telecom sector regulation on mobile money accounts. In other words, when the threshold is exceeded, policy makers should put in place other policy initiatives that can promote mobile money accounts and/or the favorable effect of telecom sector regulation on mobile money accounts. The other thresholds have the same explanation, just that the thresholds are contingent on mobile money innovation dynamics (i.e. mobile money accounts, the mobile used to send money and the mobile used to receive money) as well as on supply factors (i.e. mobile subscription, mobile connectivity performance and mobile connectivity coverage).

In order for the computed thresholds to be policy-relevant and make economic sense, they should be situated within the corresponding range (i.e. minimum to maximum levels) in the summary statistics. Comparing the computed threshold to corresponding ranges in the summary statistics, it is apparent that all computed thresholds are policy-relevant and make economic sense. It follows that policy makers can act upon the established thresholds in order to maintain the critical role of telecom regulation in driving mobile money innovations.

4.3 Further discussion on complementary policies

The importance of complementary policies at the established thresholds can be explained by a plethora of factors which are indicatve of the perspective that complementing telecom sector regulation with the engaged modulating variables is a necessary but not a sufficient condition for the promotion of mobile money innovations. Accordingly, at the established thresholds, complementary policies are worthwhile for the following reasons, *inter alia*.

As clarified by Blind *et al*. (2017), legislators, standard setters and corporate management could have different levels of knowledge and understanding about frontiers of telecom technology

such that information asymmetry plays a role in how corporate strategies leverage on existing telecom regulations to promote innovation in terms of mobile money innovations.

In the light of the above insights into information asymmetry, mismatches between existing regulations and standards from corporations can engender misunderstanding of technological frontier opportunities; mistmatches which can be addressed with complementary policies. This narrative is consistent with Keck (1998) about the government having less knowledge about how corporations can leverage on the regulations it formulates and implements. Hence, complementary policies can be justified when market actors and regulatory authorities do not have perfect information about how regulations should be consistent with current frontiers of technology. The complementary policies can thus be tailored such that both regulators and telecom corporations have robust knowledge about technological innovation opportunities from existing regulations.

The concern of information asymmetry above can be exarcebated by varying levels of market uncertainty, especially when the telecom market is characterised by technical landscapes that are heterogenous and hence, technological mismatches can be apparent owing to varying information between corporate telecom actors and regulators. This tendency is aptly summarized by Jalonen (2011): "…*that the more unknown the domain (e.g. consequences and technology) of the innovation, the more ambiguous are the regulations and, hence more uncertainty is felt by innovators*" (p. 26).

It follows from the above that in order to maintain the positive influence of telecom sector regulation on mobile money innovations as apparent in the established findings, at the established thresholds of the modulating variables, complementary policies are needed to mitigate potential information asymmetry and substantial uncertainty which can cause telecom corporations to misunderstand regulations and develop formal standards (i.e. instruments and modulating variables/strategies) that generate lower compliances in the light of existing technological innovation opportunities associated with such regulations.

5. Conclusion and future research directions

This study has assessed how coporate telecommunications (telecom) policies follow telecom sector regulation in mobile money innovation for financial inclusion in developing countries. Telecom policies are understood in terms of mobile subscriptions, mobile connectivity coverage and mobile connectivity performance while mobile money innovations represent

mobile money accounts, the mobile used to send money and the mobile used to receive money. The empirical evidence is based on Tobit regressions. Telecom sector regulation positively influences mobile money innovations. From net influences, mobile usage and connectivity policies moderate telecom sector regulation to positively influence mobile money innovations; exclusively within the remit of mobile money accounts because the corresponding net influences on the mobile used to send money and the mobile used to receive money are negative. A possible explanation is that mobile usage and connectivity dynamics have to be improved such that beyond the establishment of mobile money accouts, such mobile money accounts are used to send and receive money more significantly.

The interactive influences are consistently negative and hence, thresholds for complementary policies are provided in order to maintain the positive influence of telecom sector regulation on mobile money innovations. The computed thresholds for complementary policies are policy-relevant and make economic sense because they are within statistical range. It follows that policy makers can act upon the established thresholds in order to maintain the critical role of telecom sector regulation in driving mobile money innovations. The thresholds for complementary policies are further clarified in terms of information asymmetry and market uncertainty. In essence, the importance of complementary policies at the established thresholds have been explained by a plethora of factors which are indicatve of the perspective that complementing telecom sector regulation with the engaged modulating variables is a necessary but not a sufficient condition for the promotion of mobile money innovations.

It is important to clarify that the underlying findings also double as the main strengths of the present paper. However, restriction to the data of Lashitew et al. (2019) is a limitation of the study and hence, future studies should consider more updated data. Further research can also extend the present study by assessing which complementary policies can be employed to dampen the consistent negative interactive effects. Moreover, considering factors of information asymmetry and market uncertainty that can influence mismatch in understanding technological opportunities should also be considered in future research.

Appendices

Table 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: 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.

Appendix 3: 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 Connectivity Coverage. TSR: Telecom Sector Regulation. GDPpc: Gross Domestic Product per capita in PPP (in logs). GDPg: GDP growth. RL: Rule of Law. Urban: Urbanization.

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