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**Article**

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Article

# Mobile Money Use: The Impact of Macroeconomic Policy and Regulation

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**Abstract:** This paper examines the effects of macroeconomic policy and regulatory environment on mobile money usage. Specifically, we develop an autoregressive distributed lag model to investigate the effect of key macroeconomic variables and mobile money tax on mobile money usage in Uganda. Using monthly data spanning the period March 2009 to September 2020, we find that in the short run, mobile money usage is positively affected by inflation while financial innovation, exchange rate, interest rates and mobile money tax negatively affect mobile money usage in Uganda. In the long run, mobile money usage is positively affected by economic activity, inflation and the COVID-19 pandemic crisis while mobile money customer balances, interest rate, exchange rate, financial innovation and mobile money tax negatively affect mobile money usage.

**Keywords:** mobile money usage; mobile money tax; mobile money customer balances; mobile money registration; economic activity; inflation; interest rate; exchange rate; financial innovation; COVID-19 pandemic crisis

**JEL Classification:** E4; E5; E42; G20; G21; G28; G29; O23



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## 1. Introduction

The ongoing global COVID-19 pandemic has sparked an economic crisis that could surpass the global financial crisis of 2008–2009, in part because the containment and mitigation measures aimed at limiting the spread of the virus came at the cost of reduced economic activity in many countries (Loayza and Pennings 2020). African countries have been more severely impacted due to their limited health care capacity, larger informal sectors, shallower financial markets, and poorer governance among other things. As the pandemic ravages on, governments are forced to develop appropriate policy responses that address the unintended negative economic consequences related to the COVID-19 pandemic. While mobile money services were already facilitating financial inclusion in Africa before onset of the pandemic, policy makers put in place measures that support the widespread use of mobile money services as an effective tool for moving money within African countries under restrictions, particularly during the COVID-19 pandemic (Chadha et al. 2020).

The advent of mobile money transformed the landscape of financial inclusion in developing countries, giving access to essential financial services for the vulnerable and poor who constitute a large segment of the population. For instance, in Africa, the continent where financial exclusion is a serious impediment to development, mobile money technology has 26 times the reach of ATMs and 58 times the reach of bank branches (Ahmad et al. 2020). This is because unlike conventional banking and financial services, mobile network operators (MNOs) have networks that reach further and deeper into rural areas historically marginalised. It is thus not surprising that the scale of mobile money in Africa continues to grow, with more than 481 million registered mobile money accounts in 2019 (Andersson-Manjang et al. 2020). Nevertheless, harnessing the full potential of mobile money technology's ability to facilitate financial inclusion and consequently poverty reduction and development remains a challenge.

While there is a considerable and growing literature on mobile technology and its potential for promoting financial inclusion (Ahmad et al. 2020; Di Castri 2013; (Groupe Speciale Mobile Association) GSMA 2021; Maina 2018; Porteous 2006), a significant part of it is concerned with the management of mobile technology (e.g., (Davidson and McCarty 2011; Donner 2008)), rather than with formal empirical investigation of its implications, costs and benefits (Ahmad et al. 2020). Given the financial inclusion benefits of mobile money (see (Ahmad et al. 2020; Aron 2018; Demirguc-Kunt et al. 2018; Masocha and Dzomonda 2018; Mothobi and Grzybowski 2017) among others, an understanding of the effects of macroeconomic policy and regulation on mobile money usage is pertinent for developing an effective policy framework that is genuinely enabling for the growth and development of the mobile money industry. This is particularly important because access to financial services may be compromised by economic obstacles (Aron 2018).

In view of the paucity of empirical evidence on the impact of macroeconomic and regulatory variables on the usage of mobile money at a national level, this study examines the effect of macroeconomic policy and mobile money tax on the use of mobile money in Uganda. Uganda is one of the countries where access to and the use of mobile money have expanded rapidly in recent years (Bank of Uganda n.d.). More specifically, the study applies the ARDL framework to investigate the effect of macroeconomic and regulatory variables, namely; economic activity, inflation, interest rate, exchange rate, financial innovation and mobile money tax on the use of mobile money in Uganda using monthly data spanning the period March 2009 to September 2020. The study also investigates the effects of mobile money registrations, mobile money customer balances and COVID-19 on mobile money usage. To the best of our knowledge, no previous empirical study has explicitly investigated the effect of macroeconomic policy variables such as economic activity, inflation rate, interest rate, and exchange rate on mobile money usage in Uganda.

The rest of this paper is organised as follows: Section 2 provides an overview of the literature on macroeconomic policy and regulation in the context of mobile money use. Section 3 gives an overview of mobile money and the macroeconomic landscape in Uganda, while Section 4 describes the methodology employed in the analyses by describing the models and estimation technique used, namely, the Autoregressive Distributed Lag (ARDL) bounds testing approach introduced by Pesaran et al. (2001). Section 5 reports and discusses the empirical results and Section 6 draws some conclusions and makes policy recommendations.

## 2. Macroeconomic Policy, Regulation and Mobile Money Usage: An Overview

The growing appreciation of the importance of financial inclusion for economic growth and development has moved the subject up the development agenda in recent years (Aron 2018; Demirguc-Kunt et al. 2018; Di Castri 2013; Dipasha 2016; Kim et al. 2018; Lahaye et al. 2015). Although financial inclusion remains a global challenge, recent evidence suggests that mobile money can play a vital role in promoting financial inclusion, especially in sub-Saharan Africa (Demirguc-Kunt et al. 2018; Di Castri 2013). This notwithstanding, uncertainties remain regarding the speed and nature of customer adoption and usage in the mobile money field which is relatively new albeit fast evolving especially in Africa. In a recent survey of the literature in the context of sub-Saharan Africa, Ahmad et al. (2020) find mixed evidence on mobile money's contribution to financial inclusion and economic development and conclude by highlighting issues that require further empirical investigation, key to which are the determinants of mobile money adoption and usage. This corroborates reports from mobile money service providers in Africa which highlight uncertainties over drivers of customer adoption and regulatory issues as some of the main barriers to their growth (Maina 2018; Porteous 2006). Consequently, in order for mobile money to realize its full potential in promoting financial inclusion for those who lack it, then identifying enabling policies and regulation is important to facilitate the creation of favourable conditions to scale up access and use of mobile money systems.

The regulatory and policy environment for mobile money is complex and often ill-defined since it cuts across various regulatory domains (Maina 2018; Porteous 2006). Insight into the enabling elements of policy and regulation, particularly what promotes and what hinders mobile money adoption and usage, can help policy makers, regulators and industry players in their efforts to develop robust and inclusive mobile money systems. This is particularly important because effective and appropriate policy and regulation can advance financial inclusion, integrity and stability as well as help to reduce economic inequalities while increasing employment and economic growth by increasing widespread access to and usage of mobile money services (Di Castri 2013; GSMA 2021; Maina 2018; Porteous 2006). According to the Mobile Money Regulatory Index scores, Sub-Saharan African countries with a few exceptions have broadly enacted enabling regulatory frameworks based on their higher country index scores ranging between 70 and 100, which is an indication of more enabling regulation for widespread mobile money adoption (GSMA 2019).

Although macroeconomic and regulatory frameworks are important determinants of the success of mobile money systems, empirical evidence on the effect of macroeconomic policy and regulation on mobile money usage is very sparse in Africa, constrained by, among other things, data limitations because it is a relatively new field. A substantial number of studies are survey-based, but there is a lack of consistency among surveys, across countries and over time (Ahmad et al. 2020; Aron 2018). In addition, this literature has focused on the effects of regulation on mobile money, with little work on the effects of macroeconomic policy on mobile money (see (Di Castri 2013; Maina 2018; Rulangaranga et al. 2016)). For instance, Di Castri (2013) presents enabling regulatory solutions, backed by evidence and internationally recognised regulatory standards, that could be applied extensively across all markets which simply need to be adapted to the local context, leveraging local opportunities and adjusting to the peculiarities of each jurisdiction. He also argues that the mobile money industry has found it challenging to launch and scale services for the unbanked because many policy and regulatory environments are still not genuinely enabling. An enabling policy and regulatory framework creates an open and level playing field that fosters competition and innovation, attracts investments, and allows providers to focus on refining operations and promoting customer adoption while ineffective policies and cumbersome regulatory barriers have a negative effect on the development of mobile money and the expansion of financial inclusion (Di Castri 2013; Maina 2018).

Similarly, Maina (2018) assembles a range of key considerations for financial regulators and other stakeholders in the mobile money industry which is meant to serve as a practical guide to regulatory best practice and a window into industry perspectives among other things, drawing on the GSMA's unique insights into the mobile sector and mobile money industry. According to this report, although there is positive momentum in several markets where mobile money is operating, particularly in achieving financial inclusion and boosting the social and economic impact of private sector investments, supporting policies and enabling regulation have not kept pace with the changes largely because mobile money services are still evolving. In addition, financial regulators are now working to strike the right balance between creating an enabling environment that supports competition and innovation in the mobile money industry, and safeguarding private sector investments. Overall, the regulatory environment for mobile money services has a strong impact on whether a provider can enter the market and sustainably provide services.

One of the major areas of regulatory controversy is the taxation of Mobile money services and products. The last few years has seen the emergence of mobile money sector specific taxation across Sub-Saharan Africa largely driven by governments' need to find innovative means to widen the tax base and plug budget spending deficits (Clifford 2020; Maina 2018). Yet structural weaknesses within these environments often lead to badly designed taxes, in part due to a lack of capacity and national policy frameworks to guide at the policy level, with the result that the full impact of mobile money taxes across the whole of the tax system is not properly assessed (Clifford 2020; Maina 2018). When mobile money taxes were implemented, mobile money transaction values contracted and their

growth trajectory reduced with negative implications for wider corporate income tax (CIT) and value added tax (VAT). Given that many mobile money users belong to marginalised societal groups and the negative impact of mobile money tax on financial inclusion and broader development goals is significant (Clifford 2020; Maina 2018).

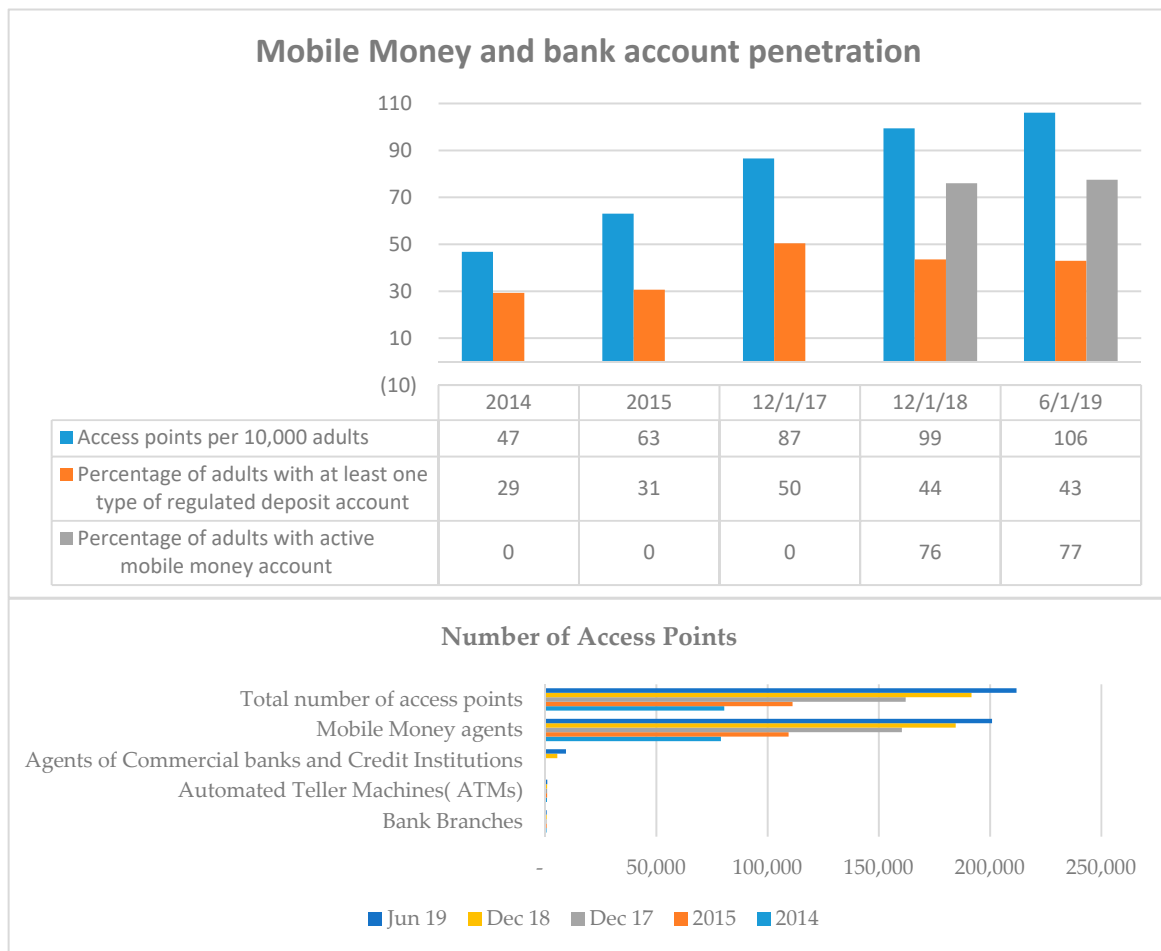
The macroeconomic policy context also plays a critical role in the success of mobile money systems. A few studies investigate the impact of mobile money on macroeconomic policy variables (See for instance (Kipkemboi and Bahia 2019; Maweje and Lakuma 2019)). However, there is a paucity of empirical studies on the impact of macroeconomic policy variables on mobile money. To the best of our knowledge, the investigation of the impact of macroeconomic policy variables on mobile money usage has not been done previously. Among the few available studies is Mahmoud (2019) who investigates the determinants of mobile money adoption and includes economic activity among the list of explanatory variables.

Thus, this paper aims to bridge the knowledge gap by providing empirical evidence of the effect of macroeconomic policy variables and regulation on mobile money usage within the context of Uganda. More specifically, we investigate the effect of macroeconomic and regulatory variables, namely; economic activity, inflation, interest rate, exchange rate, financial innovation and mobile money tax as well as mobile money registrations, mobile money customer balances and COVID-19 on mobile money usage in Uganda.

### 3. An Overview of Mobile Money in Uganda

Like many developing countries, the financial sector in Uganda has undergone rapid transformation over the last two and half decades (Maweje and Lakuma 2019; Whitworth and Williamson 2010). This growth has been possible due to reforms that enabled the development of market-based institutions, particularly in the financial sector. Prior to the early 1990s, Uganda operated under a system of direct controls on prices and flows of goods and capital, however in the early 1990s, following a decade of political instability and economic decline, the government began implementing macroeconomic reforms aimed at returning the economy onto a sustainable growth trajectory with assistance from international donors, including the International Monetary Fund and The World Bank (Whitworth and Williamson 2010; Wiegratz et al. 2018). The Government of Uganda also pursued prudent macroeconomic management under a framework of market-based policies with the aim of ensuring macroeconomic stability, promoting competitiveness and efficiency, increasing financial market intermediation and encouraging greater private sector participation. The impact of these reforms has been a substantial reduction in poverty and high and sustained economic growth, earning the country recognition as one of the fastest growing economies on the African continent, which in turn has exerted a strong influence on development thinking and international aid architecture in other developing countries in Africa (Whitworth and Williamson 2010; Wiegratz et al. 2018).

Notwithstanding these positive developments, access to formal financial services in Uganda remains low, albeit with signs of improvement (see Figure 1). Only 29 percent of the adult population had deposit accounts in formal regulated financial institutions in 2014 compared to nearly 43 percent as at June 2019. While various efforts have been made by both the government and its partners to sustainably improve financial inclusion which have seen payoffs, recent developments in Uganda are largely attributed to the adoption and evolution of mobile money services which helped to expand financial services to populations that were previously excluded. For instance, as shown in Figure 1, the percentage of adults with an active mobile money account was 77 as of June 2019 which exceeded 43 percent, the percentage of adults with at least one type of regulated deposit account in formal financial institutions including commercial banks, credit institutions and microfinance depositing taking institutions combined. In addition, as in June 2019, the number of mobile money agents stood at over 200,000 compared to 712 commercial bank branches with 9370 Commercial banks and Credit Institutions Agents and 956 Automated Teller Machines (ATMs).



**Figure 1.** Indicators on the Penetration of financial services in Uganda. Source: Bank of Uganda.

Mobile money services were introduced in Uganda in March 2009 and currently, there are six mobile money schemes, namely; MTN mobile money, Airtel money, M-Sente, Ezee money, M-cash, and Africell money. These schemes are supported by five operators who collaborate closely with five regulated commercial banks whose role is largely to hold a customer’s funds in escrow accounts and to release those funds on demand. The service has evolved from person-to-person transfers and storage of electronic value to include other services, such as a way to check bank balances; pay bills, salaries, social benefits and taxes; send cross-border remittances; transfer from a bank account to a mobile wallet; purchase mobile phone airtime; extend micro-finance services and facilitate village savings and loans accounts (VSLA), amongst other services (Lwanga and Adong 2016; Maweje and Lakuma 2017).

The use of mobile money is largely regulated through legal instruments provided in the Financial Consumer Protection Guidelines 2011 and the Bank of Uganda Mobile Money Guidelines 2013. The main objective of the regulation is to protect users’ funds in the mobile money platform, counter money laundering and terrorism, ensure the traceability of transactions and the auditability of escrow accounts, facilitate interoperability of data among operators, guarantee data back-up and business continuity, and arbitrate disputes between the various stakeholders (Maweje and Lakuma 2019). The law requires mobile money operators to register with the Bank of Uganda or partner with a regulated financial institution.

The rapid expansion of mobile money has attracted much interest and debate from government regulators, development agencies and academics alike seeking a greater understanding of mobile money technology and how it can be effectively and efficiently deployed in support of national objectives such as financial inclusion and poverty reduction

and economic growth. In the Ugandan context, there is an emerging body of literature evaluating the economic effects of mobile money both at the micro and macro levels. For instance, [Lwanga and Adong \(2016\)](#) provide a micro perspective on the impact that mobile money services have on an individual's saving behaviour. Their study finds that having a registered mobile money account increases the likelihood of saving with mobile money and conclude that overall, a low level of mobile money use as a saving mechanism may be partly explained by legal limitations that do not incorporate mobile finance services into mobile money. In addition, the absence of interest payments on mobile money savings may also act as a disincentive to save through this mechanism.

[Mawejeje and Lakuma \(2019\)](#) examine the effects of mobile money on aggregate economic activity and other macroeconomic variables and find mobile money has moderate positive effects on monetary aggregates, the consumer price index, and private sector credit. On other hand, the study finds that Mobile money deposits do respond to changes in monetary policy instruments, signalling possible ameliorating effects for the conduct of monetary policy. The study concludes that policy makers need to continue supporting the growth of mobile money platforms, particularly in developing a policy and regulatory framework through which mobile money balances can become interest-bearing assets, as this will further strengthen the monetary policy transmission mechanism.

## 4. Methodology

### 4.1. Theoretical Foundations

A growing demand for mobile money funds to facilitate increasing transactions will require a significant amount of physical currency to be moved from circulation into the banking system to back up the mobile money held in the mobile phones and as such a use of mobile money causes the currency in circulation (M0) to decrease while causing demand deposits (M1) to increase. A critical point to consider when modelling mobile money usage is the identification problem arising from the non-observability of the mobile money demand. Given that mobile money is, among other things, used as a medium of exchange to facilitate transactions which generate mobile money usage and demand, the study draws on the theoretical framework of quantity theory of money by Irvin Fisher and others ([Dimand 2019](#)) to investigate mobile money demand. We derive the demand for mobile money in accordance with Fisher's identity  $MV = PT$ , where  $PT$  represents the total value of transactions undertaken by mobile money and  $PT/V$  is the average transaction value of mobile money use, which is the dependent variable. Accordingly,  $M = PT/V$  which is the average amount of mobile money held.

The standard practice in the literature is to model the demand for real money balances as a function of a scale variable (capturing the transaction variables) and some measures of the opportunity cost of holding money, usually a short term interest rate, expected inflation, expected exchange rate depreciation or a combination of all. Accordingly, the general specification of money demand function is assumed to take the following functional form:  $M^d = f(Y, INT, INF, EX)$ , where  $M^d$  is demand for money,  $Y$  is income which represents the scale variable,  $INT$  is the interest rate,  $INF$  and  $EX$  are, respectively, inflation and the exchange rate. The a priori expected signs are positive for income elasticity and negative for interest semi-elasticity and inflation elasticity. The sign of exchange rate elasticity is theoretically ambiguous. The income elasticity is expected to be either unity according to the quantity theory, or 0.5 according to the Baumol-Tobin inventory model of money demand. It can also be greater than unity if the demand for money rises at a faster rate than income due to, for instance, monetisation, limited opportunities to economise on cash balances, and the paucity of other assets in which to hold savings.

### 4.2. Model Specification

The effect of macroeconomic and regulatory variables on mobile money usage in Uganda is investigated using an autoregressive distributed lag (ARDL) Bounds testing approach derived by [Pesaran et al. \(2001\)](#). Unlike other cointegration techniques, the

ARDL approach is advantageous because it is less restrictive, applicable regardless of the orders of integration of variables and provides unbiased coefficient estimates. Specifically, the ARDL approach does not impose a restrictive assumption that all the variables under study must be integrated of the same order and can be applied regardless of whether the underlying regressors are integrated of order one I(1), order zero I(0) or mutually cointegrated (Pesaran et al. 2001). The bounds test is applicable whether variables have mixed orders of integration (Bahmani-Oskooee et al. 2010; Morley 2006) and as such the approach does not require pre-testing the order of integration of the variables, especially when the computed Wald or F-statistic falls outside the critical value bounds which eliminates the uncertainty associated with low power of unit root tests in pre-testing the order of integration (Pesaran et al. 2001). Nevertheless, it is still necessary to conduct unit root tests such that no I(2) variable is involved since the presence of an I(2) variable renders the computed F-statistics of the bounds test for testing cointegration invalid (Ibrahim 2015). In addition, the ARDL model accounts for endogeneity, providing unbiased estimates and valid t-statistics, irrespective of the endogeneity of some regressors (Harris and Sollis 2003; Pesaran and Shin 1998) and is less sensitive to sample size (Narayan 2005; Pesaran and Shin 1999). A general ARDL relationship may be specified as follows:

$$\phi(L, p)y_t = \beta_i(L, q_i)x_{it} + \alpha'z_t + \varepsilon_t \tag{1}$$

where  $L$  is the lag operator;  $\phi(L, p) = 1 - \phi_1L - \phi_2L^2 - \phi_3L^3 - \dots - \phi_pL^p$  and  $\beta_i(L, q_i) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + \dots + \beta_{iq}L^{q_i}$  and  $z$  is a vector of deterministic variables comprising the intercept, time trends and/or exogenous variables with fixed lags,  $y_t$  is the dependent variable,  $x_{it}$  represents explanatory variables in the cointegrating vector,  $p$  and  $q_i$  are the lag lengths,  $\alpha'$  represents coefficient on the deterministic variables, and  $\varepsilon$  is the error term. The error-correction representation of Equation (1) takes the following form:

$$\Delta y_t = \sum_{i=1}^k \beta_{i0} \Delta x_{it} + \alpha' \Delta z_t - \sum_{j=1}^{\hat{p}-1} \theta_j^* \Delta y_{t-j} - \sum_{i=1}^k \sum_{j=1}^{\hat{q}_i-1} \beta_{ij}^* \Delta x_{i,t-j} - \theta(1, \hat{p}) ECT_{t-1} + \varepsilon_t \tag{2}$$

where  $\Delta$  is the first difference operator; the error-correction term is given by  $ECT_t = [y_t - \sum_{i=1}^k \hat{\theta}_i x_{it} - \hat{\Psi}' z_t]$  and  $\theta(1, \hat{p}) = 1 - \sum_{i=1}^{\hat{p}} \theta$  measures the quantitative significance of the error-correction term. The coefficients  $\theta_j^*$  and  $\beta_{ij}^*$  relate to the short-run dynamics of the model's convergence to equilibrium.

The specific form of our base model for mobile money usage can be expressed as follows:

$$\begin{aligned} \Delta \ln MMA_t = \alpha_0 &+ \sum_{k=1}^{n1} \alpha_{1k} \Delta \ln MMA_{t-k} + \sum_{k=1}^{n2} \alpha_{2k} \Delta MMB_{t-k} + \sum_{k=0}^{n3} \alpha_{3k} \Delta MMR + \sum_{k=0}^{n1} \beta_{1k} \Delta \ln CIEA_{t-k} \\ &+ \sum_{k=0}^{n2} \beta_{2k} \Delta \ln \Delta \ln INF_{t-k} + \sum_{k=0}^{n3} \beta_{4k} \Delta TB_{t-k} + \sum_{k=0}^{n5} \beta_{5k} \Delta \ln ER_{t-k} + \sum_{k=0}^{n6} \beta_{6k} \Delta \ln FI_{t-k} \\ &+ \sum_{k=0}^{n7} \beta_{7k} \Delta COVID_{t-k} + \sum_{k=0}^{n8} \beta_{8k} \Delta TAX_{t-k} + \gamma_0 \ln MMA_{t-1} + \gamma_1 MMB_{t-1} + \gamma_2 MMR_{t-1} + \varepsilon_t \end{aligned} \tag{3}$$

where  $\ln$  denotes natural logarithm,  $MMA$  is Mobile Money Usage,  $MMB$  is the balance on customers' mobile money accounts,  $MMR$  is number of registered mobile money users,  $CIEA$  denotes economic activity measured by the Composite Indicator of Economic Activity index,  $ER$  is natural log of the nominal Uganda Shilling per US Dollar (UGX/USD) exchange rate,  $INF$  is inflation,  $TB$  is 91-day Treasury bill interest rate,  $FI$  denotes financial innovation,  $COVID-19$  denotes a Dummy for the COVID-19 pandemic crisis, and  $TAX$  denotes a Dummy for Mobile Money tax. It is expected that  $\alpha_{2k} +$  or  $-$ ,  $\gamma_1 +$  or  $-$ ,  $\alpha_{3k} +$ ,  $\gamma_2 +$ ,  $\alpha_{4k} +$ ,  $\alpha_{5k} +$ ,  $\alpha_{8k} +$ ,  $\alpha_{9k} +$  and  $\alpha_{6k} -$ ,  $\alpha_{7k} -$ ,  $\alpha_{10k} -$ .

These specifications provide estimations of both long run and short run effects. The short run effects are inferred from the estimates of  $\alpha_{ik}$ , while the long run effects are inferred from  $\gamma_{ik}$  respectively normalised by  $\alpha_0$ . The test for cointegration is based on the joint F-statistic suggested by Pesaran et al. (2001). The null hypothesis of no cointegration



is tested against the alternative by restricting all estimated coefficients of lagged level variables equal to zero that is:

$$H_0 : \gamma_0 = \gamma_1 = \gamma_2 = 0 \quad (4)$$

$$H_1 : \gamma_0 \neq \gamma_1 \neq \gamma_2 \neq 0 \quad (5)$$

If the computed F-statistic lies above the upper level of the band, the null is rejected indicating co-integration while the null hypothesis cannot be rejected for values of the F-statistic that lie below the lower bound. If the F-statistic falls within the band, then inference is inconclusive. In this case, the error correction parameter can be viewed as a cointegration test (Kremers et al. 1992).

#### 4.3. Data and Measurement of Key Variables

The study uses monthly data spanning the period March 2009 to September 2020 and consists of 139 observations. The choice of the sample period and data frequency is guided by data availability. Data on the variables of interest, namely mobile money usage (MMA), balance on customers' mobile money accounts (MMB), number of registered mobile money users (MMR), economic activity (CIEA), exchange rate (ER), inflation (INF), interest rate (TB), financial innovation (FI) was obtained from Bank of Uganda's database. Table 1 provides a summary of descriptive statistics.

**Table 1.** Summary statistics.

Variable	Description	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
MMA	Natural Log of Average Mobile Money Transaction value	10.63	10.71	11.08	10.01	0.27	139
MMB	Balance on customers Mobile Money accounts (Billions)	234.09	228.58	814.11	0.60	208.74	139
MMR	Number of Registered Mobile Money Users (Millions)	14.85	18.70	30.37	0.01	9.66	139
CIEA	Natural Log of Composite Indicator of Economic Activity	4.66	4.68	4.97	4.23	0.21	139
INF	Natural Log of Inflation (Natural Log of Difference of the domestic consumer price index)	6.20	4.70	21.80	0.26	4.88	139
TB	91-day Treasury bill interest rate (percent)	11.16	10.00	23.10	3.80	4.26	139
LER	Natural Log of Nominal UGX/USD exchange rate (Average)	7.98	7.94	8.25	7.54	0.21	139
LFIN	Natural log of Financial innovation (M2/M1)	0.54	0.54	0.59	0.47	0.02	139

We estimate mobile money usage (MMA) using the average mobile money transaction value which is calculated by dividing the total value of all mobile money transactions in a given period by the number of transactions in that period. Inflation is measured as the first difference of the natural log of the consumer price index, where  $INF_t = (\ln cpi_t - \ln cpi_{t-1}) \times 100$ . The exchange rate is defined as the amount of domestic currency per unit of foreign currency and thus an increase (decrease) in exchange rate is interpreted as the depreciation (appreciation) of domestic currency against foreign currency. In addition, given that financial innovation affects the nature and composition of monetary aggregates, the ratio of M2 to M1 is used to capture the effects of financial innovation. A number of studies use M2/M1 as a proxy of financial innovation (see for instance (Ansong et al. 2011; Hye 2009)). The effects of the recent COVID-19 pandemic on mobile money use is captured using a dummy for the COVID-19 pandemic crisis which takes on the value of 1 during the COVID-19 pandemic crisis (March to September 2020) and 0 otherwise, while the effects of mobile money tax on mobile money use is captured by a dummy for mobile money tax which takes on the value of 1 following the introduction of mobile money tax (March 2018

to September 2020) and 0 otherwise. This study applies the ARDL estimation technique and E-views version 9.0 statistical package software.

## 5. Results and Discussion

### 5.1. Unit Root and Cointegration Tests Results

The ARDL technique does not require pre testing of the orders of integration of variables of interest. Nevertheless, within the ARDL framework, the series should not be  $I(2)$ , because this integration order invalidates the F-statistics and all critical values established by Pesaran. We therefore conduct unit root tests using the ADF, PP and KPSS tests to ascertain the order of integration of the variables of interest. The unit root test results presented in Table 2 indicate that there is a mixture of  $I(1)$  and  $I(0)$  variables. Since the variables are either  $I(0)$  or  $I(1)$  and none appear to be integrated at an order higher than one, we apply the ARDL technique.

It is important to ensure that the optimal lag order of the model is chosen appropriately. The ARDL bound testing approach requires the determination of the optimal lag for the cointegrating equation based on the assumption of serially uncorrelated residuals. The lags must be long enough to render *et* serially uncorrelated and not too long as to lead to an over parameterization (Narayan 2005; Pesaran et al. 2001). For the sake of parsimony, the lag length for each variable of the ARDL model is chosen based on the Schwarz information criterion (SBC) and Hannan-Quinn (HQ) information criterion assuming a maximum lag length of 12 lags. As a precaution we apply the Heteroscedasticity and Autocorrelation Consistent Covariance (HAC) estimators in the ARDL model estimations to ensure that our results are robust in the presence of heteroscedasticity and serial correlation (Note that the HAC approach alters the estimates of the coefficient standard errors of an equation but not the point estimates themselves). The SBC results indicate an ARDL (1,0,0) model hereinafter referred to model 1 as the best model while the HQ results indicate an ARDL (6,0,0) model hereinafter referred to model 2 as the best model (Both Akaike information criterion (AIC) and Hannan-Quinn (HQ) information criterion select ARDL (6,0,0) as the best model. Having dealt with the issues of lag selection, we proceed to our autoregressive distributed lag (ARDL) analysis.

The bounds test for cointegration was carried out using EVIEWS 9 based on Equation (3). The results are reported in Table 3.

For model 1, the F-test statistic of 27.6 is higher than the upper bounds of the critical values of 4.85 at the 5 percent significance level and likewise for model 2, the F-test statistic of 35.6 is also higher than the upper bounds of the critical values of 4.85 at the 5 percent significance level. Thus, the null hypothesis of no long run equilibrium relationship between mobile money usage and the explanatory long run forcing variables in Models 1 and 2 is rejected at the 5 percent significance level.

### 5.2. Discussion of Results

Given the conclusive evidence of cointegration, we proceed to estimate the long run and short run dynamics. The results presented in Table 4 correspond to ARDL specification in Equation (3) for model 1 and 2. Table 4 also presents the results for model 3, which incorporates the interaction term. The long run and short run results for the three models are qualitatively similar, with similar coefficients signs and fairly similar magnitudes (Given that the interaction variable is not statistically significant we focus our discussion on the results of models 2 and 3). For instance, in all models, the long run and short run coefficients have the expected signs with the exception of the financial innovation variable. The coefficient of the error correction term (ECT) in all models is negative and significant at the 1 percent level giving further support of a long run level relationship between mobile money usage and the long run forcing variables in both ARDL models.

Table 2. Unit root test results.

Unit Root Tests	Augmented Dicky–Fuller (ADF)		Phillips Peron (PP)		Kwiatkowski-Phillips-Schmidt-Shin (KPSS)		Inference
	Levels	1st Difference	Levels	1st Difference	Levels	1st Difference	
LMMA	−1.962228	−11.86386	−2.014659	−12.06845	0.458776	0.081336	I(1)/I(0)
MMB	0.473457	−12.89705	0.555081	−12.83595	1.372059	0.199461	I(1)
MMR	−0.118995	−11.79004	−0.109655	−11.79145	1.443672	0.156811	I(1)
LCIEA	−1.300322	−10.38295	−1.272236	−10.37384	1.454289	0.107708	I(1)
TB	−2.463695	−7.633031	−2.106246	−7.553277	0.160929		I(1)/I(0)
LER	−1.001393	−7.668598	−1.273988	−7.418793	1.394466	0.076915	I(1)
DLCPI	−3.931403		−2.693618	−8.320295	0.519801	0.041123	I(1)/I(0)
LFIN	−5.455232		−5.328579		0.294096		I(0)

Notes: The figures in this table are unit-root test statistics. The corresponding critical values for the ADF, PP and KPSS unit root tests at the 5% significance level are—2.882, −2.882 and 0.463, respectively.

Table 3. autoregressive distributed lag (ARDL) bounds cointegration test results.

Dependent Variable <sup>a</sup>	F-Statistic for Case III Intercept No Trend <sup>b</sup>	Conclusion
<b>MODEL 1 (ARDL 1,0,0)</b>		
MMA	27.57277	Cointegration
MMB	4.287839	No cointegration
MMR	0.840364	No cointegration
<b>MODEL 2 (ARDL 6,0,0)</b>		
MMA	35.60444	Cointegration
MMB	4.287839	No cointegration
MMR	1.275704	No cointegration
<b>MODEL 3 (ARDL 1,0,0)</b>		
MMA	26.86052	Cointegration
MMB	4.324306	No cointegration
MMR	0.785251	No cointegration

NOTES: <sup>a</sup> The cointegrating vector includes Mobile Money usage (MMA), Balance on customers Mobile Money accounts (MMB) and the Number of Registered Mobile Money Users (MMR) while economic activity measured (CIEA), exchange rate (ER), inflation (INF), interest rate (TB), financial innovation (FI), COVID-19 pandemic crisis (COVID-19) and Mobile Money Tax (TAX) is excluded from the cointegrating vector but included in the short run dynamics. In Model 3, the interaction term (TAX×FI) is also included in the short run dynamics. The F-test indicates which variable should be normalised when a long-run relationship exists between the lagged level variables in the cointegrating vector. Three alternative cointegrating relationships are examined with different dependent variables. If the F-statistic lies between the bounds, the test is inconclusive. If it is above the upper bound, the null hypothesis of no level effect is rejected. If it is below the lower bound, the null hypothesis of no level effect cannot be rejected. <sup>b</sup> The relevant critical value bounds of the F-statistic are obtained from Pesaran et al. (2001) Table CI(iii) Case III: Unrestricted intercept and no trend when k = 2. They are 3.79 and 4.85 for the lower and upper bound, respectively, at 95 percent significance level. In models 1, 2 and 3, the respective log likelihood and lag selection criteria based on the Schwarz criterion are 160.6, 173.9 and 160.7 and −1.9, −2.0 and −1.9.

Table 4. ARDL model results.

Regressors	MODEL 1			MODEL 2			MODEL 3		
	ARDL (1,0,0)	LONG RUN	SHORT RUN	ARDL (6,0,0)	LONG RUN	SHORT RUN	ARDL (1,0,0)	LONG RUN	SHORT RUN
Intercept	5.452 ** (2.55)		3.776 *** (5.18)	5.479 *** (4.04)		3.931 *** (6.42)	5.406 ** (2.55)		3.762 *** (5.12)
Mobile Money Usage (-1)	0.492 *** (4.22)			0.435 ** (2.40)			0.494 *** (4.38)		
Δ Mobile Money Usage (-1)						−0.054 (−0.89)			
Mobile Money Usage (-2)				−0.136 (−1.44)					
Δ Mobile Money Usage (-2)						−0.137 ** (−2.28)			
Mobile Money Usage (-3)				0.031 (0.57)					
Δ Mobile Money Usage (-3)						−0.127 * (−1.91)			
Mobile Money Usage (-4)				−0.021 (−0.35)					
Δ Mobile Money Usage (-4)						−0.104 * (−1.75)			
Mobile Money Usage (-5)				0.123 (1.42)					
Δ Mobile Money Usage (-5)						−0.001 (−0.01)			
Mobile Money Usage (-6)				0.008 (0.08)					
Balance on customers Mobile Money accounts	−0.0003 ** (−2.18)	−0.0005 ** (2.14)		−0.0002 ** (−2.54)	−0.0003 ** (−2.71)		−0.0003 ** (−2.16)	−0.0005 ** (2.10)	
Δ (Balance on customers Mobile Money accounts)			−0.0003 * (−1.87)			−0.0002 (−1.44)			−0.0003 * (−1.87)
Number of Registered Mobile Money Users	0.009 * (1.82)	0.017 ** (2.35)		0.005 (1.23)	0.008 (1.26)		0.009 * (1.83)	0.018 ** (2.37)	
Δ (Number of Registered Mobile Money Users)			0.001 (0.11)			0.001 (0.05)			0.002 (0.12)
Economic activity	0.484 * (1.87)	0.953 * (1.82)		1.038 *** (3.01)	1.852 *** (3.73)		0.477 * (1.87)	0.944 * (1.80)	
Δ (Economic activity)			0.327 (0.63)			0.545 (1.13)			0.319 (0.61)
Inflation	0.017 *** (3.64)	0.033 *** (6.56)		0.017 *** (4.11)	0.030 *** (6.64)		0.017 *** (3.67)	0.033 *** (6.55)	

Table 4. Cont.

Regressors	MODEL 1			MODEL 2			MODEL 3		
	ARDL (1,0,0)	LONG RUN	SHORT RUN	ARDL (6,0,0)	LONG RUN	SHORT RUN	ARDL (1,0,0)	LONG RUN	SHORT RUN
$\Delta$ (Inflation)			0.019 *** (3.23)			0.023 *** (4.40)			0.019 *** (3.21)
Interest rate	−0.008 ** (−2.28)	−0.015 ** (−2.73)		−0.005 * (−1.86)	−0.008 ** (−2.04)		−0.008 ** (−2.28)	−0.015 ** (−2.74)	
$\Delta$ (Interest rate)			−0.013 ** (−2.09)			−0.009 * (−1.68)			−0.013 ** (−2.08)
Exchange rate	−0.169 (−1.10)	−0.333 (−1.21)		−0.458 *** (−3.22)	−0.817 *** (−4.20)		−0.166 (−1.09)	−0.329 (−1.18)	
$\Delta$ (Exchange rate)			−0.439 (−1.56)			−0.871 *** (−3.28)			−0.439 (−1.55)
Financial innovation	−1.803 ** (−2.84)	−3.547 *** (−3.32)		−1.303 *** (−3.05)	−2.325 *** (−3.59)		−1.747 *** (−2.74)	−3.454 *** (−2.99)	
$\Delta$ (Financial innovation)			−1.191 *** (−2.94)			−0.963 ** (−2.54)			−1.176 ** (−2.59)
COVID-19 pandemic crisis	0.075 (1.41)	0.148 (1.29)		0.070 * (1.91)	0.125 ** (2.00)		0.080 (1.34)	0.159 (1.26)	
$\Delta$ (COVID-19 pandemic crisis)			0.008 (0.11)			0.007 (0.11)			0.008 (0.10)
Mobile Money Tax	−0.417 *** (−4.70)	−0.821 *** (−14.28)		−0.494 *** (−5.15)	−0.881 *** (−18.63)		−0.126 *** (−0.17)	−0.250 *** (−1.26)	
$\Delta$ (Mobile Money Tax)			−0.694 *** (−9.06)			−0.718 *** (−10.49)			−0.600 *** (−1.13)
Interaction term							−0.540 (−0.37)	−1.067 (−0.38)	
$\Delta$ (Interaction term)									−0.171 (−0.18)
ECT(-1)			−0.351 *** (−5.17)			−0.402 *** (−6.42)			−0.351 *** (−5.12)
Model Diagnostics									
Adjusted R-squared		0.91			0.93			0.91	
Log-likelihood value		162.42			174.89			162.5	
S.E. of regression		0.08			0.08			0.08	
Schwarz Bayesian Criterion		−1.96			−2.04			−1.93	
Hannan-Quinn criterion		−2.10			−2.25			−2.08	
DW-statistic		1.49			1.74			1.50	
Bounds Tests F-statistic		27.57			35.60			26.86	
Lower Bound		3.79			3.79			3.79	
Upper Bound		4.85			4.85			4.85	
Optimal lag (SC and HQ)		1			1			1	

Notes: The values in parentheses are t-ratios. The asterisks \*, \*\* and \*\*\* denote statistical significance at 10 percent, 5 percent and 1 percent significance levels. SC denotes Schwarz information Criterion and HQ Hannan-Quinn information criterion.

The coefficient of the measure of mobile money balances on customer accounts (MMB) is negative and statistically significant in the long-run for both model 1 and 2. In the long run, a 1 billion UGX increase in mobile money balances on customer accounts results in a 0.0003 to 0.0005 percentage point decline in mobile money usage for transactions usage and the effect is statistically significant at the 5 percent level. In the short run, an increase in mobile money balances on customer accounts by 1 billion Uganda Shillings (UGX) results in a 0.0002 to 0.0003 percent decline in mobile money usage and the effect is statistically significant at the 10 percent level only in model 1. While it is expected that the usage of mobile money services increases as mobile money balances increase, this may be moderated by regulatory limits on customer transactions and balances. The Bank of Uganda's mobile money regulations ([Bank of Uganda 2013](#)) require among other things that mobile money service providers set limits on frequency, volume and value of transactions and these limits, as well as any revisions thereof, be sent to Bank of Uganda for approval. According to the regulator, this is to ensure that mobile money service providers have measures in place to prevent money laundering and terrorist financing.

The negative effect of customer mobile money account balances on mobile money use may thus be a result of mobile money regulation which limits mobile money customer transactions and account balances. The mobile money services industry has sought a balance between the objectives of facilitating the financial inclusion of the poorest, making mobile money services attractive to the greatest number of people and mitigating the risks of money laundering and terrorist financing ([GSMA 2019](#)).

In contrast, the number of registered mobile money users has a positive effect on mobile money usage both at the short run and long run horizons in both models, although its impact is statistically significant at the 5 percent level only in the long run in model 1 where an increase in the number of Registered Mobile Money Users by 1 million accounts results in 0.02 percentage point increase in mobile money usage at the 5 percent level. As expected, the growth in mobile money usage is spurred by an increase in the number of mobile money users. Although all transactions are charged a predetermined fee, mobile money registration is free, simple and convenient to encourage the public's adoption and use of mobile money services in Uganda. One of the critical facilitators of mobile money usage is the ability to make a mobile money transaction upon registration for a mobile money account ([GSMA 2019](#)). Uganda's increase in mobile money registered accounts is partly attributed to the increased proliferation of mobile phone usage and the mandatory registration of SIM cards ([Lwanga and Adong 2016](#)).

As expected, we find a very strong positive association between economic activity and mobile money usage in both the short and long run. However, the effect is only statistically significant in the long run. In the long run, a one percent increase in economic activity increases mobile money usage by 0.95 to 1.85 percentage points. This implies that robust economic activity supports the long term use of mobile money in Uganda. Payment systems trace economic transactions and a well-functioning mobile money platform facilitates economic activity and supports long-run economic growth. As economic activity increases, households and businesses demand safer and ever faster payment platforms such as mobile money technology which enables e-commerce for small business owners and entrepreneurs who use mobile money as a key part of their business.

In addition, the coefficient of inflation is positive and statistically significant at the 5 percent level in both the short and long run. In the short run, a 1 percent increase in inflation is associated with a 0.02 percent rise in mobile money usage, while in the long run it leads to a 0.03 percent rise in mobile money usage in models 1 and 2. On the one hand, the positive effect of inflation on mobile money use may signal concerns from businesses and consumers afraid that rising inflation will erode their future purchasing power. In Uganda, mobile money users do not receive interest on their electronic account balances and bear the risk of loss of value through inflation. On the other hand, a moderate amount of inflation is generally considered to be a sign of a healthy economy, because as the economy grows, demand increases. In July 2011, the Bank of Uganda reformed

its monetary policy framework to meet the challenges of macroeconomic management generated by the transformation of the economy over the last 10 years, and in particular the rapid growth and diversification of the financial system (Bank of Uganda 2021). Since then, the Ugandan economy has generally continuously combined high levels of economic growth with low levels of inflation (Whitworth and Williamson 2010). In the five years to 2019 annual core inflation averaged at 4.34 percent which is below the central bank target of 5 percent over the medium term with an annual headline inflation average at 4.38 over the same period (Bank of Uganda 2021; Uganda Bureau of Statistics 2020). Thus, we conclude that the positive coefficient indicates a rise in the use of mobile money by businesses and consumers in response to moderate increases in inflation driven by rising economic activity in a growing economy.

The results reported in Table 4 also show a negative and statistically significant association between the interest rate and mobile money usage in both the short and long run in models 1 and 2. In the short run, a one percent increase in the 91-day Treasury bill interest rate reduces mobile money usage by about 0.01 percentage point, while in the long run a one percent increase in the 91-day Treasury bill interest rate results in a decline in mobile money usage of approximately 0.01 to 0.02 percentage points. While under the Bank of Uganda's Inflation Targeting (IT) for monetary policy framework the central bank rate (CBR) is the policy rate used to signal to all other rates, the 91 T-bill rate is highly correlated with the CBR and therefore was considered as a proxy for the policy rate in the analysis. Thus, an increase in the 91 day Treasury bill interest rate signals a tightening of monetary policy, reducing the supply of credit to firms and dampening economic activity. The results are an indication that the resultant fall in economic activity following a rise in the 91 day Treasury bill interest rate contracts the mobile money use as consumers and businesses cut back on spending. We also find a negative relationship between the exchange rate and mobile money usage in both models, although the effect is statistically significant in both the short and long run only in model 2. The negative relationship could arise from an exchange rate depreciation pass through to inflation which would lead to a rise in interest rates and indirectly affect mobile money usage, while the statistical insignificance of the effect may be a result of Uganda's foreign mobile money remittance market which is small but thriving due to the high transaction costs.

Further, both model 1 and 2 show a negative and statistically significant relationship between financial innovation and mobile money usage in both the short and long run. In the short run, a 1 percent increase in financial innovation is associated with a 1.0 to 1.2 percent fall in mobile money usage, while in the long run it leads to a 2.3 to 3.5 percent decline in mobile money usage. Although financial innovation is expected to positively affect mobile money use, our finding of a negative effect of financial innovation on mobile money use may be attributed to the growing dynamism in the present era of technology, where more options for financial services are available in the financial sector which offer viable alternatives to the use of mobile money services. More interestingly, the negative effect of financial innovation on mobile money use may thus be a reflection of absorption process of the unbanked mobile money users into the formal financial system. Mobile money among other benefits provides an entry point into the formal financial system, and so helps promote increased saving and self-insurance against small adverse shocks (Aron 2018; Demircuc-Kunt et al. 2018; Di Castri 2013). This implies that the increased adoption and use of mobile money should result in increased access to and use of formal financial institutions including banks, by the unbanked mobile money users. Lwanga and Adong (2016) have shown that having a registered mobile money account increases the likelihood of having some household savings. In Uganda, the mobile money platform is integrated with participating banks to provide mobile financial services products such as saving. Thus, it is imperative that government policy and regulation focuses on overall financial sector development rather than developing the banking sector at the expense of other platforms such as mobile money so as to ensure that mobile money services remain competitive in their product and service offerings as the financial sector develops.

We find a positive association between the COVID-19 crisis and mobile money usage in both the short and long run in both models. However, the effect is only statistically significant in the long run for model 2. The COVID-19 pandemic brought unprecedented challenges to the global economy, whose impact disproportionately affects poorer countries and vulnerable populations. In wake of the COVID-19 pandemic, governments, regulators and mobile money providers in many African countries responded with rafts of measures aimed at limiting the spread of the COVID-19 virus by encouraging mobile money use. For instance, in an effort to shield the most vulnerable user segments in Uganda, the Bank of Uganda and mobile money operators waived fees on all merchant payment transactions and provided total or partial fee waivers on person-to-person (P2P) transactions as well as increasing transaction and balance limits. Thus, we conclude that efforts by policy makers and operators to promote the use of mobile money during the COVID-19 crisis may have somewhat encouraged the use of mobile money as a safe and efficient money transfer and payments service.

Importantly, mobile money usage is also moderated by mobile money tax regulation. The coefficient of the measure of mobile money tax regulation carries the expected negative sign and is statistically significant in both models 1 and 2 at both the short run and long run horizons. While mobile money tax regulation is associated with a 0.7 percentage point decline in mobile money usage in the short run, in the long run it leads to a 0.8 to 0.9 percentage point decline in mobile money usage. Taxation levied on mobile money services, especially over and above standard rates, make the use of mobile money services less attractive to the detriment of the financial inclusion of marginalised groups (Ahmad et al. 2020; Andersson-Manjang et al. 2020; Bahia and Muthiora 2019; Kipkemboi and Bahia 2019; Maina 2018). In 2018, Uganda introduced a one per cent tax on all mobile money transactions, over and above the 10 per cent excise duty levied on transaction charges which was later that same year revised to 0.5 per cent on withdrawal transactions only following public outcry and pressure (Bahia and Muthiora 2019; Maina 2018; Pasti 2019). Bank of Uganda officials, who spoke out against the tax, called the new tax discriminative, unfair, and restrictive to financial inclusion (Maina 2018). This notwithstanding, the adverse impact of the tax was immediate, as customers shunned transactions and mobile money agents, particularly in rural areas, saw significant fall in traffic and revenues (Bahia and Muthiora 2019; Maina 2018; Pasti 2019). However, the common explanation for directly taxing mobile money transactions in African low income countries such as Uganda is to widen the revenue base of the government, considering the size and rapid growth in the mobile money sector, as well as the relatively narrow tax base (Ahmad et al. 2020; Maina 2018). However, rather than applying punitively direct excessive taxes on mobile money transaction values, the government could apply tax treatment that is aligned with best practice principles of taxation in order to avoid the distortionary effect of taxes on the mobile money industry's development and align mobile taxation with that applied to other sectors (Maina 2018; Pasti 2019). In addition, the government should consider leveraging mobile money to increase collection of existing taxes in a digital and efficient way by enabling the payment of fees, rates, taxes and levies due from taxpayers via mobile money services (Pasti 2019).

The coefficient of the error correction term (ECT) which measures the speed of adjustment to the long run steady state of Mobile money usage following external shocks is negative and highly significant at the 5 percent level. The coefficient of ECT is  $-0.35$ , implying that 35 percent of any deviation from equilibrium is corrected in one month. Thus, the results demonstrate that Uganda's Mobile money usage trajectory moves toward a long run steady state although the speed of adjustment is slow, estimated to be approximately 35 percentage points per month with the full adjustment to equilibrium expected to take approximately 3 months. The significant error correction term also provides further support of a long run level relationship between Mobile money usage and the long run forcing variables in the model.



### 5.3. Model Specification and Robustness Test Results

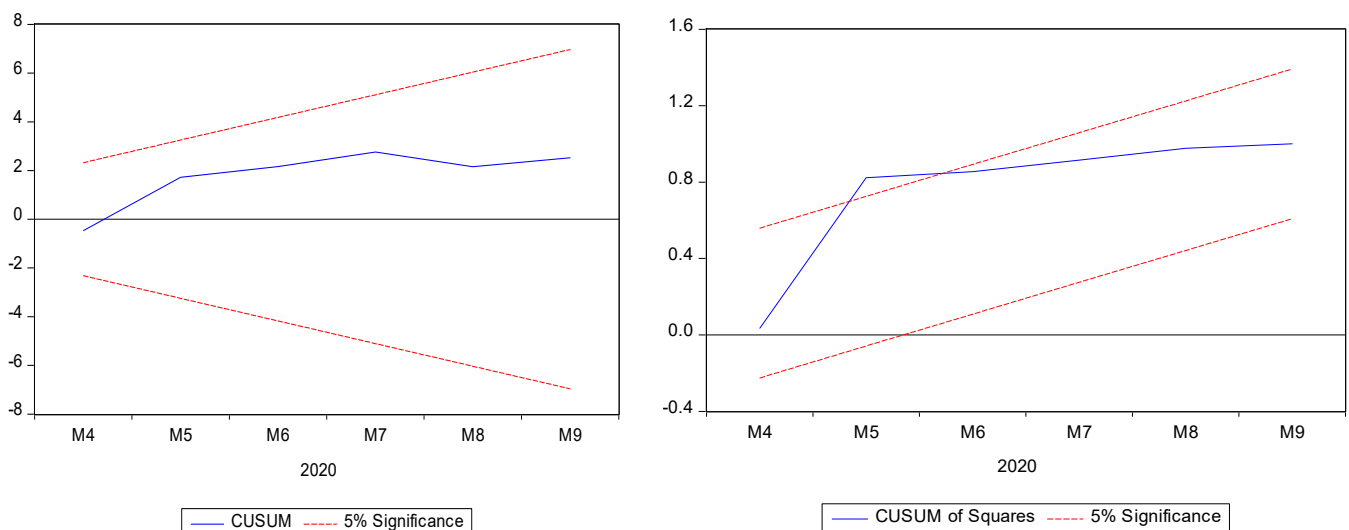
Table 5 reports the model specification and diagnostic tests used to ascertain the robustness of the estimated models. The results reveal that only the ARDL (6,0,0) model passes all the diagnostic tests with exception of the normality test suggesting that only this model can be reliable for policy making and statistical inferences. The test statistics for serial correlation, heteroscedasticity and functional form are found to be lower than the critical values at a 5 per cent significance level, leading to the acceptance of the null hypothesis of the presence of no serial correlation, homoscedasticity and a well-specified functional form. In addition, the test for the overall significance of the estimated models depends on the significance of F-statistic and the F-statistic values for both models are highly significant at 1% level of significance, an indication that all the explanatory variables in the estimated models are jointly significant in explaining the changes in mobile money usage.

**Table 5.** ARDL Model Diagnostic Tests.

Residual Diagnostics	MODEL 1	MODEL 2	MODEL 3
Serial Correlation <sup>1</sup>	1.80 [0.105]	1.94 [0.149]	1.76 [0.113]
F-statistic	148.02 [0.00]	118.36 [0.000]	133.71 [0.000]
Heteroscedasticity <sup>2</sup>	0.089 [0.58]	0.592 [0.736]	2.816 [0.019]
Functional Form <sup>3</sup>	2.18 [0.0314]	1.74 [0.084]	2.28 [0.024]
Normality <sup>4</sup>	28.261 [0.000]	80.86 [0.000]	27.00 [0.000]

Notes: <sup>1</sup> Breusch-Godfrey Lagrange multiplier test of residual serial correlation. <sup>2</sup> ARCH test for Heteroskedasticity based on the regression of squared residuals on squared fitted values. <sup>3</sup> Ramsey's RESET test for omitted Variables/Functional form. <sup>4</sup> Jarque-Bera Normality test based on a test of skewness and kurtosis of residuals. The values in parentheses are t-ratios while probabilities are brackets.

Figures 2–4 show conflicting results regarding parameter stability. In both model 1, 2 and 3, the CUSUM test suggests parameter stability, whereas the CUSUMSQ test shows signs of parameter instability. The contradiction in results of the model stability tests is caused by the fact that there is a break in the intercept of the regression equation instead of the slope coefficient, in which case, the CUSUM test has higher power compared to the CUSUMSQ test (Turner 2010). The CUSUM test which is based on the residuals from the recursive estimates, is a powerful tool for the detection of unknown structural breaks in the regression equation (Turner 2010) and as such the results of the Cumulative sum tests in this study indicate that all three ARDL models are stable, meaning that the estimators measure the relationship between the cointegrated variables accurately. The test results indicate parameter stability when the cumulative sum falls within the 5% critical lines.



**Figure 2.** Plot of CUSUM and CUSUMSQ tests for Model 1.

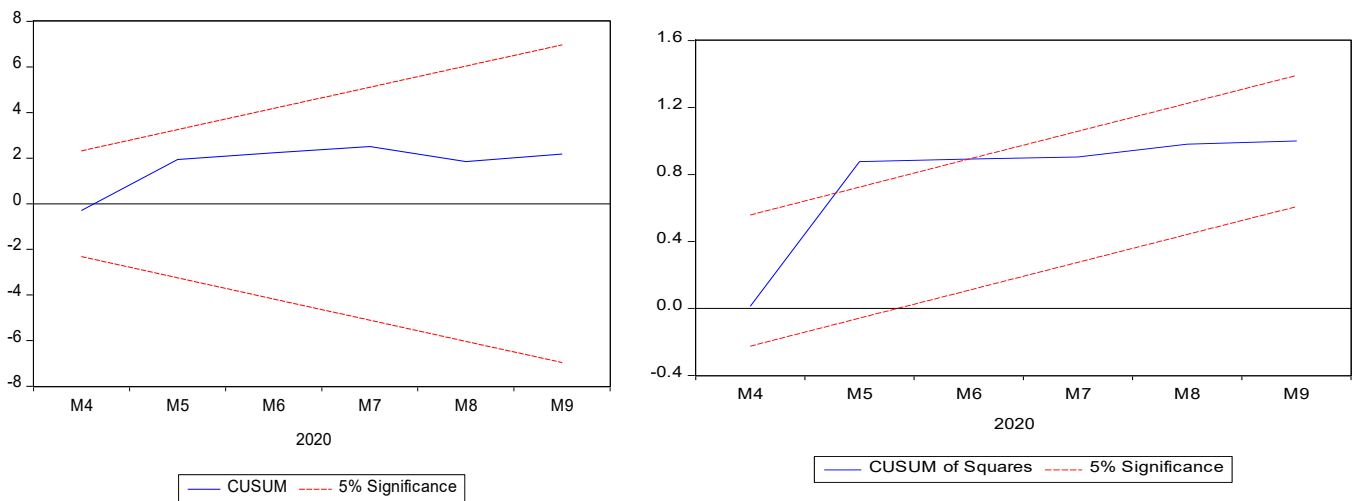


Figure 3. Plot of CUSUM and CUSUMSQ tests for Model 2.

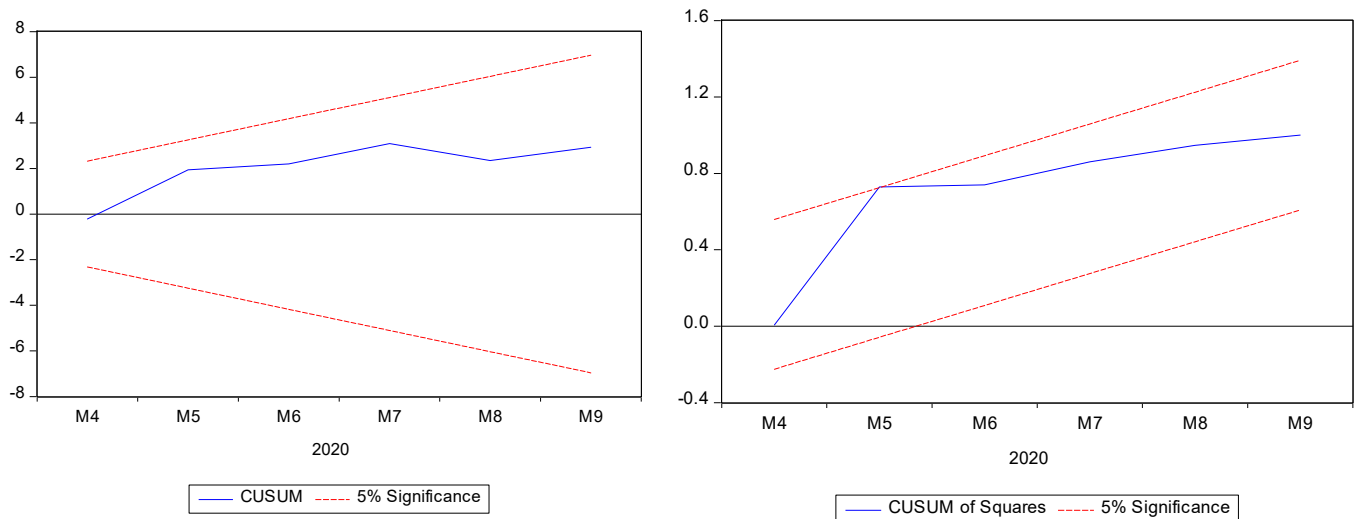


Figure 4. Plot of CUSUM and CUSUMSQ tests for Model 3.

### 6. Conclusions

This paper provides new insights on the effects of macroeconomic and regulatory policy on mobile money usage in Uganda, within the ARDL cointegration theoretic framework. We posit that macroeconomic and regulatory variables such as economic activity, inflation, interest rate, exchange rate, and mobile money tax play a vital role in the use of mobile money. The cointegrating test results indicate a long run equilibrium relationship between mobile money usage, mobile money customer account balances and mobile money registration. Our empirical findings show that there exist short run and long run effects of macroeconomic variables and regulatory tax on mobile money usage. In the short run, mobile money usage is largely positively affected by inflation while financial innovation, exchange rate and mobile money tax are the main negative determinants of mobile money usage in Uganda. In the long run, positive innovation in mobile money use in Uganda are mainly driven by economic activity and the COVID-19 pandemic while negative innovations are largely explained by financial innovation, the exchange rate and mobile money tax. Based on the potential benefits of mobile money, we recommended that governments subsidize the development of local mobile money infrastructure and adopt policies that create an enabling environment for the development, adoption and continued usage of mobile money in Uganda.

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