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The impact of regulation on the spread and growth of mobile money in selected sub-Saharan African countries

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- Regulation
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Abstract

Several countries in sub-Saharan Africa (SSA) have implemented regulatory reforms in the mobile money sector since 2011. Therefore, this paper investigates the impact of mobile money regulation on mobile money spread and growth in 16 selected SSA countries from 2011 to 2018, a period allowing for an analysis of foundational regulatory effects before the confounding influence of recent global disruptions or major technological shifts. The baseline results from the estimated panel data fixed effects model indicate that more enabling mobile money regulatory frameworks promote mobile money spread and growth in the selected SSA countries. Further analysis shows that authorisation and know your customer requirements encourage mobile money spread, while consumer protection and enabling infrastructure and investment environment promote mobile money growth. Thus, policymakers and regulators, in their efforts to design regulations that protect financial system integrity and stability, should concurrently ensure mobile money regulation is more enabling to promote its widespread adoption and address the needs of the underserved.

1. Introduction

Mobile money provides essential financial services to the previously unbanked and underbanked segments of the population through the use of mobile phones. It has spread more rapidly in developing countries than in developed countries. According to the Global System for Mobile Communications Association (GSMA), the first mobile money service, Smart Money, was launched in the Philippines in 2001 (GSMA, 2019). Since its inception, the industry has achieved significant milestones, with over two billion registered accounts and more than half a billion monthly active accounts globally by the end of 2024. In terms of geographical distribution, sub-Saharan Africa (SSA) remains the epicentre of mobile money, accounting for over 1.1 billion registered accounts and 53% of global live services in 2024. Over two-thirds of new registered accounts in 2024 originated from sub-Saharan Africa, which continues to be a global leader in mobile money innovation (GSMA, 2025). Nonetheless, the rapid growth of mobile money and its diversity pose challenges for regulators. For instance, given the complexity of the mobile money ecosystem—with its several components such as mobile network operators, customers, banks, agents and remittance partners—regulators struggle to balance the promotion of innovation and financial inclusion with the protection of the financial system's integrity and stability. Consequently, the regulatory environment has been highlighted by various studies as one of the most crucial factors affecting the implementation and success of mobile money services (Di Castri, 2013; Evans and Pirchio, 2015; Ahmad et al., 2020; Kawamoto et al., 2023).

A few years after the launch of M-Pesa, the first mobile money service in Africa (Kenya) in 2007, mobile money services spread to other SSA economies. Subsequently, various SSA countries adopted different mobile money regulatory frameworks. For example, Kenya initially operated under the mobile network operators (MNOs)-led model, but with a restriction on agent exclusivity. However, this restriction was abolished in 2014 to ease competition among mobile money providers (Aron, 2017). On the contrary, Nigeria adopted a bank-led model, which inhibits MNOs from leading the provision of mobile money services (Ondiege, 2015). Ghana also used a bank-led model until reforms in 2015 allowed the Bank of Ghana to permit MNOs to establish subsidiaries to facilitate mobile money services (Bahia and Muthiora, 2019). Similarly, Uganda operated under an MNO-led model with an agent exclusivity restriction, which was removed in 2013 (Macmillan et al., 2016). Lesotho, notably, adopted both MNO-led and bank-led models, while South Africa followed a bank-led model (Aron, 2017). Thus, mobile money regulations have been continuously evolving in the SSA region, making it imperative to determine how these regulatory developments have impacted the spread and growth of mobile money.

It is against this background that the paper aims to determine the impact of regulation on mobile money development in selected SSA countries from 2011 to 2018. This period is chosen to analyse foundational regulatory effects prior to the confounding influence of more recent global disruptions or major technological shifts. Unlike other previous studies that focused on the impact of regulation on the mobile money usage (e.g., Gutierrez and Singh, 2013; Bahia et al., 2020), this study contributes to the literature by analysing the impact of regulation on the spread and growth of mobile money using a panel data fixed effects model. This model controls not only for the unobserved, time-invariant heterogeneity but also for the heterogeneity in observed characteristics over a multiple-period setting. To the best of our knowledge, this is the first study to assess the impact of regulation on the spread and growth of mobile money in the context of SSA countries.

The rest of the study is organised as follows: Section 2 reviews the literature on the nexus between regulation and the spread and growth of mobile money. Section 3 discusses the data and specifies the empirical models and estimation strategies for this study. Section 4 presents and analyses the results. Section 5 offers the conclusion and policy recommendations.

2. Literature review

As a financial service, mobile money is subject to a range of regulations. These include existing laws concerning issues such as business practices, telecommunications regulation and financial regulation (Aron and Muellbauer, 2019; Kawamoto et al., 2023). Business law includes provisions for customer protection, privacy and data protection. Telecommunications regulations encompass competition policies, while financial regulation includes prudential management of funds rules, Know Your Customer (KYC), Anti-Money Laundering (AML), transaction limits and agent network rules. The literature states that one of the motivations for putting these kinds of regulations in place is market failure. According to Ofori (2020), some instances of market failure in the financial sector include externalities, asymmetric information, moral hazard and principal-agent problems. In the case of the first problem, externalities, financial institutions and markets hold huge amounts of investors' money and also operate payment systems upon which the economy is essentially dependent. Given this fundamental role played by the financial system, any problem within the financial sector may have a disruptive impact on the entire economy. Hence, there is a need for regulating the financial sector to preserve its reputation and generally maintain confidence and stability in the financial system.

Regarding the second problem, asymmetric information, this occurs when the directors and managers of financial institutions possess information on the soundness of their institution that is superior to the knowledge of other economic agents who lend to or invest in the institution. This may result in problems such as insider trading and the concealment of important information from investors. Therefore, regulation is required to protect the rights of economic agents and ensure their safety. This can be achieved by prohibiting insider trading on non-public information and by imposing laws that require companies to disclose their financial information to the public (Madise, 2019).

The third problem, moral hazard, arises when insurance against an event occurring increases its likelihood of occurring more than if the event were not insured. For instance, insured financial institutions may take more excessive risks than they otherwise would, knowing that investors or depositors will be protected if the institution faces problems. Thus, regulators can intervene by setting minimum capital requirement rules to protect financial service consumers, safeguard the integrity of the financial system, and ensure financial stability (Lee and Longe-Akindemowo, 1999).

Lastly, in the case of the principal-agent problem, the directors and managers are the agents, while the shareholders and investors are the principals. The problem occurs when the agents pursue their own interests instead of those of the principals. Therefore, regulation is needed to compel companies to establish adequate governance measures and/or obligate agents to disclose the financial performance of companies. Alternatively, a market may prefer to be free and left to regulate itself,

primarily because regulation can be regarded as an economic cost. In line with Bahia and Muthiora (2019), regulation can indeed limit the development of mobile money. Restrictive regulatory frameworks may stifle innovation and investment, limit the deployment of new services and increase costs for consumers, all of which can undesirably affect adoption and activity rates. Furthermore, regulation may allow or restrict banks or non-banks from operating as mobile money providers. This can inhibit the entry of some players into the mobile money space, thereby limiting competition and innovation.

Nonetheless, there is a paucity of empirical evidence regarding the impact of regulation on mobile money development within the context of developing economies. The limited existing empirical literature primarily focuses on the impact of regulation on mobile money usage rather than other crucial development aspects, such as its spread and growth. For instance, Gutierrez and Singh (2013) revealed that an enabling regulatory framework, which included provisions allowing both banks and non-banks to provide services, promoting consumer protection, enabling infrastructure interoperability and permitting mobile money agent operations, was associated with higher mobile money usage in 35 countries during 2011. Similarly, Bahia et al. (2020) found a strong association between an enabling regulatory framework and higher mobile money usage across 46 countries in 2017. Their favourable regulatory index indicators encompassed allowing both banks and non-banks to offer mobile money services, permitting international mobile money remittances, promoting consumer protection, allowing providers to appoint agents, avoiding restrictive transaction limits, taxes and pricing regulations, enabling non-banks to access national settlement infrastructure, and allowing mobile money providers to earn and utilize interest without constricting conditions.

On the other hand, other studies have utilised descriptive analysis to infer the impact of regulation on the spread and/or growth of mobile money. For example, Ondiege (2015) observed that Nigeria, despite having the highest number of mobile money providers in Africa, was experiencing low adoption and growth of mobile money due to its bank-led model. This study further highlighted that regulations allowing MNO-led operations appeared more successful in increasing subscription rates, penetration and financial inclusion compared to bank-led models. Alternatively, Evans and Pirchio (2015) indicated that the MNO-led mobile money model seemed to promote growth in 22 developing countries across Africa, Asia and Latin America, whereas bank-led models appeared to inhibit it. Moreover, mobile money schemes seemed to have a high likelihood of succeeding in poorer countries lacking basic infrastructure, while agent spread growth correlated with the increased adoption of mobile money services.

This study derives the following observations from the reviewed literature. First, regulation comes with both economic benefits and costs, and it is one of the factors that significantly impact mobile money development. Second, there is a paucity of empirical literature related to the impact of regulation on mobile money development; some studies empirically assessed the impact of regulation, but only on the usage of mobile money, while others were primarily descriptive. Lastly, previous studies investigating the impact of regulation on mobile money development were based on cross-sectional analysis and failed to capture the impact of regulation over time. Therefore, this study contributes to the empirical literature by examining the impact of regulation on the spread and growth of mobile money in the selected SSA countries using a panel data model analysis, as explained in the next section.

3. Data and Methodology

3.1 Data Description

The study uses data from 16 selected SSA countries from 2011 to 2018, a period chosen to analyse foundational regulatory effects before recent global disruptions or major technological shifts. Appendix Table A1 defines all variables used in this study, with mobile money spread and growth data sourced from the International Monetary Fund (IMF)'s Financial Access Survey. Mobile money regulation is measured using the GSMA Mobile Money Regulatory Index for 2018, supplemented by a custom index for 2011, 2014 and 2017, constructed from country-specific regulatory documents following the GSMA (2020) methodology. This index is interpolated for years without direct data, acknowledging that some countries operated with draft laws. Exclusions from the sample include French-speaking countries due to language barriers and other SSA economies due to data unavailability during the study's timeframe. The study further computes the index aggregation weights based on the Principal Component Analysis (PCA) methodology. PCA allows the study to measure which combination of the regulatory components explains most of the variation in the regulatory index (Gutierrez and Singh, 2013). Using the PCA index also enables the study to test the robustness of the results when applying a different method of weighting and aggregation (Bahia et al., 2020). The data for country-level control variables are drawn from the following sources: the IMF's Financial Access Survey, which provides data on branch and ATM penetration and the number of registered mobile money accounts per 1,000 adults; World Development Indicators, which offers data on GDP per capita, urban population, population density and total population; the World Bank Doing Business Project, which provides data on the legal rights index; and World Governance Indicators (WGI), which supply data on political stability and the absence of violence or terrorism, government effectiveness and control of corruption.

3.2 Model Specification

The study adopts the model used by Bahia *et al*. (2020) to estimate the impact of mobile money regulation on mobile money development aspects. The specifications of the relationship between the spread and growth of mobile money and mobile money regulation are expressed as follows, respectively:

$$MMS_{it} = \alpha_1 MMRI_{it} + \boldsymbol{\alpha}_2' \boldsymbol{X}_{it} + \gamma_i + \varepsilon_{it} \quad (1)$$

$$MMG_{it} = \beta_1 MMRI_{it} + \boldsymbol{\beta}_2' \boldsymbol{X}_{it} + \delta_i + \varepsilon_{it} \quad (2)$$

where MMS_{it} and MMG_{it} are the spread and growth of mobile money in country *i* at time *t*, respectively; $MMRI_{it}$ is the mobile money regulatory index; $\boldsymbol{X}_{it}$ is a vector of country-level control variables; α's and β's are slope coefficients to be estimated; γ_i and δ_i are country fixed effects; and ε_{it} is the error term.

Mobile money regulation can either promote or limit mobile money spread and growth in selected SSA countries, primarily by allowing or restricting banks and non-banks as providers (GSMA, 2016, 2018; Bahia and Muthiora, 2019). Several control variables are also expected to influence mobile money development. A larger mobile money market and increased agent platforms are anticipated to boost its spread and growth, as higher adoption promotes these aspects (Evans and Pirchio, 2015). Similarly, rising GDP per capita and ATM and bank penetration are expected to enhance mobile money's reach, given their role in improving digital financial inclusion and supporting agent networks (Berdibayev and Kwon, 2020). Conversely, an increase in the urban population may decrease mobile money's spread and growth due to a wider array of financial service choices (Gutierrez and Singh, 2013; Bahia *et al.*, 2020). While a larger total population might negatively impact mobile money usage, high population density is seen as beneficial (Bahia *et al.*, 2020). Interestingly, a stronger legal rights index is projected to negatively affect mobile money's spread and growth, as weaker legal environments often correlate with underdeveloped financial systems and a greater need for mobile money (Pelletier *et al.*, 2020). Finally, political stability, government effectiveness and strong control over corruption are expected to increase mobile money's spread and growth by improving overall digital financial services inclusion (Berdibayev and Kwon, 2020).

3.3 Estimation Strategy

To determine how regulation impacts mobile money's spread and growth, the study estimates equation (1) using either pooled ordinary least squares (OLS), fixed effects or random effects models, all suitable for micro-panel data (Soha *et al.*, 2018). The choice between these models depends on the nature of individual country effects. If these effects are constant across all countries, pooled OLS is efficient. However, if unobserved country effects exist and are correlated with independent variables, fixed effects are preferred. If they are uncorrelated, the random effects model is more suitable. The study applies the Chow test to decide between pooled OLS and fixed effects (Atonie *et al*., 2010), and the Breusch and Pagan (1980) Lagrange Multiplier (LM) test to choose between pooled OLS and random effects. Finally, the Hausman test is used to select between the random effects and fixed effects models.

The study also conducts several diagnostic tests for micro-panel data. Correlation tests and the Variance Inflation Factor (VIF) test will check for multicollinearity (Gujarati, 2004). To assess cross-sectional dependence, the Pesaran (2021) cross-sectional dependence (CD) test is used, as common shocks or unobserved characteristics can bias estimators and standard errors if independence is violated. Lastly, the modified Wald test is applied to check for heteroscedasticity in the fixed effects model (Gujarati, 2004).

4. Empirical Analysis

4.1 Summary Statistics

The descriptive statistics for all variables used in the study's analysis are provided in Table A2 in the appendix. Overall, these statistics show relatively low variation in the regulatory index both within and between the selected SSA countries. Moreover, there is a slightly high variation in the spread and growth of mobile money, and in the selected country-level

control variables, within the selected SSA countries over the period under consideration. Exceptions include the urban population variable and the legal rights index. Therefore, the following variables are converted to logarithms to minimise data variance: the spread and growth of mobile money, mobile money market size, GDP per capita, population density and total population. Correlations among the variables used in this study are presented in Table 1. There is a positive and significant correlation between the spread of mobile money and the mobile money regulatory index (including the PCA index) across the selected SSA countries over the period under consideration. Additionally, a positive and significant correlation exists between the growth of mobile money and the mobile money regulatory index (including the PCA index).

Table 1. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) MMS	1.00														
(2) MMG	0.77	1.00													
	(0.00)														
(3) MMRI	0.36	0.24	1.00												
	(0.00)	(0.01)													
(4) MMRIPCA	0.25	0.17	0.54	1.00											
	(0.00)	(0.06)	(0.00)												
(5) Mobile Money Market Size	0.84	0.78	0.28	0.13	1.00										
	(0.00)	(0.00)	(0.00)	(0.16)											
(6) GDP per Capita	-0.34	-0.24	-0.43	-0.39	-0.33	1.00									
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)										
(7) Urban Population	-0.31	-0.18	-0.27	-0.26	-0.22	0.63	1.00								
	(0.00)	(0.04)	(0.00)	(0.00)	(0.01)	(0.00)									
(8) Population Density	0.21	-0.01	0.35	0.27	-0.03	-0.12	-0.41	1.00							
	(0.02)	(0.94)	(0.00)	(0.00)	(0.78)	(0.16)	(0.00)								
(9) Total Population	0.00	0.06	-0.04	0.24	-0.07	-0.16	0.11	0.17	1.00						
	(0.99)	(0.53)	(0.64)	(0.01)	(0.46)	(0.07)	(0.22)	(0.06)							
(10) Branch Penetration	-0.08	-0.11	-0.08	0.13	-0.25	0.69	0.20	0.38	-0.14	1.00					
	(0.35)	(0.21)	(0.35)	(0.14)	(0.01)	(0.00)	(0.02)	(0.00)	(0.12)						
(11) ATM Penetration	-0.13	-0.14	-0.16	0.04	-0.30	0.75	0.27	0.31	-0.04	0.96	1.00				
	(0.14)	(0.12)	(0.07)	(0.63)	(0.00)	(0.00)	(0.00)	(0.00)	(0.63)	(0.00)					
(12) Legal Rights Index	0.06	-0.09	0.42	0.16	0.01	-0.50	-0.22	0.23	0.27	-0.40	-0.44	1.00			
	(0.53)	(0.34)	(0.00)	(0.07)	(0.89)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)				
(13) Political Stability	-0.13	-0.16	-0.11	-0.33	-0.065	0.53	0.36	-0.19	-0.73	0.28	0.22	-0.27	1.00		
	(0.14)	(0.07)	(0.23)	(0.00)	(0.47)	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.01)	(0.00)			
(14) Government Effectiveness	-0.10	-0.16	-0.12	-0.36	-0.09	0.70	0.40	0.13	-0.27	0.40	0.40	-0.15	0.67	1.00	
	(0.28)	(0.07)	(0.20)	(0.00)	(0.32)	(0.00)	(0.00)	(0.15)	(0.00)	(0.00)	(0.00)	(0.10)	(0.00)		
(15) Control of Corruption	-0.12	-0.19	-0.07	-0.34	-0.10	0.61	0.38	0.14	-0.46	0.39	0.36	-0.23	0.81	0.83	1.00
	(0.17)	(0.03)	(0.42)	(0.00)	(0.25)	(0.00)	(0.00)	(0.11)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	

Note(s): *p*-values are in parentheses; MMS = spread of mobile money; MMG = growth of mobile money; MMRI = mobile money regulatory index; MMRIPCA = mobile money regulatory index from principal component analysis (PCA).
Source: Authors' computation.

The study suspects that multicollinearity exists between branch and ATM penetration, between control for corruption and political stability, and also between control for corruption and government effectiveness, as their correlation values are greater than 0.8. Therefore, the study further conducts a Variance Inflation Factor (VIF) test for multicollinearity, with results presented in Table 2. The VIF values for ATM penetration, branch penetration and GDP per capita are all greater than 10, indicating multicollinearity. The degree of multicollinearity between ATM and branch penetration is particularly high, approaching perfect collinearity. To address this issue, the study includes each collinear variable in the estimation model separately.

Table 2. Variance Inflation Factor (VIF) results for multicollinearity test

Variables	Variance Inflation Factor (VIF)
ATM penetration	27.03
Branch penetration	23.80
GDP per capita (in log form)	11.55
Government effectiveness	9.41
Total population (in log form)	8.80
Control for corruption	8.18
Political stability	7.15
Population density (in log form)	6.74
Urban population	3.46
MMRI	2.25
MMRIPCA	4.97
Legal rights index	1.88
Mobile money market size	1.50
Mean VIF	9.31

Note(s): VIF value greater than 10 indicates the presence of multicollinearity; MMRI = mobile money regulatory index; MMRIPCA = mobile money regulatory index from principal component analysis (PCA).
Source: Authors' computation.

4.2 Impact of Regulation on the Spread and Growth of Mobile Money

The estimated results on the impact of regulation on the spread and growth of mobile money in the selected SSA countries are reported in Tables 3 and 4, respectively, along with their diagnostic tests. The Chow test values for all estimated models are statistically significant at a 1% level. Hence, the results reject the null hypothesis of constant or equal individual country effects and confirm that the fixed effects model is preferred over the pooled OLS model. Furthermore, the LM test values for all estimated models are statistically significant at a 1% level. Thus, the results reject the null hypothesis of the absence of random effects and indicate that the random effects model is favoured over the pooled OLS model. Lastly, the study uses the Hausman test to choose between the fixed effects and random effects models. The chi-square statistics from the Hausman test are significant at a 1% level for all estimated models. Therefore, the null hypothesis that random effects estimators are consistent and efficient is rejected, leading to the conclusion that the fixed effects estimators are favoured. This study further conducts other diagnostic tests to determine the validity of the fixed effects estimation results. First, the study tests for cross-sectional dependence using the Pesaran CD test. As shown in Tables 3 and 4, the CD test values for all estimated models are statistically insignificant at all levels. Therefore, the results fail to reject the null hypothesis of cross-sectional independence and conclude that there is no cross-sectional dependence. Second, the

study conducts a heteroscedasticity test using the modified Wald test for group-wise heteroscedasticity in the fixed effects model. The chi-square statistics of the Wald test from the baseline models are statistically significant at a 1% level for almost all estimated models. Therefore, the results reject the null hypothesis of homoscedasticity and indicate that heteroscedasticity is present. To control for heteroscedasticity, the study then runs fixed effects models with robust standard errors, and their estimated results are the ones presented in Tables 3 and 4.

The fixed effects results from Table 3 show that mobile money regulation generally has a positive and significant impact on the spread of mobile money in the selected SSA countries over the period under consideration. The results under this model further reveal that mobile money market size, GDP per capita, and the legal rights index have a positive and significant impact on the spread of mobile money. Conversely, an increase in the percentage of the population living in urban areas decreases the spread of mobile money, while the effect of other control variables is statistically insignificant. Furthermore, models (2) to (4) and (7) in the same table indicate that authorisation, consumer protection, KYC, as well as infrastructure and investment environment, respectively, have a positive and significant impact on the spread of mobile money in the selected SSA countries. Nonetheless, model (6) from that table shows that the agent network has a negative but insignificant impact on the spread of mobile money, while model (5) indicates that transaction limits appear to impact the spread of mobile money positively, although the effect is also insignificant.

Table 3. Fixed effects estimation results (dependent variable: log of spread of mobile money)

Independent Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
MMRI	0.03***	-	-	-	-	-	-
	(0.01)						
Authorisation	-	0.01***	-	-	-	-	-
		(0.00)					
Consumer Protection	-	-	0.01**	-	-	-	-
			(0.00)				
Know Your Customer	-	-	-	0.02***	-	-	-
				(0.00)			
Transaction Limits	-	-	-	-	0.01	-	-
					(0.00)		
Agent Network	-	-	-	-	-	-0.02	-
						(0.01)	
Infrastructure and Investment Environment	-	-	-	-	-	-	0.03***
							(0.01)
Mobile Money Market Size	0.71***	0.70***	0.70***	0.71***	0.88***	0.68***	0.69***
	(0.10)	(0.10)	(0.11)	(0.11)	(0.10)	(0.11)	(0.11)
GDP per capita	4.56**	4.66**	4.80**	4.56**	-0.04	4.66**	5.21**
	(1.69)	(1.69)	(1.99)	(1.84)	(0.19)	(2.02)	(1.94)
Population Density	1.84	1.31	2.75	2.92	0.09	2.85	2.92
	(2.20)	(2.28)	(2.47)	(2.27)	(0.18)	(2.49)	(2.29)
Urban Population	-0.14*	-0.11	-0.12	-0.16*	-0.03**	-0.10	-0.15**
	(0.07)	(0.07)	(0.08)	(0.08)	(0.01)	(0.07)	(0.07)
Branch Penetration[a]	0.01	0.01	-0.00	-0.00	0.04***	-0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Legal Rights Index	0.09*	0.10*	0.10*	0.08	0.07	0.10*	0.08
	(0.05)	(0.04)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)
Constant	-38.99***	-37.19***	-43.56***	-41.02***	-0.99	-41.11***	-47.07***
	(9.70)	(9.83)	(10.86)	(10.38)	(2.31)	(10.78)	(10.90)
Observations	128	128	128	128	128	128	128
R-squared	0.74	0.74	0.73	0.74	0.67	0.73	0.74
Number of Countries	16	16	16	16	16	16	16
Country Fixed Effects	Yes	Yes	Yes	Yes	-	Yes	Yes
LM test[b]	10.46	25.42	16.75	15.79	27.55	28.97	12.52
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Chow test[c]	6.93	7.37	6.78	7.16	6.89	6.71	5.94
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Hausman test[d]	44.99	22.34	24.93	28.33	22.37	21.66	27.20
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Pesaran CD test[e]	0.07	0.42	-0.41	-0.28	1.12	-0.11	-0.30
	[0.94]	[0.68]	[1.32]	[1.22]	[0.26]	[1.09]	[1.24]
Modified Wald test[f]	3971.45	3625.43	3498.65	5326.44	-	5513.06	4775.24
	[0.00]	[0.00]	[0.00]	[0.00]		[0.00]	[0.00]

Note(s): ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively; robust standard errors are in parentheses; MMRI = mobile money regulatory index; [a] Branch penetration and ATM penetration have close to perfect multicollinearity, including these variables interchangeably does not change the estimation results; [b] H_0: No random effects; [c] H_0: Constant individual country effects; [d] H_0: random effects are consistent and efficient; [e] H_0: cross-sectional independence; [f] H_0: homoscedasticity; The following variables are in log form: mobile money market size, GDP per capita and population density.
Source: Authors' computation.

Table 4. Fixed effects estimation results (dependent variable: log of growth of mobile money)

Independent Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
MMRI	0.05*	-	-	-	-	-	-
	(0.03)						
Authorisation	-	0.01	-	-	-	-	-
		(0.02)					
Consumer Protection	-	-	0.05***	-	-	-	-
			(0.00)				
Know Your Customer	-	-	-	0.03	-	-	-
				(0.02)			
Transaction Limits	-	-	-	-	-0.00	-	-
					(0.01)		
Agent Network	-	-	-	-	-	0.02	-
						(0.02)	
Infrastructure and Investment Environment	-	-	-	-	-	-	0.055*
							(0.03)
Mobile Money Market Size	0.91***	0.90***	0.88***	0.92***	1.34***	0.92***	0.88***
	(0.26)	(0.26)	(0.24)	(0.23)	(0.21)	(0.23)	(0.21)
GDP per capita	9.74***	10.39***	8.98***	9.76***	-0.38**	11.33***	10.89***
	(2.76)	(2.80)	(2.66)	(2.44)	(0.17)	(2.81)	(2.49)

Population Density	1.01	1.05	4.00	2.86	-0.13	1.25	3.04
	(3.62)	(4.88)	(3.35)	(3.42)	(0.21)	(4.10)	(3.48)
Urban Population	-0.05	-0.00	-0.06	-0.09	-0.02	-0.01	-0.08
	(0.17)	(0.19)	(0.17)	(0.17)	(0.02)	(0.18)	(0.16)
Branch Penetration[b]	-0.02	-0.03	-0.02	-0.04	0.05***	-0.03	-0.05
	(0.03)	(0.04)	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)
Legal Rights Index	0.014	0.03	0.03	0.01	-0.06	0.04	-0.00
	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Constant	-77.03***	-80.58***	-82.92***	-80.69***	1.570	-89.53***	-91.90***
	(18.49)	(20.74)	(17.04)	(16.20)	(2.97)	(19.22)	(15.65)
Observations	128	128	128	128	128	128	128
R-squared	0.77	0.76	0.78	0.77	0.65	0.76	0.77
Number of Countries	16	16	16	16	16	16	16
Country Fixed Effects	Yes	Yes	Yes	Yes	-	Yes	Yes
LM test[c]	9.80	13.90	12.95	12.08	10.20	6.00	13.03
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]
Chow test[d]	8.75	7.87	9.32	8.71	7.80	6.88	8.63
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Hausman test[e]	83.95	33.28	40.33	37.23	36.07	37.01	40.25
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Pesaran test[f]	-0.31	-0.87	-0.84	-0.96	-1.19	-1.06	-1.15
	[1.24]	[1.62]	[1.60]	[1.66]	[1.76]	[1.71]	[1.75]
Modified Wald test[g]	21051.91	28061.10	4645.25	6096.08	-	6098.05	12049.82
	[0.00]	[0.00]	[0.00]	[0.00]		[0.00]	[0.00]

Note(s): ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively; robust standard errors are in parentheses; MMRI = Mobile Money Regulatory Index; [a] Branch penetration and ATM penetration have close to perfect multicollinearity, including these variables interchangeably does not change the estimation results; [b] H_0: No random effects; [c] H_0: Constant individual country effects; [d] H_0: random effects are consistent and efficient; [e] H_0: cross-sectional independence; [f] H_0: homoscedasticity; The following variables are in log form: Mobile money market size, GDP per capita and population density.

Source: Authors' computation.

When it comes to the impact of regulation on the growth of mobile money, model (1) in Table 4 reveals that a higher score of mobile money regulatory index (MMRI) increases the growth of mobile money, though significant only at the 10% level. The results under the same model further show that mobile money market size and GDP per capita have a positive and significant impact on the growth of mobile money, while the impact of other control variables is statistically insignificant. Furthermore, models (3) and (7) in Table 4 indicate that consumer protection and the infrastructure and investment environment have a positive and significant impact on the growth of mobile money in the selected SSA countries during the period under consideration. Nonetheless, models (2) and (4) through (6) from the same table show that other index dimensions have an insignificant impact on the growth of mobile money.

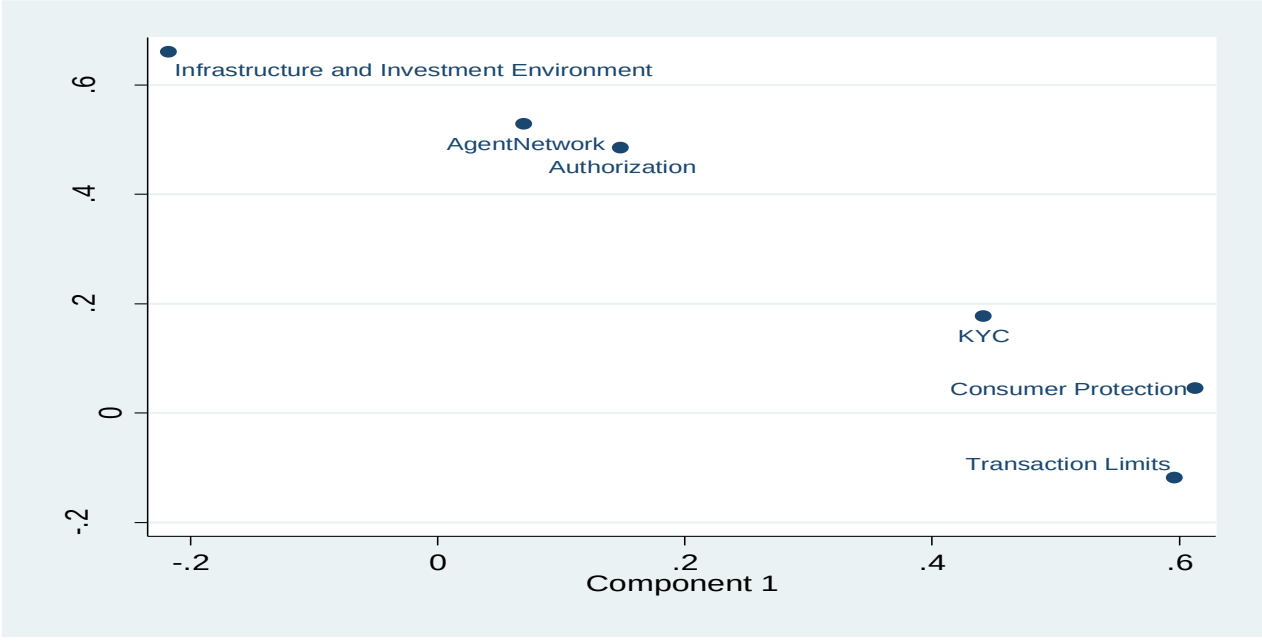
Overall, the findings from both Table 3 and Table 4 generally indicate that more enabling mobile money regulation promotes the spread and growth of mobile money in the selected SSA countries. These results align with findings obtained by Gutierrez and Singh (2013) and Bahia et al. (2020), who found that enabling mobile money regulatory frameworks were strongly associated with the development of mobile money services in terms of usage.

4.3 Robustness Check

The study undertakes further analysis and robustness checks by first including variables from the WGI (political stability and absence of violence or terrorism, government effectiveness, and control of corruption) to check the robustness of the results obtained in Tables 3 and 4 under model (1). These indicators are included simultaneously to control for their relative effects on the spread or growth of mobile money. This approach reflects the nature of governance dimensions and allows for a more comprehensive assessment of their relative influence. The study further constructs the mobile money regulatory index using the PCA methodology. This PCA index is then used to check the robustness of the results when applying a different method of weighting and aggregation for the regulatory index.

The PCA results show that the first two principal components have eigenvalues greater than one, and they cumulatively explain 61% of the variation in the data. Furthermore, the study explores which dimensions of the mobile money regulatory index score higher on Component 1 and Component 2. Figure 1 presents a plot of these results. Consumer protection, KYC and transaction limits score higher on Component 1 than on Component 2. These dimensions involve provisions of laws and regulations directly related to users. On the other hand, authorisation, agent network and infrastructure and investment environment have higher scores on Component 2 than on Component 1. These dimensions are more oriented towards mobile money providers.

Figure 1. Principal components by index dimension for selected SSA countries (2011-2018)



Note(s): The plot shows the distribution of index dimensions on each component; KYC = Know Your Customer.
Source: Authors' computation.

Given that diagnostic test results remain comparable to those obtained earlier, Table 5 presents the fixed effects estimation results under robust standard errors. These results account for the variables from the WGI, under models (1) and (2), and utilise the mobile money regulatory index from the PCA (MMRIPCA)[1], under models (3) and (4). After controlling for WGI variables, the mobile money regulatory index (MMRI) continues to show a positive and significant impact only on the spread of mobile money. Conversely, when using the MMRIPCA, the results still depict that mobile money regulation has a significant and positive impact on both the spread and growth of mobile money. Therefore, the results are generally robust when including WGI variables or when employing an alternative method for weighting and aggregating the mobile money regulatory index.

Table 5. Fixed effects estimation results (robustness check)

Independent Variables	**Dependent Variables**			
	Log of Spread of Mobile Money (1)	**Log of Growth of Mobile Money (2)**	**Log of Spread of Mobile Money (3)**	**Log of Growth of Mobile Money (4)**
MMRI	0.04***	0.04	-	-
	(0.01)	(0.03)		
MMRIPCA	-	-	0.33***	0.87***
			(0.10)	(0.25)
Mobile Money Market Size	0.73***	0.88***	0.70***	0.89***
	(0.104)	(0.246)	(0.11)	(0.25)
GDP per capita	4.59**	10.79***	4.45**	8.94***
	(1.57)	(2.81)	(1.87)	(2.82)
Population Density	0.58	0.89	2.67	2.76
	(1.94)	(3.25)	(2.28)	(3.47)
Urban Population	-0.09	-0.03	-0.13	-0.05
	(0.06)	(0.18)	(0.07)	(0.18)
Branch Penetration[a]	0.01	0.00	0.00	-0.02
	(0.02)	(0.04)	(0.02)	(0.03)
Legal Rights Index	0.08*	-0.02	0.10*	0.02
	(0.04)	(0.08)	(0.05)	(0.09)
Political Stability	0.74**	0.95*	-	-
	(0.34)	(0.50)		
Government Effectiveness	0.46	-1.55	-	-
	(0.81)	(1.06)		
Control of Corruption	-0.06	-1.19	-	-
	(0.55)	(1.29)		
Constant	-36.57***	-84.88***	-39.55***	-73.99***
	(10.69)	(17.90)	(10.52)	(18.76)
Observations	128	128	128	128
R-squared	0.77	0.79	0.74	0.77

[1]The results presented in Table 5 employed principal component 1, with similar findings obtained when using principal component 2.

Number of Countries	16	16	16	16
Country Fixed Effects	Yes	Yes	Yes	Yes
LM test[b]	4.92	2.76	22.26	9.70
	[0.01]	[0.05]	[0.00]	[0.00]
Chow test[c]	5.84	8.50	7.19	9.00
	[0.00]	[0.00]	[0.00]	[0.00]
Hausman test[d]	25.02	47.65	25.02	40.34
	[0.01]	[0.00]	[0.00]	[0.00]
Pesaran test[e]	0.42	-0.87	-2.71	-0.70
	[0.67]	[1.62]	[1.21]	[1.52]
Modified Wald test[f]	1922.21	341.32	3120.68	14351.47
	[0.00]	[0.00]	[0.00]	[0.00]

Note(s): ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively; robust standard errors are in parentheses; MMRI = mobile money regulatory index; MMRIPCA = mobile money regulatory index from principal component analysis (PCA); [a] Branch penetration and ATM penetration have close to perfect multicollinearity, including these variables interchangeably does not change the estimation results; [b] H_0: no random effects; [c] H_0: constant individual country effects; [d] H_0: random effects are consistent and efficient; [e] H_0: cross-sectional independence; [f] H_0: homoscedasticity; The following variables are in log form: mobile money market size, GDP per capita and population density.

Source: Authors' computation.

5. Conclusion

The literature remains unclear whether mobile money regulatory reforms promote or inhibit its spread and growth. Given that mobile money regulation has been evolving in several SSA countries since 2011, this study used a panel data fixed effects model to assess the impact of such reforms on mobile money's spread and growth in 16 selected SSA economies from 2011-2018. The baseline results provide evidence that an enabling mobile money regulatory framework promotes both the spread and growth of mobile money in these countries during the study period. These findings are generally robust to the addition of WGI variables or different weighting and aggregation of the mobile money regulatory index using PCA. Moreover, the study's findings further establish that the regulatory index's dimensions of authorisation and enabling KYC requirements promote mobile money's spread. Meanwhile, the components of consumer protection and an enabling infrastructure and investment environment promote mobile money's growth.

Based on these findings, policymakers and regulators, while designing regulations to protect the financial system's integrity and stability, should ensure mobile money regulation is more enabling. This will promote its spread and growth and address the needs of the underserved population. Enabling regulatory frameworks should therefore include: allowing both banks and non-banks (including MNOs) to issue a variety of mobile money services; permitting international mobile money remittances; allowing document types beyond government-issued identity documents for KYC verification and entry-level account opening; providing KYC verification infrastructure for mobile money providers; and protecting consumers and their funds. Although this study found a strong relationship between mobile money regulation and its spread and growth, future research should explore the effects of 'de facto' regulation (the quality and performance of existing regulations and supervisory power) as opposed to the 'de jure' frameworks used here. Additionally, future studies should investigate the possibility of a dynamic and non-linear impact of regulation on mobile money's spread and growth. Lastly, future research should focus their analysis of regulatory impact resulting from the influence of significant global events, such as the accelerated digital payment adoption post-COVID-19 pandemic or the widespread implementation of advanced interoperability frameworks.

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