Understanding the greater diffusion of mobile money innovations in Africa

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Abstract

The present research extends Lashitew, van Tulder and Liasse (2019, RP) in order to understand the greater diffusion of mobile money innovations in Africa. To make this assessment, a comparative analysis is engaged between sampled African countries and the corresponding sampled developing countries. Three main types of predictor groups are used for the study, namely: demand, supply and macro-level factors. The empirical evidence is based on Tobit regressions. The tested hypothesis is confirmed because from a comparative analysis between African-specific estimates and those of the sampled countries, not all factors driving mobile money innovations in Africa are apparent in the findings of Lashitew et al. (2019). An extended analysis is also performed to take on board the concern of multicollinearity from which, the best estimators from the study are derived. Comparative findings from correlation analysis show that an African specificity is largely traceable to the 'unique mobile subscription rate' variable. An in-depth empirical analysis further confirms an African specificity in the outcome variables (especially in the mobile used to send/receive money) which, may be traceable to informal sector variables not documented in Lashitew et al. (2019). Scholarly and policy implications are discussed.

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

1. Introduction

This research extends Lashitew, van Tulder and Liasse (2019, RP)[2] in order to comparatively clarify why Africa is in the driver's seat when it comes to mobile phone innovations for financial inclusion. The premise of the study is fundamentally motivated by the fact that while a substantial part of the empirical results section of the underlying study is devoted to explaining why Africa is in the driver's seat, the empirical analysis on which the leading role of Africa is drawn is a significant African dummy estimated coefficient. However, it is relevant to understand factors underlying the higher significant magnitude of the African dummy in order to provide both scholars and policy makers with the attendant variables that are driving mobile money innovations in Africa. The premise of this research is put in more perspective in what follows.

To put the above motivation in more context, this study aims to clarify the following statement: "*Finally, the significant dummy variable for Africa across the regressions indicates the greater diffusion of mobile money innovations in the continent that is not captured by other variables*" (Lashitew et al., 2019, p.1207). By 'other variables', Lashitew et al. (2019) are referring to the engaged demand, supply and macro-level factors. However, the "*the greater diffusion of mobile money innovations in the continent*" can either be captured "*by other variables*" or not, if an African-centric estimation is taken on board within the framework of a comparative analysis. The present study aims to clarify these variables because they are not apparent from the underlying study from an African-centric perspective. This is essentially because; the factors referred to by the underlying study to elucidate the role of Africa as a frontier continent in mobile money innovations are specific to all sampled developing countries. In order to clarify this conflation, a comparative analysis between the estimates of African countries and estimates from the sampled developing countries is worthwhile.

Two more motivational elements are worth taking on board in order to further articulate the relevance of this study, notably: (i) the role of financial inclusion and mobile money innovations in the light of challenges pertaining to sustainable development goals and (ii) the importance of replicating research in social sciences. The underlying elements are elicited in turn.

First of all, it is important to note that sustainable development challenges, especially those surrounding poverty alleviation are more apparent in Africa, compared to other

[2] The terms 'underlying literature' 'underlying study' and Lashitew et al. (2019) are used interchangeably throughout this study.

developing countries in the world. This is also the reason for a more robust comparative analysis of the underlying study in order to better grasp African-centric factors that are relevant in financial inclusion by means of mobile money innovations. To put this point into more perspective: (i) compared to other developing countries, most African countries failed to reach the millennium development goal (MDG) related to extreme poverty alleviation (Tchamyou, Asongu & Odhiambo, 2019a; Tchamyou, Erreygers & Cassimon, 2019b). Moreover current projections articulate that the goal of reducing extreme poverty to an acceptable threshold of 3% by 2030 is unfeasible unless inclusive policies are comprehensively implemented (Bicaba, Brixiová & Ncube, 2017).

(ii) There is a substantial bulk of literature on the rewards of mobile phone innovations in improving inclusive economic and human developments in Africa (Asongu, 2013; Afutu-Kotey, Gough & Owusu, 2017; Gosavi, 2018; Minkoua Nzie, Bidogeza & Ngum, 2018; Asongu, Nwachukwu & Aziz, 2018; Uduji & Okolo-Obasi, 2018a, 2018b; Humbani & Wiese, 2018; Issahaku, Abu & Nkegbe, 2018; Abor, Amidu & Issahaku, 2018; Asongu & Odhiambo, 2020)[3]. Inclusive development can be understood in terms of absolute pro-poor inclusion (i.e. reduction of poverty) and/or relative pro-poor inclusion (i.e. reduction of inequality) (Asongu & Nwachukwu, 2017).

The highlighted strand of inclusive development literature is broadly in accordance with Lashitew et al. (2019) which is premised on the importance of mobile money innovations for inclusive development outcomes. However, as articulated above, the conclusions of the underlying study cannot enable an inference of specific factors that explain Africa's leading position in terms mobile innovations. Hence, in order to better inform policy makers and concerned scholars, a comparative empirical exercise is worthwhile in the light of the growing relevance of replicating scientific research for better scientific scholarly communication (Cook, 2014; McEwan, Carpenter & Westerman, 2018; Pridemore, Makel & Plucker, 2018).

Second, replications in social science are fundamental for a multitude of reasons, amongst others: "*the replicability of research results is also a central tenet to the scientific research process*" (Cook, 2014, p. 233) and "*Replications are an important part of the research process because they allow for greater confidence in the findings*" (McEwan et al., 2018, p. 235) and "*the replicability of research results is also a central tenet to the scientific research process*" (Cook, 2014, p. 233). In the same vein, the present study replicates Lashitew et al. (2019) in order to clarify factors driving Africa's leading position in mobile

[3] For brevity and flow as well as to avoid duplicating information, the interested reader can consult Lashitew *et al*. (2019) for an elaborate discussion of various strands in the literature.

phone innovations owing to the motivation provided above. It follows that the testable hypothesis being envisaged is the following:

Hypothesis 1: With a comparative analysis between African-specific estimates and those of the sampled developing countires, not all factors driving mobile money innovations in Africa are apparent in the findings of Lashitew et al. (2019).

In order to test the above hypothesis, the findings of Lashitewet al. (2019) are compared with corresponding African-specific estimates and differences (in terms of magnitudes and signs) are articulated to validate or reject the tested hypothesis and by extension, clarify whether a comprehensive comparative analysis is worthwile.

The closest study to this paper is Asongu, Biekpe and Cassimon (2020) which has investigated mobile phone diffusion innovations within the context of Lashitew et al. (2019) and accounted for multicollinearity within the framework of developing countries. The present paper departs from Asongu et al. (2020) on at least three fronts, notably, in terms of: (i) the motivation and focus on Africa instead of other developing countries outside Africa. The perculiarity of Africa in the light of the findings of Lashitew et al. (2019) on the one hand, and challenges to SDGs on the other hand, has been discussed in the preceding paragraphs. (ii) Within the specific emphasis of multicollinearity, this study shows that there is a disctinctive African feature which is treaceble to the unique mobile phone subscription rate. Hence, while Asongu et al. (2020) have taken on board the concern of multicollinearity, the specificity of unique mobile phone subscription rate in the continent engenders distinct specifications owing to more concerns of multicollieanrity in the African sub-sample. (iii) There are apparent differences in the findings and corresponding implications.

On the differences in findings, when the concern of multicollinearity is taken on board, the findings of the African sample are largely insignificant compared to previous findings on developing countries from Lashitew et al. (2019). Moreover, even when the concern of multicollinearity is not considered, some significant differences in findings are also apparent. (i) On the determinants of mobile money accounts, the main factors driving mobile money accounts in African countries, compared to other developing countries are automated teller machine penetration, unique mobile subscription rate and GDP growth. Moreover, mobile phone connectivity performance and the rate of urbanization which were previously insignificant in Lashitew et al. (2019) appear to negatively influence mobile money accounts while telecom sector regulation which was attributed as a driver of mobile money accounts is not significantly positive. (ii) With respect to the mobile used to send money, the negative relevance of the rule of law is not apparent because the corresponding

rule of law estimate is not significant in the African sample. (iii) Concerning the mobile use to receive money, the negative incidences of mobile connectivity performance and the rule of law are not apparent because the corresponding mobile connectivity performance and rule of law estimates are not significant in the African sample.

The rest of the study is organized as follows. Section 2 is concerned with the data and methodology. The empirical results are disclosed in Section 3. Section 4 concludes with implications and future research directions.

2. Data and methodology

2.1 Data

In accordance with the motivation in the previous section, this study uses the same dataset as in Lashitew et al. (2019). This data entail averages for the period 2010-2014 that are gathered from a plethora of sources. First, the dependent variables which are from the Financial Inclusion Indices (Findex) database entail three main dynamics, namely: 'mobile money accounts', 'mobile used to send money' and 'mobile used to receive money'. Second, the predictors are classified into three main categories. (i) Demand factors which are obtained from the Global Financial Structure Database (GFSD) are banking sector concentration, the number of automated teller machines (ATMs) and the percentage of adults who have an account at a formal financial institution. (ii) Supply factors from Waverman and Koutroumpis (2011), the World Development Indicators (WDI) of the World Bank and the Global System for Mobile Communications Association (GSMA), are telecommunication (or telecom) sector regulation obtained from Waverman and Koutroumpis (2011), mobile connectivity coverage and mobile connectivity performance from the GSMA and "gross and unique subscription" and mobile phone penetration rates from the GSMA and WDI.

Third, four macro-level indicators are considered for the study. They include: the rule of law from World Governance Indicators (WGI) of the World Bank on the one hand and on the other, Gross Domestic Product (GDP) growth, the urbanization rate and GDP per capita, from WDI.

Note should be taken of the fact that the sampled countries from the Americas, the Middle East, Africa and Asia are all developing nations for which data is available at the time of the study of Lashitew et al. (2019). Moreover, the choice of the demand, supply and macro-level oriented indicators is informed by the attendant literature on financial inclusion, notabaly, Demirgüç-Kunt and Klapper (2012), Demirgüç-Kunt, Klapper and Van Oudheusden (2015), Asongu and Asongu (2018) and Asongu and Odhiambo (2018). Demand factors are

drawn from Muwanguzi and Musambira (2009), Van der Boor, Oliveira and Veloso (2014) and Demirgüç-Kunt et al. (2015). Supply-oriented determinants are sourced from Waverman and Koutroumpis, (2011), Van der Boor et al. (2014), Demirgüç-Kunt and Klapper (2013), Mas and Morawczynski (2009), Gruber and Koutroumpis (2013) and the GSMA (2018). Last but not the least, macro-level financial inclusion determinants are informed by the World Bank (2016) and Murendo, Wollni, De Brauw and Mugabi (2018). Given that this is a replication study, the apriori expectations are that the estimated coefficients in terms of signs and magnitude of significance should be consistent with those in Lashitew et al. (2019). The above discussion of variables is substantiated in the Appendices with: (i) definitions and sources of variables (see Appendix 1) and (ii) a summary statistics for both the full sample and the African sub-sample (see Appendix 2).

It is apparent from the summary statistics that African countries are leading in mobile money innovations because of comparatively higher magnitudes of corresponding mean values. While this tendency is captured in the regressions of Lashitew et al. (2019) from estimated African dummies, such a tendency cannot be generalized to other factors driving mobile money innovations associated from estimated coefficients from the full sample. This is essentially because, *inter alia*, African countries, for the most part, do not exhibit higher mean values in the predicting factors being considered. It follows that brief comparative insights from the summary statistics further justify this replication exercise in the light of objectives discussed in the introduction.

2.2 Methodology

The estimation approach used to examine the hypothesis being tested in this study is also consistent with the empirical approach adopted by Lashitew et al. (2019), namely: Tobit regressions. Moreover, as has been argued in contemporary literature (see Ajide, Raheem & Asongu, 2019; Asongu & Nwachukwu, 2016), the adoption of the estimation technique requires that the outcome indicator should be defined within a given interval. This narrative on specificities informing the choice of the attendant approach is consistent with a less contemporary strand of Tobit-centric literature which also argues for the adoption of the estimation technique when minimum and maximum values fall within a defined interval (Kumbhakar & Lovell, 2000; Koetter & Vins, 2008; Coccorese & Pellecchia, 2010; Ariss, 2010). Hence, the choice of the estimation technique is consistent with the extant literature on the need for an estimation technique to be consistent with data behavior (Sadik-Zada, Löwenstein & Ferrari, 2018; Sadik-Zada, 2019).

With the above insights fully acknowledged, it is worthwhile to note that, as disclosed in Appendix 2, all the three dependent variables being considered in the study are defined within an interval of 0% and 100%. This is essentially because the mobile money adoption rates are by construction censored from 0 to 100. In the light of this censoring, an Ordinary Least Squares (OLS) estimation technique is unlikely to produce consistent estimates given that the attendant estimation approach is not desgined to consider the conditional adoption probability of limit observations which are characterised by countries with a 100% adoption rate or a 0% adoption rate (Amemiya, 1984). Consequently, a double censored Tobit estimation strategy is adopted for this study in order to account for the censoring of the engaged mobile money adoption dynamics at extreme points of the corresponding distributions.

Equations (1) and (2) represent the standard estimation procedure for Tobit regressions (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 important to clarify that the following assumptions are typical of the Tobit model: (i) the residuals are distributed normally and (ii) the latent unbounded outcome variables are a linear function of predicting variables (Amemiya, 1984). The predictors reflect two marginal impacts: (i) one is the marginal effect of the predictors on the latent, unobserved adoption rate and (ii) the other reflects the observed, censored adoption rate. Consistent with Lashitew et al. (2019), in the findings that are reported in the next section, only the marginal effects on the censored, rate of adoption are provided given that they are feasible in terms of economic interpretation. Furthermore, as a means of robustness checks, when replicating Lashitew et al. (2019), the paper departs from the underlying by: (i) disclosing estimated coefficients in three decimal places, compared to two decimal places as in the underlying study and (ii) reporting probability (p) values in place of standard errors. It follows that in the light of the hypothesis being tested; the present study first discloses the findings of Lashitew et al. (2019) on the

bases of three decimal places and p-values before comparing them with the novel African-specific findings. Moreover, the choice of the p-values instead of the standard errors is because the former is a criterion that facilitates the assignment of astericks (*, ** & ***) to the corresponding significance levels (respectively, 10%, 5% and 1%).

3. Empirical results

3.1 Baseline specifications without a concern about multicollinearity.

Table 1 which presents the empirical findings is divided into three main categories representing each of the three outcome variables, namely: mobile money accounts, the mobile used to send money and the mobile used to receive money. There are two main specifications in each category, one that replicates the findings of Lashitew et al. (2019) in terms of three decimal places and p-values and the other, that provides corresponding African-centric results for comparative analytical purposes.

In the light of findings provided, the tested hypothesis is valid because when the African-centric findings are compared with those of Lashitew et al. (2019), there are apparent differences in terms of signs and magnitudes of estimated coefficients as it pertains to factors driving mobile money innovations in Africa. In orther words, with a comparative analysis between African-specific estimates and those of the sampled developing countires, not all factors driving mobile money innovations in Africa are apparent in the findings of Lashitew et al. (2019). In what follows, the comparative analysis is put in more perspective with emphasis on each of three mobile money innovation outcomes.

On the determinants of mobile money accounts, the main factors driving mobile money accounts in African countries, compared to other developing countries are ATM penetration, unique mobile subscription rate and GDP growth. Moreover, mobile phone connectivity performance and the rate of urbanization which were previously insignificant in Lashitew et al. (2019) appear to negatively influence mobile money accounts while telecom sector regulation which was attributed as a driver of mobile money accounts is not significantly positive.

Concerning the fact that the number of observations is less than 30, it is worthwhile to emphasize that the rule of thumb choice of 30 as a minimum number of observations for statistical relevance is arbitrary: "*We must remember that information on these should be gathered by the researcher through literature search, pilot study and consulting experts in the field. Hence, there is no such thing as a magic number when it comes to sample size calculations and arbitrary numbers such as 30 must not be considered as adequate*" (Kar &

Ramalingam, 2013, p.179). Moreover, given that the purpose of this study is a replication exercise to improve the understanding of findings from an earlier study, there is no feasible way to increase the number of observations without compromising the purpose for which such an increase is required.

Table 1: Mobile phones innovations and financial inclusion

	Mobile money accounts		**Mobile used to send money**		**Mobile used to receive money**	
	Africa	Lashitew et al. (2019)	Africa	Lashitew et al. (2019)	Africa	Lashitew et al. (2019)
Demand Factors						
Bank Accounts	0.262	0.023	0.244	-0.003	0.297	-0.011
	(0.353)	(0.524)	(0.236)	(0.939)	(0.233)	(0.840)
ATM penetration	**0.858*** **	**-0.024***	-0.132	-0.031	-0.224	-0.030
	(0.004)	**(0.078)**	(0.367)	(0.195)	(0.248)	(0.253)
Bank sector concentration	**-0.321** **	**-0.050***	0.004	0.000	-0.018	-0.003
	(0.019)	**(0.064)**	(0.973)	(1.000)	(0.886)	(0.919)
Supply Factors						
Unique Mobile Subscription. rate	**0.361** **	0.046	0.056	0.004	0.006	-0.013
	(0.020)	(0.121)	(0.733)	(0.883)	(0.972)	(0.707)
Mobile Connectivity Performance	**-5.104** **	0.047	-1.371	-0.139	-1.566	**-0.177***
	(0.030)	(0.379)	(0.221)	(0.120)	(0.229)	**(0.095)**
Mobile Connectivity Coverage	0.065	0.046	-0.096	0.017	-0.102	0.038
	(0.669)	(0.116)	(0.533)	(0.630)	(0.576)	(0.369)
Telecom Sector Regulation	20.482	**6.963*** **	11.483	2.875	15.184	4.503
	(0.157)	**(0.009)**	(0.206)	(0.357)	(0.180)	(0.212)
Macro-level factors						
GDP per capita PPP (log)	-2.588	-1.367	**8.356*** **	**3.128** **	**10.552*** **	**3.952** **
	(0.517)	(0.189)	**(0.007)**	**(0.016)**	**(0.008)**	**(0.013)**
GDP growth	**2.339** **	**0.597*** **	-0.038	0.254	-0.538	0.160
	(0.016)	**(0.001)**	(0.957)	(0.284)	(0.541)	(0.850)
Rule of Law	-7.848	-1.509	-7.355	**-4.026*** **	-8.832	**-5.342*** **
	(0.151)	(0.150)	(0.151)	**(0.009)**	(0.153)	**(0.004)**
Urbanization	**-0.572** **	-0.028	-0.255	-0.033	-0.230	-0.028
	(0.023)	(0.442)	(0.176)	(0.443)	(0.295)	(0.852)
Region dummies						
Africa	---	**8.871*** **	---	**3.322***	---	**5.861** **
		(0.000)		**(0.087)**		**(0.016)**
Asia	---	**4.147** **	---	-1.410	---	-0.394
		(0.013)		(0.417)		(0.837)
Americas	---	**5.833*** **	---	**-3.592** **	---	**-3.333***
		(0.004)		**(0.033)**		**(0.071)**
Middle East	---	**7.069*** **	---	-4.999	---	-4.023
		(0.006)		(0.112)		(0.192)
Observations	28	102	30	108	30	108

GDP: Gross Domestic Product. PPP: Purchasing Power Parity. *,**,***: significance levels of 10%, 5% and 1% respectively.

With respect to the mobile used to send money, the importance of GDP per capita in driving the outcome variable as established by Lashitew et al. (2019) is confirmed owing a higher magnitude from the African-centric sample while the negative relevance of the rule of law is not apparent because the corresponding rule of law estimate is not significant in the

African sample. Concerning the mobile use to receive money, the relevance of GDP per capita in boosting the dependent variable as documented in Lashitew et al. (2019) is also confirmed giving a higher magnitude from the African-centric sample whereas negative incidences of mobile connectivity performance and the rule of law are not apparent because the corresponding mobile connectivity performance and rule of law estimates are not significant in the African sample.

3.2 Extended analysis with a concern about multicollinearity

In the light of the motivation for this study in the introduction, and following Asongu et al. (2020), an extended analysis is engaged in order to take on board the concern about multicollinearity. A threshold of 0.600 is used because it is the average of 0.500 suggested by Wichers (1975) and Obrien (2007) and, 0.700 posited by Kennedy (2008). The corresponding correlation coefficients that exceed the threshold are highlighted in bold in Appendices 3a and 3b. While Appendix 3a is the correlation matrix from Asongu et al. (2020) focusing on the developing countries, Appendix 3b is the corresponding correlation matrix for this study which exclusively focuses on African countries. The italized correlations in Appendix 3b are additional correlations exceeding the attendant threshold that are not apparent in Appendix 3a. When these additional corrorelation coefficients are compared and constrasted, it becomes apparent that unique mobile subscription rate is the peculiarity because it is independently correlated with ATM penetration, mobile connectivity performance and the urbanization rate. It follows that the African perculiarity is traceable to its unique mobile penetration rate. Three insights are worth articulating from this preliminary comparative finding: (i) the justification for positioning a study exclusively on Africa is sound in the light of differences in correlation patterns and (ii) the stylized facts on an African-specificity used to motivate the positioning of the study is apparent in the data behavior, especially as it pertains to 'unique mobile subscription rate' and (iii) consequently, the corresponding specifications are different from those of Asongu et al. (2020) in the light of the identified additional concerns of multicollinearity. Accordingly, the additional correlations owing to the specificity of Africa are addressed by removing the unique 'mobile mobile subscription rate' variable from the first-four specifications of Asongu et al. (2020) and introducing a fifth specification in which the unique mobile subscription rate is apparent but not ATM penetration, network connectivity coverage and urban population.

Table 2: Mobile money accounts and mobile money innovations

	Dependent variable: Mobile money accounts				
	Replications for Africa while controlling for multicollinearity				
	First Specif.	**Second Specif.**	**Third Specif.**	**Fourth Specif.**	**Fifth Specif.**
Demand Factors					
Bank Accounts	0.096 (0.568)	---	---	---	---
ATM penetration	---	0.159 (0.232)	---	---	---
Bank sector concentration	-0.161 (0.143)	**-0.204*** **(0.097)**	-0.161 (0.129)	-0.202 (0.101)	-0.190 (0.121)
Supply Factors					
Unique Mobile Subscription. rate	---	---	---	---	-0.014 (0.802)
Mobile Connectivity Performance	---	---	0.138 (0.829)	---	
Mobile Connectivity Coverage	---	---	---	0.075 (0.349)	---
Telecom Sector Regulation	**19.107*** **(0.093)**	**20.804**** **(0.020)**	**24.901***** **(0.003)**	**16.641**** **(0.047)**	**20.852**** **(0.018)**
Macro-level factors					
GDP per capita PPP (log)	---	---	---	---	---
GDP growth	**1.796***** **(0.005)**	**2.046***** **(0.000)**	**1.985***** **(0.000)**	**2.151***** **(0.000)**	**2.033***** **(0.000)**
Rule of Law	---	---	---	---	
Urbanization	**-0.191**** **(0.031)**	**-0.196**** **(0.034)**	**-0.171**** **(0.033)**	---	---
Observations	29	32	32	32	32

GDP: Gross Domestic Product. PPP: Purchasing Power Parity. *,**,***: significance levels of 10%, 5% and 1% respectively. Specif: Specification. The difference in observations between Table 1 and Table 2 is contingent on the number of missing observations in the variables which are adopted in the estimation exercise. For Table 1 in which the concern of multicollinearity is not taken on board, more variables (which are also characterized by missing observations for some countries) are adopted.

Table 2, Table 3 and Table 4 respectively provide findings for mobile money accounts, the mobile used to send money and the mobile used to receive money. In the light of the narrative in the previous paragraph, each table consists of five specifications. It is important to note that while Lashitew et al. (2019) does not account for multicollinearity, Asongu et al. (2020) which focuses on developing countries exclusively accounts for multicollinearity within the context of developing countries. It follows that in the presentation and discussion of findings in the present study, comparative reference is made to the two underlying studies as well as the African-centric findings in Section 3.1 of the present study that do not take on board the concern about multicollinearity.

The following findings can be established from Table 2 on mobile money accounts: (i) Bank sector concentration and the urbanization rate are negatively related to the outcome variable while telecom sector regulation and GDP growth have positive nexuses with mobile money accounts. (ii) It is apparent that the findings in Table 2 are different from those of

Section 3.2 above and Lashitew et al. (2019). (iii) ATM penetration and mobile connectivity coverage which negatively affect mobile money accounts in Asongu et al. (2020) for developing countries are not significantly apparent in this study for African countries.

Table 3: Mobile used to send money and mobile money innovations

	Dependent variable: Mobile used to send money				
	Replications for Africa while controlling for multicollinearity				
	First Specif.	**Second Specif.**	**Third Specif.**	**Fourth Specif.**	**Fifth Specif.**
Demand Factors					
Bank Accounts	0.104	---	---	---	---
	(0.477)				
ATM penetration	---	0.028	---	---	---
		(0.829)			
Bank sector concentration	-0.126	-0.113	-0.096	-0.099	-0.108
	(0.402)	(0.477)	(0.520)	(0.569)	(0.513)
Supply Factors					
Unique Mobile Subscription. rate	---	---	---	---	-0.002
					(0.972)
Mobile Connectivity Performance	---	---	-0.575	---	
			(0.169)		
Mobile Connectivity Coverage	---	---	---	-0.049	---
				(0.571)	
Telecom Sector Regulation	-1.444	9.739	13.920	12.245	9.825
	(0.867)	(0.399)	(0.176)	(0.342)	(0.313)
Macro-level factors					
GDP per capita PPP (log)	---	---	---	---	---
GDP growth	-0.755	-0.271	-0.383	-0.367	-0.327
	(0.372)	(0.765)	(0.655)	(0.667)	(0.735)
Rule of Law	---	---	---	---	---
Urbanization	0.050	-0.001	-0.006	---	---
	(0.760)	(0.992)	(0.962)		
Observations	31	31	32	32	32

GDP: Gross Domestic Product. PPP: Purchasing Power Parity. Specif: Specification. The difference in observations between Table 1 and Table 3 is contingent on the number of missing observations in the variables which are adopted in the estimation exercise. For Table 1 in which the concern of multicollinearity is not taken on board, more variables (which are also characterized by missing observations for some countries) are adopted.

In Tables 3 and 4, with the exception of mobile connectivity performance which is negatively associated with the mobile used to receive money (i.e. in Table 4), not significant findings are apparent. This starkly contrasts with the findings in Section 3.1 above and Lashitew et al. (2019) (which do not accout for multicollinearity) and the results of Asongu et al. (2020) (which account for multicollinearity for developing countries) because,significnant findings are apparent in Section 3.1, Lashitew et al. (2019) and Asongu et al. (2020).

Five insights emerge from this comparative constrat above: (i) An African specificity in mobile money innovations is apparent; (ii) this specifity is more pronounced when the concern about multicolliearity is taken on board; (iii) the attendant specificity can be seen in the light of determinants of mobile money innovations in developing countries; (iv) given the

apparent dominance of African countires in the three outcome variables compared to other developing countries (see Appendix 2), it can be inferred that drivers of mobile money innovations in African countries are largely captured by the informal sector compared to formal sector variables used in this study and (v) statistically insignificant estimates have as much economic meaning and policy relevance as statistically signifiicant estimates. This fifth point is put in more perspective in what follows.

Table 4: Mobile used to received money and mobile money innovations

	Dependent variable: Mobile used to receive money				
	Replications for Africa while controlling for multicollinearity				
	First Specif.	**Second Specif.**	**Third Specif.**	**Fourth Specif.**	**Fifth Specif.**
Demand Factors					
Bank Accounts	0.086 (0.627)	---	---	---	---
ATM penetration	---	-0.018 (0.908)	---	---	---
Bank sector concentration	-0.181 (0.306)	-0.152 (0.401)	-0.137 (0.421)	-0.136 (0.494)	-0.150 (0.430)
Supply Factors					
Unique Mobile Subscription. rate	---	---	---	---	-0.015 (0.879)
Mobile Connectivity Performance	---	---	**-0.901*** **(0.093)**	---	
Mobile Connectivity Coverage	---	---	---	-0.079 (0.469)	---
Telecom Sector Regulation	0.933 (0.929)	14.549 (0.238)	20.504 (0.101)	19.232 (0.203)	15.772 (0.173)
Macro-level factors					
GDP per capita PPP (log)	---	---	---	---	---
GDP growth	-1.259 (0.267)	-0.688 (0.572)	-0.780 (0.491)	-0.760 (0.500)	-0.718 (0.569)
Rule of Law	---	---	---	---	
Urbanization	0.116 (0.526)	0.038 (0.838)	0.028 (0.860)	---	---
Observations	31	31	32	32	32

GDP: Gross Domestic Product. PPP: Purchasing Power Parity. *: significance level of 10%. Specif: Specification. The difference in observations between Table 1 and Table 4 is contingent on the number of missing observations in the variables which are adopted in the estimation exercise. For Table 1 in which the concern of multicollinearity is not taken on board, more variables (which are also characterized by missing observations for some countries) are adopted.

The underlying in depth empirical analysis has confirmed an African specificity in the outcome variables (especially in the mobile used to send and mobile used to receive money), with insignificant results. An implication of the insignificant results is that, drivers of money money innovation in an African context may be traceable to the informal sector variables not documented in Lashitew et al. (2019). In a nutshell, we have shown that insignificant findings are as much relevant as significant findings because of the clarifications and interpretations of insignificant results in this study.

4. Concluding implications and future research directions

The present research has extended Lashitew, van Tulder and Liasse (2019) in order to understand the greater diffusion of mobile money innovations in Africa. To make this assessment, a comparative analysis is engaged between sampled African countries and the corresponding sampled developing countries. Three main types of predictor groups are used for the study, namely: demand, supply and macro-level factors. The empirical evidence is based on Tobit regressions. The tested hypothesis is confirmed because from a comparative analysis between African-specific estimates and those of the sampled countries, not all factors driving mobile money innovations in Africa are apparent in the findings of Lashitew et al. (2019). On the determinants of mobile money accounts, the main factors driving mobile money accounts in African countries, compared to other developing countrieses are automated teller machines (ATMs) penetration, unique mobile subscription rate and GDP growth. Moreover, mobile phone connectivity performance and the rate of urbanization which were previously insignificant in the Lashitew et al. (2019) appear to negatively influence mobile money accounts while telecommunication sector regulation which was attributed as a driver of mobile money accounts is not significantly positive. Comparative findings pertaining to 'the mobile used to send money' and 'the mobile used to receive money' have been discussed.

An extended analysis has also been performed to take on board the concern about multicollinearity, from which the best estimators from the study are derived. Comparative findings from correlation analysis show that an African specificity is largely traceable to the 'unique mobile subscription rate' variable. From this additional analysis, two main tendencies are apparent when the new findings are compared and constrasted: (i) African-centric findings which do not account for multicollinearity; (ii) a previous study focusing on developing countries which take the concern about multicollinearity on board and (iii) and Lashitew et al. (2019) focusing on developing countries which does not account for multicollinearity. First, in the light of robust estimates, the African specificity is obvious because ATM penetration and mobile connectivity coverage which negatively affect mobile money accounts for developing countries are not significantly apparent in this study for African countries.

Second, five insights which further consolidate an African specificity are derived when the findings on mobile money used to send/receive money are compared and constrasted. (i) An African specificity in mobile money innovations is apparent. (ii) This specificity is more pronounced when the concern about of multicolliearity are taken on board.

(iii) The attendant specificity can be seen in the light of determinants of mobile money innovations in developing countries. (iv) Given the apparent dominance of African countires in the three outcome variables compared to other developing countries, it can be inferred that drivers of mobile money innovations in African countries are largely captured by the informal sector compared to formal sector variables used in this study. (v) Statistically insignificant estimates have as much economic meaning and policy relevance as statistically signifiicant estimates because of the clarifications and interpretations of insignificant results in this study.

An implication of the insignificant results is that, drivers of money money innovation in an African context may be traceable to informal sector variables not documented in Lashitew et al. (2019). Thus by revealing insignificant findings with corresponding implications in a replication exercise, this study contributes at the same time to the literature on the need to replicate studies in order to better inform scholars and policy makers as well as to the strand of literature on fighting publication bias in social sciences in which, strong, significant and expected findings are reported while weak, insignificant and unexpected findings are discarded and/or consigned to the "file drawer" (Rosenberg, 2005; Franco, Malhotra & Simonovits, 2014; Asongu, 2015; Boateng, Asongu, Akamavi & Tchamyou, 2018).

Given that the tested hypothesis has withstood empirical scrutiny, there are obviously corresponding implications for scholars and policy makers. On the front of scholars, this paper has contributed to the extant literature on the need to replicate studies in order to disclose complementary findings based on a rigourous scientific analtytical procedure (Cook, 2014; Pridemore et al., 2018; McEwan et al., 2018). The replication exercise from a scholarly standpoint has thus, been worthwhile because while Lashitew et al. (2019) has for the most part, built on African-centric experiences to clarify corresponding findings, the attendant narratives are not supported by African-centric estimated coefficients.

With regard to the policy front, financial inclusion is particularly relevant to African countries in the light of concerns surrounding sustainable development goals (SDGs) (see Tchamyou et al., 2019b), which we have clarified in the introduction. Hence, the understanding of factors that drive mobile money innovations for financial inclusion in view of promoting inclusive development have been clarified in this study in order to inform policy makers on the specific predictors that drive financial inclusion in Africa, contingent on the findings of Lashitew et al. (2019). Accordingly, this research has shown that these determinants can be largely traceable to drivers in the informal sector not documented in Lashitew et al. (2019).

African countries have a larger informal sector because they are averagely poorer compared to the other sampled developing countries in Asia, America and the Middle East. Moreover, the suggestion on the comparatively larger informal sector does not negate the fact that other sampled developing countries have large informal sectors. Hence, it should be understood in relative terms. In fact even the problem statement of "understanding the greater diffusion of mobile money innovations in Africa" is also relative because while in Lashitew et al. (2019), other developing countries reflect significant positive dummies (i.e. in mobile money account regressions), the positive magnitude of the African dummy is highest.

The findings of this research only enable nexuses to be established. Hence, as more data become available, it would be worthwhile to improve the established findings by examining whether the attendant nexuses withstand empirical scrunity within a panel framework. Moreover, a comparative analysis between developed, developing and African countries could provide more insights into the investigated nexuses for scholars and policy makers.

The conclusions of this study obviously leave room for informal sector variables to be considered in future studies in order to elicit drivers of mobile money innovations in Africa. This direction of future research can consider an extensive literature review on the drivers of mobile money adoption and link them to the comparative findings of the present study.

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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 tomobile phones based on data from WDI. We used additional data from GSMA (2014) to calculateunique mobile subscription rates by correcting for double SIM-card ownership, which differs betweenrural and urban areas. This correction is based on survey evidence that urban and rural users own2.03 & 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 variablestelecom 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 remainingvariables, averages are taken over the years 2010–2014 to smooth out potential year-to-year variations.

Appendix 2: Summary Statistics

Variables	Full Sample					African sub-sample				
	Mean	**S.D**	**Min**	**Max**	**Obs**	**Mean**	**S.D**	**Min**	**Max**	**Obs**
Dependent variables										
Mobile accounts (%)	3.30	7.90	0.00	58.39	145	8.030	12.297	0.000	58.392	47
Sending money (%)	3.10	7.58	0.00	60.48	146	7.071	11.921	0.000	60.478	46
Receiving money (%)	4.47	9.58	0.00	66.65	146	10.037	14.738	0.000	66.652	46
Demand factors										
Account at formal fin. Inst. (%)	45.72	31.73	0.40	99.74	147	21.479	15.926	1.521	80.123	42
ATM penetration	43.28	45.03	0.33	279.71	148	11.084	14.789	0.360	59.092	49
Banking sector concentration	71.94	20.70	9.49	100.00	143	79.607	15.986	51.317	100	43
Supply factors										
Unique mobile subscription rate	61.73	23.29	4.23	133.64	199	48.936	23.440	14.292	121.059	54
Mobile connec. (performance)	11.92	14.69	0.04	67.19	147	2.068	2.881	0.041	11.062	44
Mobile connec. (coverage)	62.18	27.29	8.88	99.60	147	34.963	16.629	8.876	76.057	44
Telecom regulation	0.41	0.17	0.00	0.74	128	0.326	0.149	0.000	0.51	43
Macro-level factors										
GDP per capita (PPP)log	9.161	1.226	6.473	11.794	152	8.025	1.036	6.473	10.485	53
GDP growth	3.90	2.82	-4.92	11.10	153	4.515	2.997	-5.745	10.647	52
Rule of Law	-0.09	1.01	-2.42	1.98	157	-0.719	0.620	-2.417	0.911	54
Urbanization (%)	58.22	22.85	8.81	100	155	41.987	17.561	11.195	86.337	54

Notes: The average values for the dependent variables are calculated across all countries, including those in which mobile money services are not available. Fin: financial. Inst: Institutions. Connec: Connectivity. The full sample is disclosed in two decimal places because it is drawn from Lashitew et al. (2019).

Appendix 3a: Correlation matrix (Full sample)

	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.

Source: Asongu et al. (2020).

Appendix 3b: Correlation matrix (African sub-sample)

	Mobile inclusion variables			Demand Factors			Supply Factors				Macro-level Factors			
	MMA	Send M	Receiv.M	BankAc	ATM Pen	BankSC	UMSr	MCP	MCC	TSR	GDPpc	GDPg	RL	Urban
MMA	1.000													
Send M	0.550	1.000												
Receiv.M	0.477	0.980	1.000											
Bank Ac	0.282	0.221	0.207	1.000										
ATM Pen	0.067	0.053	0.050	**0.746**	1.000									
BankSC	-0.475	-0.203	-0.197	-0.219	0.071	1.000								
UMSr	0.076	0.184	0.196	0.541	*0.674*	-0.127	1.000							
MCP	0.029	-0.055	-0.062	**0.820**	**0.807**	-0.163	0.532	1.000						
MCC	0.109	0.066	0.077	**0.703**	**0.726**	-0.031	*0.682*	**0.632**	1.000					
TSR	0.285	0.255	0.281	0.502	0.427	-0.288	0.472	0.409	0.443	1.000				
GDPpc	-0.035	0.327	0.369	**0.586**	**0.683**	-0.093	**0.851**	**0.529**	**0.700**	0.522	1.000			
GDPg	0.309	-0.087	-0.158	0.024	-0.267	-0.205	-0.224	-0.218	-0.245	-0.342	-0.257	1.000		
RL	0.068	-0.092	-0.109	**0.519**	**0.630**	-0.016	0.572	**0.475**	**0.581**	**0.368**	**0.515**	-0.109	1.000	
Urban	-0.229	0.163	0.214	0.236	0.407	0.085	*0.666*	0.154	0.395	0.234	**0.755**	-0.062	0.177	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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