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MACROECONOMIC EFFECTS OF MOBILE MONEY IN UGANDA

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ABSTRACT

This paper examines the effects of mobile money, a rather new innovation in Uganda's financial sector landscape on aggregate economic activity and other macroeconomic variables. We first estimate the long-run effect of mobile money deposits and value of transactions on monetary aggregates using vector error correction (VEC) techniques. We then estimate the short-term effects of mobile money on selected macroeconomic variables using Structural Vector Autoregressive (SVAR) methods. Results show modest macroeconomic impacts: mobile money has moderate positive effects on monetary aggregates, the consumer price index, and private sector credit. Mobile money deposits do respond to changes in monetary policy instruments, signalling possible ameliorating effects for the conduct of monetary policy. These results provide evidence for policy makers to continue supporting the growth of mobile money platforms. In particular, policy makers should provide the policy and regulatory framework through which mobile money balances can become interest-bearing assets, as this will further strengthen the monetary policy transmission mechanism.

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1. INTRODUCTION

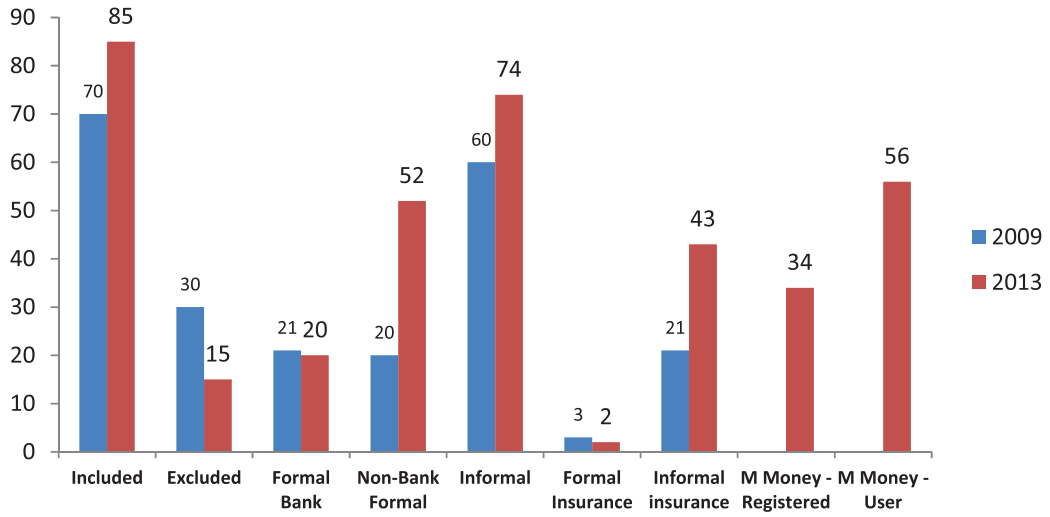
There is growing enthusiasm for, and increasing research about, the potential benefits of new financial innovations for reducing poverty and achieving inclusive economic growth. Equally interesting are the implications of such financial innovations for the conduct of monetary policy. One such innovation that has revolutionised the financial sector landscape with regard to the way people save, make payments and transfer money is the advent of mobile money transactions. There is now growing interest in how mobile money may affect household welfare at the micro level and monetary aggregates at the macro level.

The financial sector in Uganda has expanded rapidly over the last two decades. This growth has been possible due to reforms that enabled competition, particularly in the banking sector. However, despite these positive developments, access to formal financial services is still low: in 2013, only 20 percent of the population had access to formal regulated financial intermediation services (EPRC 2013). The introduction of mobile money in 2009 has helped to expand formal financial services to populations that were previously excluded. Adoption of mobile money has been relatively rapid: a recent FINSCOPE survey showed that 56 percent of all adults were using mobile money services in 2013, of which 34 percent were registered users (Figure 1).

By August 2016, the value of mobile money transactions had reached UGX 3.6 trillion (Figure 2). Balances on mobile money accounts reached UGX 326 billion – the equivalent of 2.6% and 1.8% of M2 and M3, respectively. The rapid expansion of mobile money has attracted much debate about its implications for the growth of the financial sector and the effectiveness of monetary policy. On the one hand, mobile money can facilitate the effectiveness of monetary policy to the extent that it improves financial inclusion. This is because households that have access to formal financial markets may have complete access to instruments that facilitate saving and borrowing. Consequently, changes in policy interest rates have a direct effect on these households' inter-temporal consumption and investment decisions.

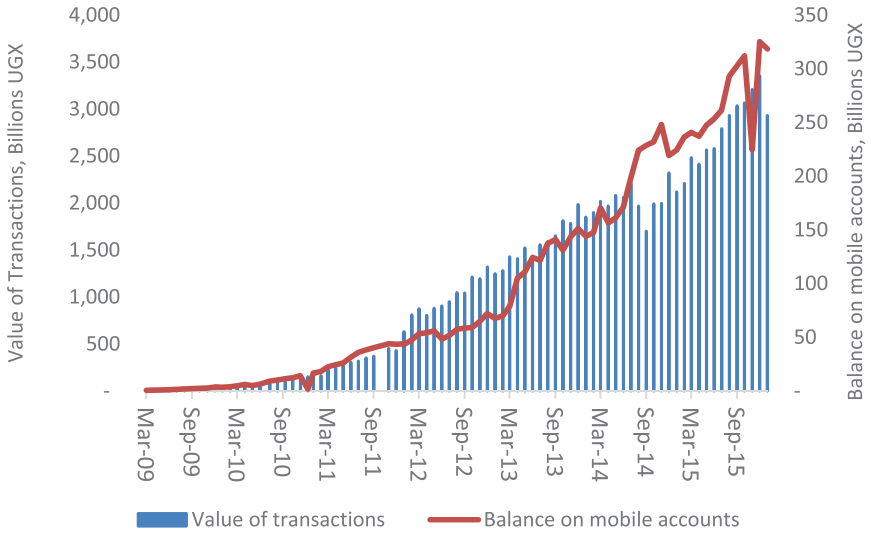
At the national level, literature evaluating the economic impacts of mobile money has started to emerge. Lwanga and Adong (2016) have shown that having a registered mobile money account increases the likelihood of having some household savings. This implies that in the presence of imperfections in the financial markets, the increased adoption and use of mobile money should result in increased formal bank savings.

Figure 1: Usage of financial services in Uganda, %



Source: Author computations from 2009 and 2013 FINSCOPE surveys

Figure 2: The volume of mobile money in Uganda



Source: Bank of Uganda

At the regional level, available studies (mostly focused on Kenya) have shown minimal macroeconomic risks associated with the expansion of mobile money. Weil *et al*., (2012) show that mobile money is a means of transfers and savings and that the velocity of mobile money has risen over time, which is an indication of increased use of mobile money in transactions. Importantly, Weil *et al*., (2012) show that the velocity of mobile money is not higher than the velocity of cash or other monetary aggregates in Kenya, meaning that the monetary implications, if any, are expected to be minimal. Adam and Walker (2015) find that mobile money should increase the macroeconomic stability of the countries in which it is widespread, contrary to popular expectations that it would destabilise the conduct of monetary policy in those countries.

There are concerns, however, that the proliferation of mobile transactions will change the landscape for traditional banking, with implications for financial sector development, the conduct of monetary policy, and financial regulation. Kamukama and Tumwine (2012) conclude that the proliferation of mobile payments may disadvantage commercial banks by weakening their liquidity positions. Concerns have also been raised about the implications of mobile money for the conduct of monetary policy in Uganda.

The adoption and use of mobile money implies a gradual substitution of real cash balances for bank deposits. This leads to a larger money multiplier because all mobile money balances have to be backed up by cash deposits in an escrow account of a partner commercial bank. Moreover, mobile money will obviously increase the velocity of money in circulation because it reduces the transactions and time costs of making retail payments. Indeed, innovations in the financial sector, including mobile money, have been shown to have statistically significant positive long-run effects on money velocity in Uganda (Nampewo and Opolot 2016).

At a 2015 conference convened by the International Growth Centre in Kampala under the theme "*Mobile Money and the Economy*", the Governor of the Bank of Uganda expressed his concerns as follows:

> *"…if more radical mobile banking business models are eventually developed in which mobile money becomes a substitute for demand deposits in banks, the ability of central banks to control interest rates could be undermined. This is because central banks control short-term interest rates by varying the liquidity available for commercial banks to meet their reserve requirements. But if mobile money eventually leads to a diminution of the role which commercial banks play in the*

financial system, the interest rate transmission mechanism, which relies on movements in short term inter-bank rates being transmitted along the yield curve to all other interest rates in the economy, will be weakened, which in turn will weaken the transmission mechanism of monetary policy…" (Tumusiime-Mutebile 2015)

Despite these concerns, the linkages between mobile money and its effects on the economy and conduct of monetary policy have received limited attention. Against this background, this study explores the macroeconomic effects of mobile money in Uganda. In particular, this study examines the effects of mobile money on money aggregates, interest rates, consumer price index, private sector credit, and gross domestic product. An important aspect of the study involves establishing the implications of mobile money shocks for the conduct of monetary policy.

The rest of the paper is structured as follows: section two introduces discussions about the status, growth and regulation of mobile money. Section three presents a brief survey of the literature and the analytical framework. Methods and data used in the analysis are discussed in section four. The results are presented and discussed in section five. Finally, section six concludes with policy recommendations.

2. BACKGROUND: THE STATUS, GROWTH AND REGULATION OF MOBILE MONEY IN UGANDA

Status

Mobile money services were introduced in Uganda in March 2009. Currently, there are six mobile money schemes: 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 financial institutions: Stanbic Bank, Barclays Bank, DFCU Bank, Centenary Bank and Equity Bank. Uganda's business model follows the Smart Money model of Smart Communication of the Philippines, where a Mobile Network Operator (MNO) collaborates with a commercial bank to offer Mobile Money Services (MMS) (Ssonko 2011). The commercial bank's role is largely to hold a customer's funds in escrow accounts and to release those funds on demand.

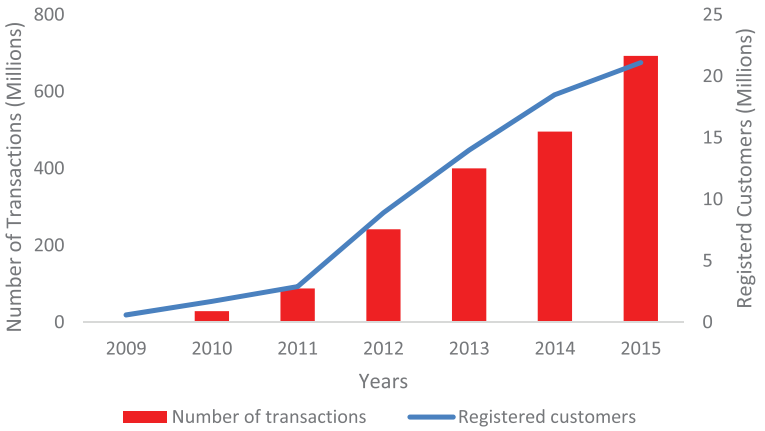
The service has evolved from person-to-person transfers and storage of electronic value to include other services, such as a way to check bank balances; pay bills, salaries, social benefits and taxes; send cross-border remittances; transfer from a bank account to a mobile wallet; purchase mobile phone airtime; extend micro-finance services and facilitate

Table 1: Timeline of evolution of mobile money in Uganda

Date	Innovations and governance of mobile money in Uganda
Mar 2009	Mobile money is introduced in Uganda
Mar 2009	Domestic transfers/remittances P2P introduced
Jul 2010	Government payments of social benefits (G2P) introduced
Jan 2010	Merchant payments – enabling SMEs and corporates to receive payments P2B – introduced
Jun 2011	Financial Consumer protection guidelines take effect
Oct 2013	Mobile money guidelines come into force
Apr 2014	Mobile banking; transfers from bank account to M-wallet commences
Jun 2015	Bulk payments: salaries, wages B2P (e.g., sugar, tea and construction firms) commences
Aug 2015	Cross border transfers enabled
Nov 2015	Statutory payments (Taxes) P2G commence
Mar 2016	Group wallets for SACCOs and VSLA on the mobile money platform
Jun 2016	International transfers enabled
Aug 2016	Micro loans and savings programs on the mobile money platform introduced
Jan 2017	Insurance service on the mobile money platform introduced

Source: Key Informant Interviews with industry – January 2017

Figure 3: Growth in Mobile Money Services



Source: Bank of Uganda 2015

village savings and loans accounts (VSLA), amongst other services (see table 1).

Mobile money is also increasingly being used as a way to store value. As alluded to earlier, mobile money encourages savings by providing a secure and widespread mechanism to facilitate formal savings across socioeconomic boundaries. In Uganda, the mobile money platform is integrated with participating banks to provide mobile savings products. Those with mobile money accounts are 32 percent more likely to report having some savings compared with those without accounts (Lwanga and Adong 2016).

Growth

Growth in mobile money services in Uganda has been relatively strong. This growth is attributed to increased demand for domestic remittances, deepening of the quality of existing financial services, and improvements in the regulatory framework, amongst other reasons (Evans and Pirchio 2014). Uganda has 21.1 Million registered mobile money accounts (Figure 3), which is greater than half of the country's population of 35 Million.[1]

After 5 years of operation of mobile money services, the average adoption rate stands at 250,000 persons per month from inception (March 2009) to December 2015. The increase in access to formal financial services, from 28 percent in 2009 to 54 percent in 2013, was partially due to increased access to mobile money services (EPRC 2013). Thirty-five percent of Ugandan adults have a registered mobile money account (Intermedia 2016). An additional 13 percent access services via somebody else's account, including that of an agent. Mobile money account ownership surpasses the use of both banking and nonbanking financial institutions (Ibid).

In 2015, more than 20 million transactions were conducted via mobile money services (figure 2). These transactions amounted to over UGX 32.5 trillion, or USD 9 billion, for the year that ended in December 2015 (Bank of Uganda 2016). This represents a nominal increase of UGX 8.5 trillion, up from the UGX 24 trillion recorded in 2014. An average of UGX 18 Billion, or USD 5.14 million, is transferred through mobile money each day, mostly in small amounts averaging just over Ug. Shs 70,000 (USD 20) per transaction. In addition, there is hope that access to mobile money services can be expanded. A significant portion of Ugandans know about mobile money and do not use it. Close to 43 percent are considered "aware nonusers," and they are primarily poor, rural and less educated (Intermedia, 2016). The main constraints on aware nonusers include access to technology and lack of technical skills.

Regulation

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 law requires

1 See UBOS (2016), "National Population and Housing Census 2014", Uganda Bureau of Statistics: Kampala

mobile money operators to register with the Bank of Uganda or partner with a Bank of Uganda registered institution (Bank of Uganda 2013).

The above regulations affirm the roles of the Bank of Uganda as a regulator and of the Uganda Communication Commission (UCC) as a licensor. It is essential for service providers (agents and operators) to adopt the practice of Know Your Customer (KYC) by conducting a set of due diligence measures to identify and monitor customers' transactions. In addition, the operator must not be bankrupt and must implement appropriate technology to deliver the service. The responsibility of the user/customer to protect transaction data is also emphasized.

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. However, there are opportunities to further streamline the Bank of Uganda Mobile Money Guidelines 2013 by defining the nature and the scope of mobile money services in the face of emerging technologies and innovations. In particular, policies should examine innovations that could lead to payment of interest on money balances saved on the mobile money platform. Payment of interest would encourage both saving and the use of the service.

3. LITERATURE REVIEW AND ANALYTICAL FRAMEWORK

3.1 Literature Review

There is a growing body of literature showing that mobile phone-based technologies play a critical role in fostering financial inclusion and growth, particularly by reducing transaction costs and time constraints (Andrianaivo and Kpodar 2011). Relatedly, previous research suggests that mobile money may help to mitigate the incompleteness of financial markets, and this could have implications for macroeconomic stability (Adam and Walker 2015; Weil *et al*., 2012).
The debate about the macroeconomic effects of the various facets of financial innovations, including mobile money, has gained momentum over the last few years. Sahay *et al*., (2015) provide a detailed discussion of the macroeconomic effects of financial inclusion, with a special focus on economic growth, financial and economic stability, and inequality. First, they argue that financial inclusion increases economic growth – but only up to a certain point, indicating that financial inclusion is not a guarantee of growth. Second, they argue that unregulated credit expansion could be the basis for elevated financial risks. Third, they argue that in contrast to credit access, other forms of financial inclusion do not have adverse impacts on financial stability.

Research investigating the effects of mobile money on financial sector development is limited and inconclusive. Earlier studies suggested that mobile money could be detrimental to the ability of banks to mobilise savings and deposits (Kamukama and Tumwine 2012). However, such findings have been challenged by, among others, Nampewo *et al*., (2016), who used vector error correction modelling and Granger causality analysis to show that mobile money is an important driver of private sector credit supply via its effect on savings and deposit mobilisation.

Ndirangu and Nyamongo (2015) used Auto Regressive Distributed Lag (ARDL) to investigate the effect of innovations in Kenya's financial sector on the stability of the money demand function. They find that the rapid pace of financial innovations during the 1998-2013 period has not distorted the equilibrium money demand function.

Nampewo and Opolot (2016) examined the impact of financial innovations on money velocity in Uganda. They were primarily interested in determining whether money velocity is still important in Uganda's inflation-targeting regime. Using the co-integrated autoregressive distributed lag (ARDL) econometric approach, they find negative and positive effects of financial innovations on the velocity of money in the

short and long-run, respectively.

Weil *et al*., (2012), focusing on the "new" phenomenon that is mobile money in Kenya, were among the first to examine the implications of innovations in the financial sector for the conduct of monetary policy. While they document high velocity in mobile money transactions, they find that M-Pesa velocity is not any higher than the velocity of other monetary aggregates, and they conclude that the implications of mobile money on the conduct of monetary policy are, at best, minimal.

Adam and Walker (2015) have developed a Dynamic Stochastic General Equilibrium Model, which clearly distinguishes between households in the rural and urban economies, to examine the macroeconomic impacts of the rapidly spreading use of mobile money. In their model, mobile money serves as a remittance tool that enables urban households to send money to their rural counterparts; the money thus serves as insurance against unanticipated income fluctuations. Their results showed that mobile money might not undermine the conduct of monetary policy; rather, it may improve macroeconomic stability. These findings support the spread of mobile money services.

There have been concerns that financial inclusion through the spread and use of mobile money would lead to elevated inflationary risks. The potential impact of mobile money on inflation was first discussed by Simpasa and Gurara (2012), who argued that increases in money velocity could propagate inflation, thus complicating the conduct of monetary policy. However, such arguments were contested by Aron *et al*., (2015), who, while focusing their analysis on Uganda, developed inflation forecasting models following error correction techniques and did not find sufficient evidence to support the proposition that mobile money is inflationary.

There is a growing body of literature showing the implications of the extent of financial inclusion for the design of monetary policy. Mehrotra and Yetman (2014) develop a theoretical framework to examine the effects of financial inclusion on maximising monetary policy; they show a positive relationship between the number of financially included households and the ratio of output to inflation volatility.

Financial inclusion could improve the effectiveness of monetary policy through its effect on the development of the financial sector. Opolot *et al*., (2013) have argued that the efficacy of both monetary policy and the monetary policy transmission mechanism depends on the strengths of the country's "financial architecture". This implies that greater financial inclusion could improve the effectiveness of monetary policy to the extent that it improves the size, stability and composition of the formal financial sector. Indeed, Mehrotra and Yetman (2015) argue that an increase in financial inclusion affects the effectiveness of monetary policy in two distinct ways. First, financial inclusion helps more households to smooth their consumption over time, thus influencing basic monetary policy choices, including the target price index. Second, financial inclusion encourages households to hold more financial assets outside of cash and non-cash physical assets.

3.2 Analytical Framework

Mobile money and money demand

There are two competing views of the likely impact of mobile money on money demand. The first view contends that financially excluded persons may accumulate their savings in the form of non-financial assets, such as land, livestock, and jewellery (Mehrotra and Yetman (2015). For many households, mobile money may present opportunities to substitute such non-financial assets with electronic money, thus increasing the demand for broad money. Under such circumstances, we would expect mobile money to be positively associated with monetary aggregates. The second view contends that financial innovations may reduce the demand for money, owing to improvements in transaction efficiency (Ndirangu and Nyamongo 2015). In particular, mobile money may reduce the transaction demand for money if it reduces the transaction costs and risks involved in dealing with cash, such as travelling to the bank, waiting time, and risk of exposure to losses, such as through theft.

Mobile money and inflation

With regard to the potential relationship between mobile money and inflation, there are two alternative views. Mobile money could prove to be inflationary if it affects the velocity of money circulation without necessarily improving the levels of aggregate output. This is the view that was propagated by Simpasa and Gurara (2012), among others. However, there may well be countervailing effects, where mobile money improves productivity and economic efficiency, leading to lower transaction costs, higher output and – consequently – lower or no effect on inflation, as discussed by Aron *et al*., (2015).

Mobile money, interest rates, credit and aggregate output

Mobile money could affect interest rates through its effect on money demand and the supply of private sector credit. If mobile money leads to a reduction/ increase in money demand and inflation, then monetary authorities might respond by pursuing tight monetary policies, leading to high interest rates. Mobile money may affect interest rates to the extent that it leads to the creation of credit by commercial banks. The role of mobile money in credit creation has been studied by Nampewo *et al*., (2016), who highlight the crucial role of savings and deposit mobilisation. Finally, if mobile money leads to economic efficiency through reduced transaction costs and better allocation of resources and credit, then it follows that aggregate economic activity will be supported.

Figure 4 summarises the analytical framework that we adopt in this paper. Within this framework, mobile money is expected to have a directly observable impact on money stock, and this will have successive impacts on inflation, interest rates, private sector credit and aggregate economic activity.

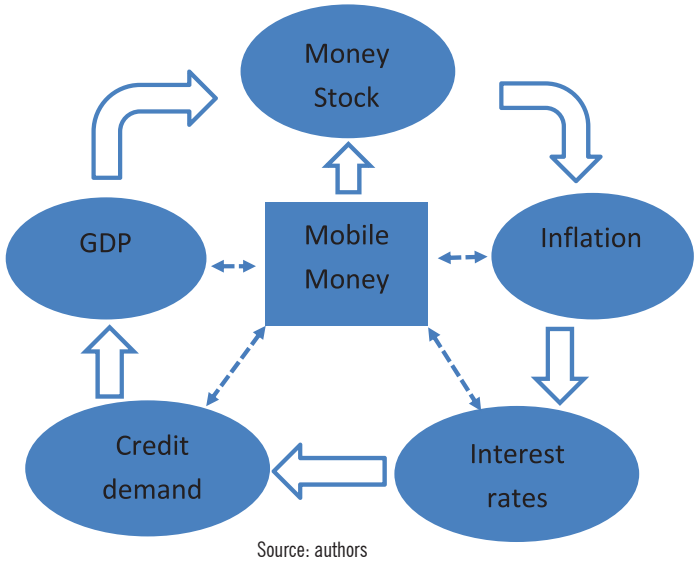
4. METHODS AND DATA

4.1 Methods

4.1.1 Vector error correction methods

We use vector error correction methods to investigate the dynamic linkages between mobile money balances and money demand. A major advantage of using vector error correction methods is that they provide convenient ways of dealing with non-stationarity in data series without the loss of critical information that is inherent in data generating processes in levels. In particular, when the variables under consideration are first-difference stationary, vector error correction frameworks can be used in a manner that avoids loss of information by modelling the linear combinations of the data in levels.

Figure 4: Analytical framework



Source: authors

Assume a k-dimensional vector autoregressive representation that can be expressed in equation 1) below:

$$Z_t = \mathrm{B}(L)Z_t + \mu_t \qquad 1$$

Where $Z_t' = z_{1t}, z_{2t}, \ldots, z_{kt}$ is a vector of endogenous variables; $B' = (B_1, B_2, \ldots, B_p)$ represents a kxk matrix of coefficients; L is the lag operator; $\mu_t \sim iid\ N(0, \delta)$ is a k-dimensional vector of Gaussian errors, with; $E(\mu_t) = 0$; and $t = 1, 2, \ldots, T$ indexes the time periods.

The expression in equation 1) may be expressed in an error correction formulation, combining both the levels and first differences of the data series as shown in equation 2). Importantly, the multicollinearity problem that is often present in time series data is reduced by this transformation.

$$\Delta Z_t = \alpha\beta' Z_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Z_{t-i} + \mu_t \qquad 2$$

Where Z_t is a vector of endogenous variables of interest; $\alpha\beta'$ and Γ_i are the long-run and short-run coefficients to be estimated by the Johansen (1988) procedure; $i = 1, \ldots, k-1$ represents the optimal lags included in the system computed using appropriate lag selection criteria. If the variables in Z_t are first-difference stationary or integrated of first order – i.e., I(1) – then the long run matrix $\alpha\beta'$ can be said to be of reduced rank where α represents the adjustment parameters and β is the matrix of long run coefficients.

In order to obtain the long run equilibrium, we proceed as follows. We investigate the time series properties of the data series. It is important that all variables are difference stationary. We then estimate a vector autoregressive (VAR) model and obtain the appropriate lag length. We test for cointegration and determine the number of co-integrating relationships in the long run matrices $\alpha\beta' Z_{t-1}$ following the Johansen procedure. We then estimate the unrestricted co-integrating relations in the vector error correction model to determine the equilibrium long-run relationship. Finally, we test for model stability.

4.1.2 The Structural Vector Autoregressive (SVAR) Model

The Structural Vector Autoregressive (SVAR) approach allows for contemporaneous feedback between variables while imposing the minimal structural restrictions on the model (Kim & Roubini 2000). In a vector autoregressive framework, all variables are endogenous and, as a reduced form representation of a large class of structural models, a SVAR model offers both empirical predictability and a link between data and theory by using the assumptions underlying the structure of the economy (Hamilton, 1994). Thus, we can formulate a reduced form representation of a structural autoregressive model, as shown in equation (3).

$$`AZ_t = \gamma + \sum_{i=1}^{p} A_i Z_{t-i} + B\mu_t \qquad 3$$

where $\mathrm{Z_t}$ is an $nx1$ vector of endogenous variables; A and B are invertible $n\,x\,n$ matrices capturing contemporaneous relations among variables in vector Z_t, γ, is a vector of constants; A_i are nxn matrices of unknown parameters on lagged values of $\mathrm{Z_t}$ to be estimated; μ_t is an $n\,x\,1$ vector of uncorrelated structural innovations or shocks corresponding to each element of Z_t with covariance matrix $E|u_t u_t'| = \Sigma_\epsilon$ for $t = 1, 2, 3, \ldots, T$; and n is the number of variables in the system. A reduced form representation of equation (3), generated by multiplying through both sides by the inverse of matrix A, is shown in equation (4).

$$Z_t = \varphi + \sum_{i=1}^{p} \phi_i Z_{t-i} + \varepsilon_t \qquad 4$$

Where $\varphi = A^{-1}\gamma$; $\phi_i = A^{-1}A_i$; and $\varepsilon_t = A^{-1}B\mu_t$

In the formulation given in equation (3), structural shocks are orthogonal to each other. We use the Cholesky decomposition of the variance-covariance matrix of the reduced VAR residuals, Σ_ϵ, to generate the structural shocks. To identify A and B, and thus generate impulse response functions, at least $2\mathrm{n}^2 - \mathrm{n}(\mathrm{n}+1)/2$ additional restrictions are required in addition to normalization restrictions for the system to be just identified (Lutkepohl 2005).

We adopt a recursive identifying structure whereby a priori restrictions are imposed on contemporaneous interactions among Z_t variables in order to identify the coefficient matrix A. Thereafter, the dynamic impact of μ_t can be traced on the path of any element in Z_t .

In this specification, mobile money balances (LMMB), money stock (LM2), the consumer price index (LCPI), treasury bill rates (TB365), private sector credit demand (LPSC), and aggregate economic activity (LGDP) are entered as endogenous variables. All variables, with the exception of the treasury bill rates, are expressed in natural logarithm.

The order of variables is important in the SVAR model because it defines the transmission of the structural shocks in a way that mimics economic theory. Following our analytical framework, we assume that the mobile money balances are only affected by own innovations; money stock is only affected by mobile money; the consumer price index is affected by money stock and mobile money; treasury bill rates are assumed to be influenced by the consumer price index, money stock and mobile money; private sector credit is influenced by treasury bill rates, the consumer price index, money stock and mobile money. Finally, we assume that that GDP is affected by all endogenous variables included in the model as described above. The ordering of the variables is expressed in matrix form in the identification scheme in equation 5 below: = 5)

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{LMMB} \\ \mu_t^{LM2} \\ \mu_t^{LCPI} \\ \mu_t^{TB365} \\ \mu_t^{LPSC} \\ \mu_t^{LGDP} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{LMMB} \\ \varepsilon_t^{LM2} \\ \varepsilon_t^{LCPI} \\ \varepsilon_t^{TB365} \\ \varepsilon_t^{LPSC} \\ \varepsilon_t^{LGDP} \end{bmatrix} \quad 5$$

Table 2: Descriptive statistics

Variable	Obs	Mean	Median	Std Dev	Min	Max
LMMB	90	3.887	4.193	1.731	-0.509	5.808
LMMVT	90	6.242	7.114	1.964	-0.716	8.207
LM2	90	9.024	9.060	0.269	8.437	9.417
LCPI	90	4.850	4.895	0.166	4.533	5.069
TB365	90	10.822	9.596	4.366	3.696	20.282
LPSC	90	8.894	8.980	0.356	8.176	9.367
LGDP	90	8.296	8.292	0.105	8.094	8.452

4.2 Data

We use monthly data spanning a period of 90 months between March 2009 and August 2016. This period is important because it relates to the introduction of mobile money services in Uganda. The data that we use were collected from the bank of Uganda and the Uganda Bureau of Statistics. In particular, this study uses the natural logarithm of mobile money balances (LMMB); the natural logarithm of money stock (LM2); the natural logarithm of the consumer price index (LCPI); 365-day treasury bill rates (TB365)[2]; the natural logarithm of private sector credit demand (LPSC); and the natural logarithm of GDP (LGDP). The Uganda Bureau of Statistics only compiles quarterly GDP data; so, we use the quarterly GDP interpolated to monthly series. The graphical representation of the data is provided in appendix 1. The descriptive statistics of the data are provided in table 2 below:

Before proceeding with the analysis, it is important to establish the time series properties of the data. We employed the Dickey-Fuller Generalised Least Squares (DFGLS) procedure provided by (Elliott *et al*., 1996) to test for unit roots in the data generating processes. The DFGLS procedure was preferred because of its power and superior performance, especially with relatively small samples. In conducting the unit root tests, we considered both trend and intercept in the data generating processes. The unit root test results (table 3) show that all variables have unit roots and therefore follow I(1) processes.

Table 3: Stationarity tests

Variable	DFGLS Unit Roost Test Statistics		Order of Integration
	In levels	In first differences	
LMMB	-1.065	-10.172***	I(1)
LMMVT	-0.873	-11.961***	I(1)
LM2	-1.558	-3.471***	I(1)
LCPI	-1.322	-6.322***	I(1)
TB91	-2.233	-5.451***	I(1)
LPSC	-0.505	-8.866***	I(1)
LGDP	-0.592	-5.772	I(1)

Notes: ***, **, * indicate significance of the Elliott–Rothenberg–Stock DFGLS test statistic at the 1%, 5% and 10% levels, respectively

2 We preferred to use the 365-day treasury bill rates rather than the 91-day treasury bill rates because the former give better estimates in the model.

5. RESULTS AND DISCUSSION

5.1 Money demand

In estimating the money demand function, we proceed as follows. First, we estimate the traditional Keynesian representation that only includes three variables: the natural logarithm of real broad money, excluding foreign currency deposits (LRM2), the natural logarithm of the real gross domestic product (LRGDP), and the 365-day treasury bill rates (TB365). We then re-estimate the model and include, separately, the natural logarithms of real mobile money balances (LRMMB) and the real mobile money value of transactions (LRMMVT).

In estimating these functions, we applied one lag for each variable as indicated by the Schwartz Information criterion, as shown in table 4 below. The Hannan-Quinn Information criterion indicates an optimal lag length of two, and each of the LR, FPE and AIC all indicated a lag length of eight; however, we did not use them because of issues with degrees of freedom, given the relatively small sample that we have to work with.

The Johansen co-integration procedure indicates that there exists at least one cointegrating relationship that explains an equilibrium long-run relationship in the money demand equation (table 5). In particular, the maximum Eigen-value is greater than the associated critical value, suggesting that the null hypothesis of "no cointegration" is rejected in favour of the alternative hypothesis for the rank at the 1 percent level of significance.

Table 5: Cointegration test based on the trace and max tests

H_0	Trace test	Max test
$r = 0$	32.435**	17.826**
$r = 1$	15.166	12.256

***, **, * denote rejections of the hypothesis at the 1%, 5%, and 10% levels, respectively

Taking the Keynes (1936) postulation as a starting point for our analysis, we estimate the demand for real money balances (LRM2) as a function of real aggregate demand (LPSC) and the opportunity cost of holding money, taking the 365-day treasury bill rate (TB365) as the policy instrument such that

$$LRM2_t = f(TB365_t, LRGDP_t) \quad 6$$

$f'_{TB} < 0$ and $f'_{LGDP} > 0$, implying that real money demand is reduced by the policy (interest) rates and increased by real output. In this regard, we expect the income elasticity of real money demand to be unity. We expand the Keynesian formulation to include real mobile money balances (LRMMB) and the real value of transactions (LRMMVT). The goal is to examine how mobile money affects the demand for money, not necessarily to arrive at the true money demand function for Uganda. Consequently, the money demand function that we estimate takes the form

Table 4: Lag length selection in the money demand function

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-42.650	NA	0.001	1.113	1.201	1.148
1	304.511	660.453	0.60e-07	-7.134	-6.782*	-6.993
2	319.476	27.374	1.39e-07	-7.279	-6.663	-7.032*
3	329.425	17.472	1.36e-07	-7.303	-6.422	-6.949
4	341.078	19.610	1.28e-07	-7.367	-6.223	-6.908
5	344.111	4.882	1.49e-07	-7.222	-5.813	-6.656
6	359.556	23.733	1.28e-07	-7.379	-5.706	-6.707
7	365.336	8.457	1.41e-07	-7.301	-5.363	-6.523
8	380.123	20.557*	1.25e-07*	-7.442*	-5.240	-6.558

Note: * Lag order selected by the criterion at the 5% level

Table 6: The long run money demand model

	(1)	(2)	(3)
LRM2	1.000	1.000	1.000
LRGDP	1.514 [8.761] ***	1.454 [3.203] ***	1.365 [11.873] ***
TB365	-0.039 [-6.574] ***	-0.048 [-6.469] ***	-0.017 [-7.315] ***
LRMMB		-0.143 [-2.618] ***	
LRMMVT			-0.118 [-7.901] ***
Constant	3.294	2.674	2.139
Error correction	-0.154 [-4.472] ***	-0.067 [-3.407] ***	-0.123 [-2.026] **
Notes: 1. The coefficients, t-statistics are tabulated in square brackets. 2. Significance levels: *** =significant at the 1% level, ** =significant at the 5% level, *=significant at the 10% level			

$$LRM2_t = f(TB365_t, LRGDP_t, LRMMB_t) \quad 7$$

Results for the long-run money demand function are presented in table (6). Panel (1) includes only the real gross domestic product and treasury bill rates. The results conform to Keynes' (1936) expectations, where the coefficient on real money is near unity and real money balances respond to interest rates. The model in panel (2) builds upon panel (1) to include real mobile money balances. The results suggest that real mobile balances reduce real money demand: a 1 percent increase in real mobile money balances is associated with a 0.143 percent reduction in real money demand. Similarly, the results in panel (3) indicate that a 1 percent increase in the value of real mobile money transactions is associated with a 0.118 percent reduction in real money demand.

The error correction terms for the three models in table 5 are negative and significantly different from zero, implying that 15%, 6.7% and 12.3% of disequilibria in the long-run relationships in panels (1), (2), and (3), respectively, are corrected in the subsequent time period.

The inverse roots of the characteristic polynomial indicate that the preferred model (model 2) is stable, observing that all roots are located within the unit circle (Appendix 2)[3]. These results corroborate earlier research showing that innovations in the financial sector are negatively associated with money demand in the long run (see, for example, Dunne and Kasekende 2016).

5.2 The macroeconomic effects of mobile money

To evaluate the short-term macroeconomic effects of mobile money, we estimate the SVAR model presented in section 4.1.2. In the SVAR, we include a selection of macroeconomic variables that include the natural logarithms of nominal mobile money balances (LMMB), money stock (LM2), the consumer price index (LCPI), the 365-day Treasury bill rates (TB365), nominal private sector credit (LPSC), and nominal gross domestic product (LGDP), in that order. As discussed earlier, the SVAR identifies structural shocks in the VAR system by imposing restrictions that mimic economic theory. The SVAR estimated in this paper assumes that the variables are related in a recursive manner in the order explained above.

In estimating the SVAR, we applied one lag for each variable in the underlying VAR as indicated by the Schwartz and Hannan-Quinn Information criteria, as shown in table 7 below. While the FPE and AIC indicated a lag length of eight, and the LR indicated an optimal lag length of 7, we opted to work with a shorter lag length because of concerns about loss of degrees of freedom and efficiency given the relatively small sample size.

3 Indeed, all three models are stable, and the results from the characteristic polynomials are available upon request

Table 7: Lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	153.512	NA	1.84e-08	-3.622	-3.475	-3.563
1	684.661	984.567	8.01e-14	-15.967	-15.086*	-15.613*
2	717.211	56.366	6.71e-14	-16.151	-14.537	-15.503
3	744.525	43.970	6.45e-14	-16.207	-13.859	-15.265
4	772.055	40.958	6.27e-14	-16.269	-13.187	-15.032
5	796.451	33.322	6.72e-14	-16.254	-12.439	-14.723
6	837.861	51.510	4.90e-14	-16.655	-12.105	-14.828
7	893.755	62.710*	2.61e-14	-17.408	-12.125	-15.287
8	927.189	33.433	2.52e-14*	-17.614*	-11.597	-15.198

The results presented in figure 4 show the short run effects of mobile money on the set of macroeconomic variables. The blue lines show the reaction of a given variable due to a Cholesky one-standard-deviation-innovation in mobile money balances. The red lines show the confidence bands around the estimated impulse.

Our findings show that the macroeconomic effects of mobile money are modest at best. With regard to the effect on money stock, a one-standard-deviation positive shock in mobile money balances results in an increase in money stock in the first eight months, after which the effect starts to decline. However, this result is not statistically significant, and it projects weak mobile money effects on money demand. This result is consistent with the theory that mobile money may lead to liquidation of non-financial assets, which results in larger money stock in the short run, especially in developing countries such as Uganda that are still at lower levels of financial inclusion.

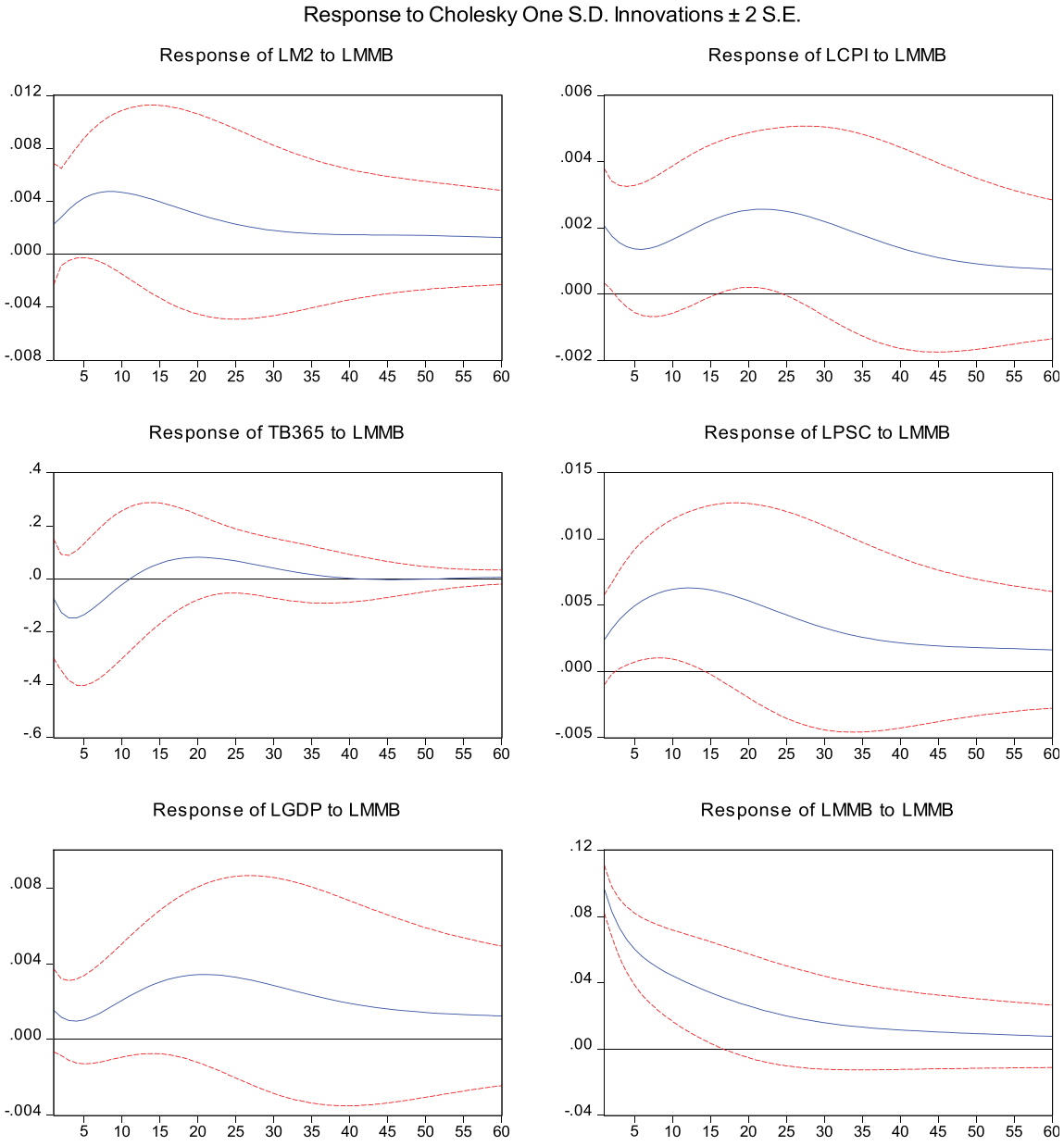
The effect of a positive mobile shock on the consumer price index is similar to that of the money stock. A one-standard-deviation positive shock in mobile money balances initially results in a decline in the consumer price index during the first six months, which thereafter gradually rises, becoming significant between the eighteenth and twenty-fourth months. While these results do not concur with earlier work by Aaron *et al*., (2015), who found modest if insignificant effects of mobile money on inflation processes, they are certainly in line with Simpasa and Gurara (2012), who first discussed the possible inflationary effects of mobile money. The inflationary effect is probable if, as evidenced from our results, mobile money does not lead to an improvement in gross domestic product. If mobile money strongly facilitates transactions, and not the creation of value added, then this might serve to increase the money velocity – as discussed in Nampewo and Opolot (2016).

A positive shock in mobile money is associated with a reduction in the treasury bill rates. A one-standard-deviation positive shock in mobile money balances results in a decline in the treasury bill rates within the first four months. However, this effect is only modest and not statistically significant.

The effect of a positive mobile money shock on private sector credit is positive and statistically significant between the third and thirteenth months. The impact of a mobile money shock on private sector credit reaches its maximum during the twelfth month. These findings are consistent with earlier work by Nampewo *et al*., (2016), who show that mobile money is associated with the supply of credit by commercial banks. Indeed, this finding is also consistent with the negative impact of mobile money on treasury bill rates.

The structural model that we estimate is well specified. Robustness tests do not reveal any major problems with the model. The inverse roots of the characteristic polynomial indicate that the model is stable, as shown

Figure 4: The macroeconomic impacts of mobile money balances



in appendix 3.

To corroborate the findings, we re-estimate the SVAR using the natural logarithm of the value of mobile money transactions. The results (provided in appendix 4) are largely unchanged except for larger and statistically significant effects on money demand, interest rates, and GDP. This indicates that the transactional value of mobile money has stronger macroeconomic effects that its savings value.

5.3 Mobile money and the conduct of monetary policy

With regard to the implications of mobile money for the conduct of monetary policy, we evaluate the responses of mobile money balances and other key macroeconomic variables to policy rate shocks.

The results presented in figure 5 show that mobile money balances respond to changes in the policy rate. Specifically, a one-standard-deviation positive shock in the monetary policy rate results in a decline in mobile money balances. The impact of treasury bill

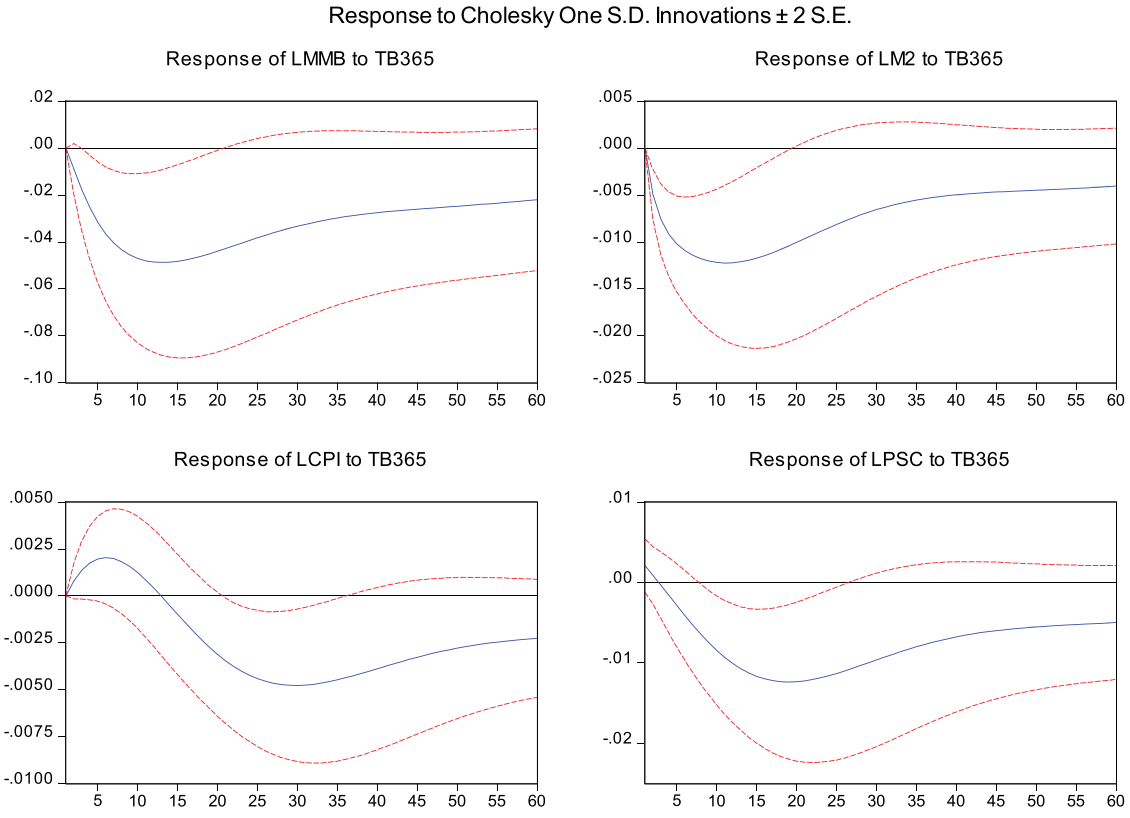
rates on mobile money balances reaches its maximum between the twelfth and fourteenth months. These findings alleviate any fears that the development of mobile money technologies might weaken the mechanisms of monetary policy transmission. Indeed, these results are consistent with earlier work by Adam and Walker (2015), who used DSGE methods to show that mobile money technology does not undermine the transmission of monetary policy but rather increases macroeconomic stability.

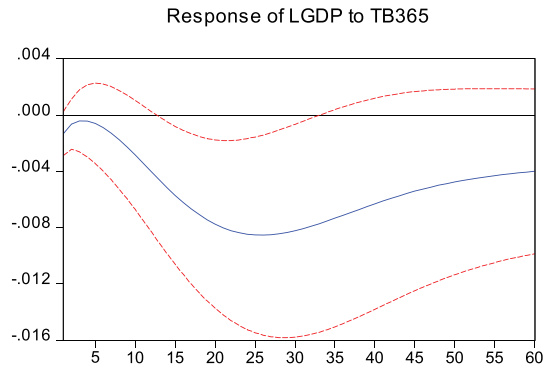
The effects of treasury bill rate shocks on the remaining macroeconomic variables conform to a priori expectations. A one-standard-deviation shock to treasury bill rates results in a decline in the demand for money, and the effect is statistically significant within the 18 months following the shock. High interest rates incentivise economic agents to substitute liquid assets for financial assets, thus reducing the demand for money. This is consistent with Keynes' (1936) postulation of the money demand function.

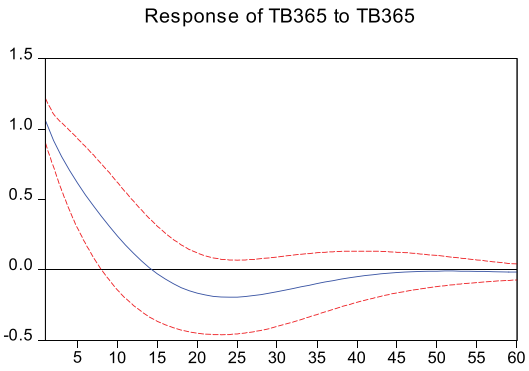
An increase in treasury bill rates initially results, albeit insignificantly, in an increase in the consumer price within the first six months, after which the CPI starts to decline significantly. The maximum impact of a monetary policy shock on the CPI is realised within 21 months, before it becomes insignificant within 34 months. This finding indicates that the effects of monetary policy on inflation take time to reach their full strength.

A positive shock to treasury bill rates affects gross domestic product and private sector credit. The impact of a treasury bill shock on private sector credit is at its maximum eighteen months after the shock. Likewise, the effect of a shock to treasury bill rates on gross domestic product is at its maximum sixteen months after the shock. These results are consistent with Nampewo *et al*., (2013), who showed that interest rate shocks affect aggregate production, with potential implications for the demand for private sector credit.

Figure 5: Mobile money balances and the conduct of monetary policy







Again, as in the previous sub-section, we re-estimate the SVAR model using the logarithm of the value of mobile money transactions in order to gauge the differentiated implications for the conduct of monetary policy. The results (provided in appendix 5) are largely unchanged, except that mobile money transactions are not statistically significantly responsive to shocks in the policy rate. This implies that the improvements in the conduct of monetary policy are stronger for the "savings" motives of mobile money as opposed to the "transactions" motives.

6. CONCLUSIONS AND POLICY OPTIONS

Access to quality and affordable financial products remains a key challenge to the growth and competitiveness of Uganda's economy. The development of innovative financial products, including products used on mobile platforms, has been at the forefront of improving financial inclusion outcomes across a growing number of African countries. Uganda is one country where the access to and use of mobile money has expanded rapidly over the last few years.

Despite the known benefits of mobile money with regard to easing commerce, savings and risk management, there have been concerns that it might undermine financial sector stability and alter the landscape for the conduct of monetary policy. This paper set out to examine the macroeconomic impacts of mobile money. In particular, the paper investigates the responsiveness of key macroeconomic variables – including interest rates, money stock, the consumer price index and private sector credit – to changes in mobile money balances. An important aspect of this paper is its consideration of the implications of mobile money for the conduct of monetary policy. In particular, we are interested in whether mobile money balances respond to short-term changes in the central bank policy rates.

The econometric analysis that we adopt is based on two separate but complementary approaches: the vector error correction (VEC) and the structural vector autoregressive (SVAR) methods. First, vector error correction methods show that mobile money reduces the demand for money in the long run. This is true if the new technology allows people to substitute liquid assets for mobile money deposits. This result is unchanged even when we consider the value of mobile money transactions. Second, structural vector autoregressive models indicate moderate short-term macroeconomic impacts of mobile money. In particular, positive shocks to mobile money balances are positively associated with a higher consumer price index and more private sector credit. Importantly, shocks to the mobile money values of transactions exhibit larger effects on money demand and GDP. The effect on other macroeconomic variables is invariably modest. Finally, mobile money balances are sensitive to monetary policy shocks, while the mobile money values of transactions are not. These results suggest that 1) Mobile money has helped households to substitute liquid and other lumpy assets for financial assets; 2) Mobile money has modest macroeconomic impacts; 3) Mobile money has the potential to improve the effectiveness of the conduct

of monetary policy. These results provide additional evidence for policy makers to continue supporting the growth of mobile money platforms. In particular, policy makers should provide the policy and regulatory framework through which mobile money balances can become interest-bearing assets. This will further strengthen the monetary policy transmission mechanism because economic agents will be able to more directly respond to changes in the policy rate. Exploring mechanisms through which mobile money can more ably contribute to growth is an important area for further investigation.

These results, however, should be interpreted with caution given the relatively short time span of the analysis. In addition, given that the adoption and use of mobile money are still developing at a breakneck pace, there might be non-linearities that could mask the full effects of mobile money. Finally, ongoing innovations in the mobile money markets – such as the introduction of microcredit facilities – might alter the established macroeconomic consequences of mobile money.

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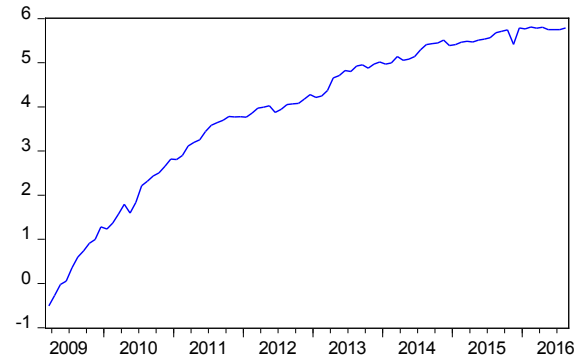
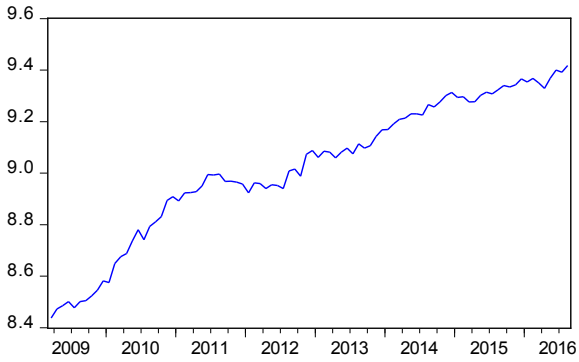
Appendix 1: Graphic Exposition of the data

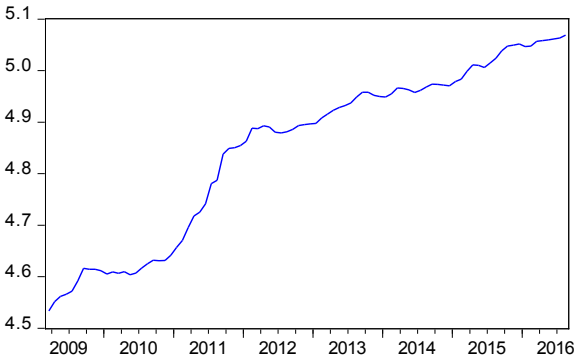
LMMB



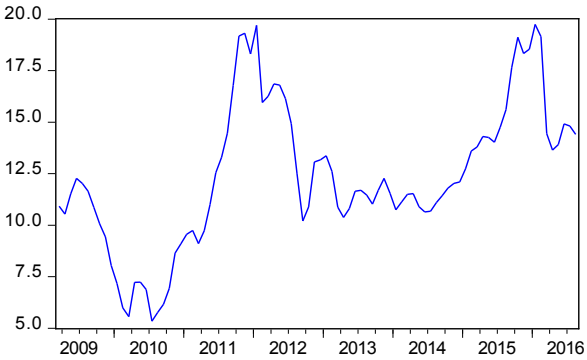
LM2



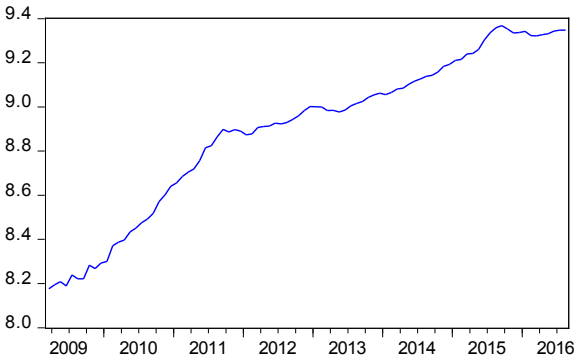
LCPI



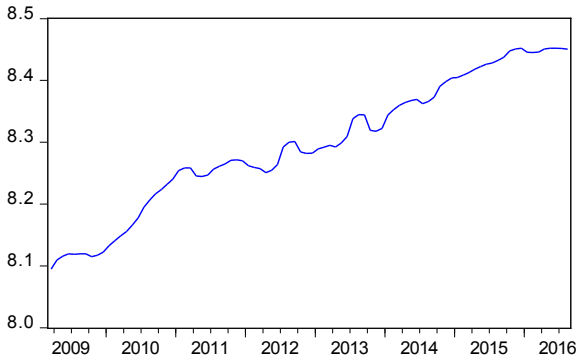
TB365



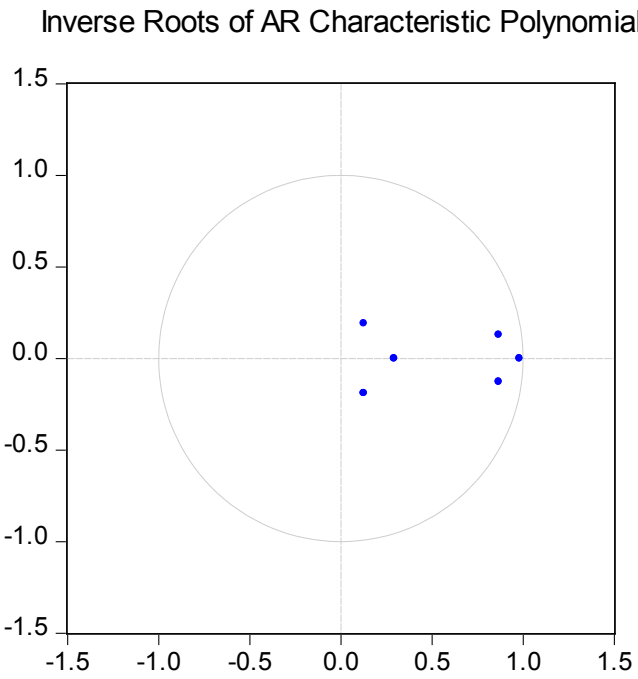
LPSC



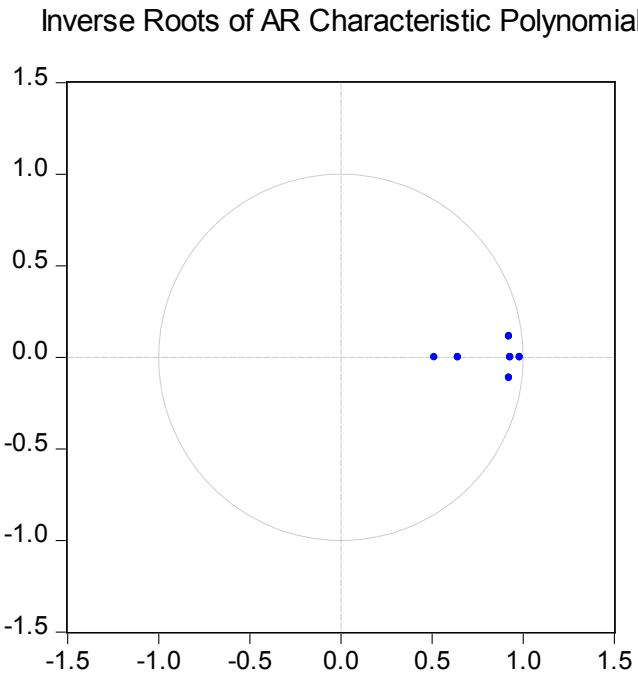
LGDP



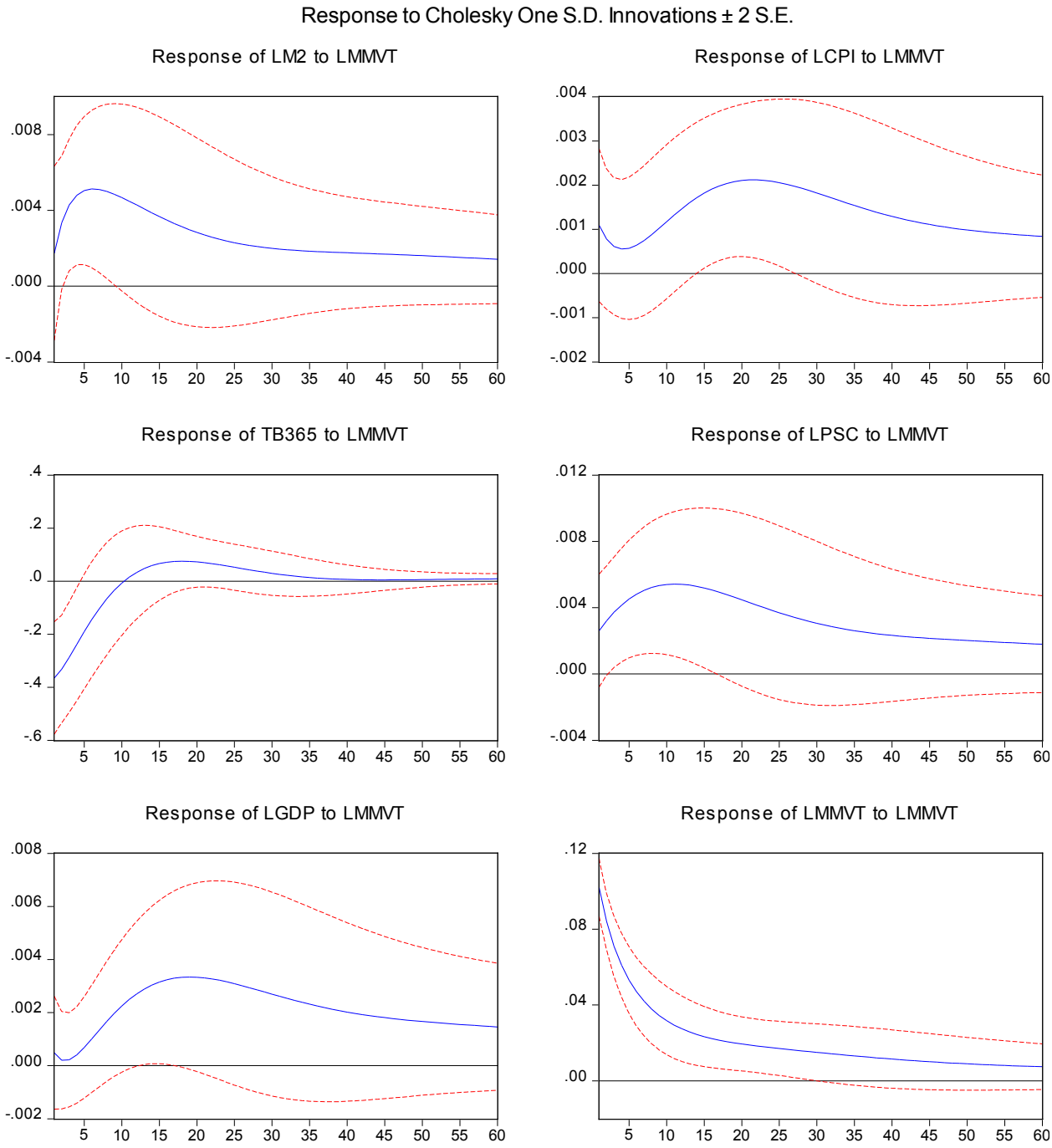
Appendix 2: The characteristic polynomial roots for the money demand function



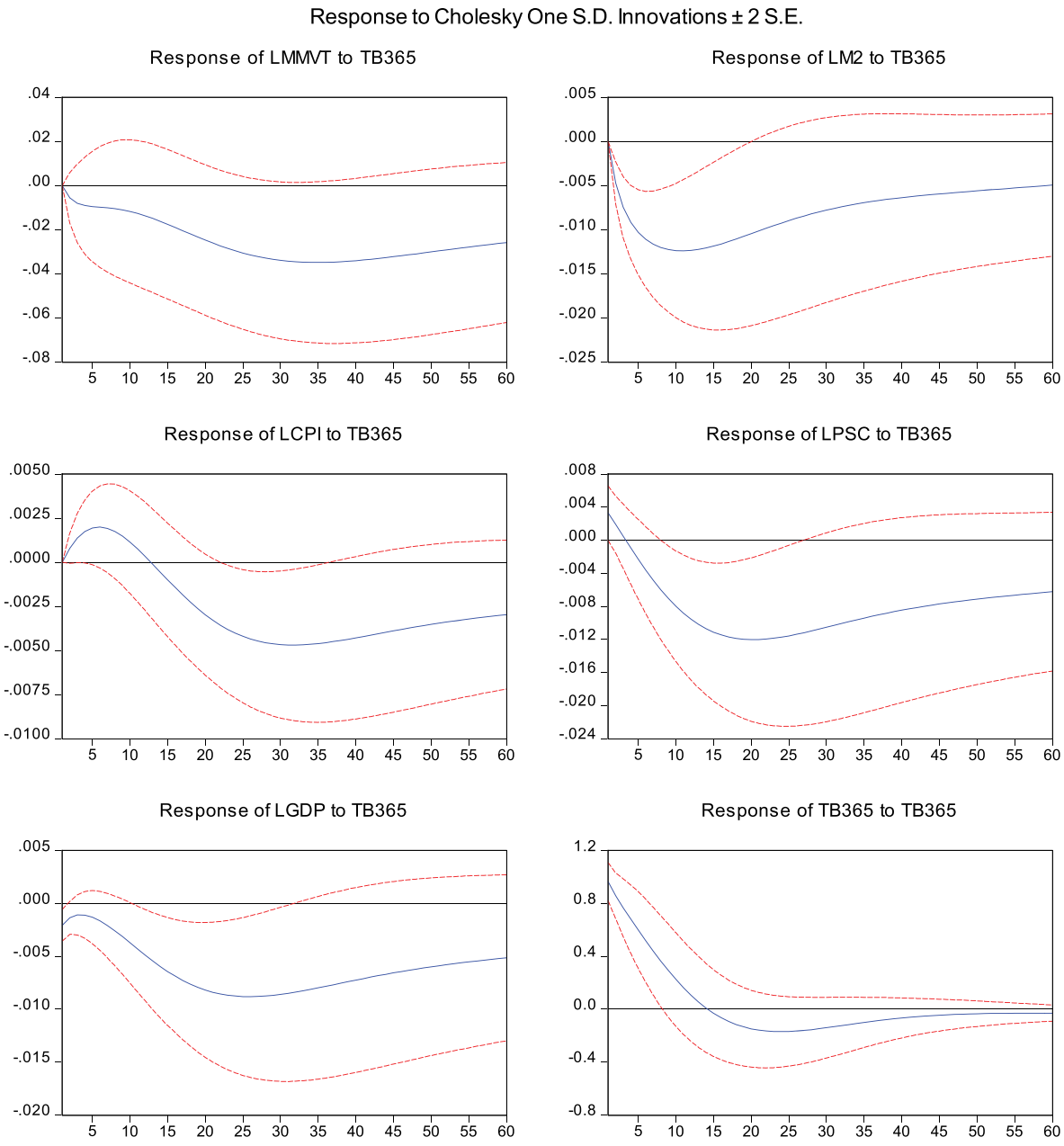
Appendix 3: The characteristic polynomial roots for SVAR model



Appendix 4: Macroeconomic effects of mobile money transactions



Appendix 5: Mobile money transactions and the conduct of monetary policy



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