Financial Innovation and Money Demand with a Focus on Mobile Money: The case of Kenya

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Abstract

Over the years, several countries have experienced growth in financial innovation which has implications for monetary policy. Kenya has been at the forefront of a unique type of financial innovation, mobile money (M-PESA), introduced in 2007. This paper re-estimates the relationship between financial innovation and money demand in Kenya with a focus on mobile money using the ARDL approach to cointegration between 2000 Q1 to 2014 Q2. The results suggest that money demand is stable. However, this is only evident with inclusion of mobile money which is not only positively related to money demand but also leads to a decrease in the interest rate elasticity of demand.

Keywords: Money demand, financial innovation, mobile money, Kenya, ARDL
JEL Classification: E41, E42, E52

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"Preliminary draft, comments are welcome. Please do not quote"

1. Introduction

Over the years, numerous empirical studies have attempted to investigate the stability of money demand given its importance for the successful implementation of monetary policy (see inter alia Bahmani-Oskooee and Gelan(2009), Hoffman et al (1995), Bahmani-Oskooee(2001), Adam(1992) and Darrat(1985)). Most of the earlier studies in advanced economies and particularly in the USA such as Brunner and Meltzer (1963) and Meltzer(1963) found that the demand for money is stable, in the sense that the monetary authority can effectively control inflation through adjusting the money supply while instability of the money demand can hinder the proper monitoring of prices[1] (Hamori, 2008). Developing countries have not been an exception when it comes to a stable money demand function. For example studies by Suliman and Dafaalla (2011) for Sudan, Bahmani-Oskooee and Gelan (2009), and Hamori (2008) for Africa, and Mwenga (1990) and Adam (1992) for Kenya all found that money demand is stable with exclusion of financial innovation.

However, in light of the recent growth in financial innovation spanning over the last few decades, there are mixed results in regards to the stability of money demand. Thus, it has become increasingly important to study the stability of money demand because financial innovation can potentially affect the demand for money through over estimation of the money demand. Prior to the mid-1970s when most empirical results showed a stable money demand, a limited number of variables such as the interest rate and output were sufficient to achieve a stable money demand (Goldfeld and Sichel,1990). In view of the growth in financial innovation, several studies such as Arrau and De Gregorio (1993), Ireland (1995), Attanasio et al (2002), Alvarez and Lippi(2009), Nagayasu(2012), Arrau et al (1995), Mannah-Blankson and Belyne(2004), Hafer and Kutan(2003) and Hye(2009) have attempted to analyze money demand with inclusion of financial innovation.

Financial innovation is often difficult to measure and there are several definitions that capture this in the literature[2]. Financial innovations have evolved over time for example individuals moved away from holding cash to assets and the use of ATMS, Debit cards, electronic banking among others. Most recently, mobile money (M-PESA)[3], a type of financial innovation that differs from the previous innovations was introduced in Kenya by Safaricom, a mobile network operator in 2007. M-PESA provides transactions that include depositing, transferring,

[1] For efficiency of the monetary transmission mechanism, the velocity of money should also be stable and this can be determined through testing the stability between money, output and prices (Bahmani-Oskooee and Gelan, 2009).

[2] For example, Arrau and De Gregorio (1991) define financial innovation to include both technological processes and financial regulation or deregulation. In addition, Melnik and Yashiv (1994) refer to financial innovation as "introduction of new liquid assets that partially replace traditional money in agent's portfolios, technological progress in banking services that reduces the costs of transactions and changes in the regulatory environment that facilitate transactions." Furthermore, Arrau et al (1995) refers to financial innovation as permanent changes to the money demand that are not caused by opportunity cost i.e. interest rates and scale variables such as GDP or consumption for the case of a household money demand.

[3] M stands for mobile and PESA means money in Swahili

withdrawing funds using cell phone technology and also enables customers to save, pay bills and purchase goods and services inter alia without the use of a bank account (Jack and Suri, 2011 and Jack et al, 2010). More recently, individuals can get loans based on credit history from M-PESA (Safaricom, 2014). Although, mobile money started off as a payment system, it has quickly evolved and it is being used by both the banked and the un-banked population. Individuals who would otherwise not have had access to financial services can now do so with easier access through an alternative form of cash, mobile money.

Mobile money also differs from other financial innovations through its effect on money demand. Most financial innovations are often expected to have a negative relationship with money demand because individuals move away from holding cash to assets and as a result they demand less money. However, mobile money is an alternative form of cash i.e. e-money and not necessarily an alternative form of asset other than cash. Therefore, as mobile money usage increases, demand for money increases as well. This implies that one would expect the relationship between mobile money and money demand to be positive.

This new financial innovation, makes Kenya a particularly interesting case study. There is still a limited amount of studies that have investigated the relationship between financial innovation and money demand[4]. Except for Sichei and Kamau (2012) who capture the effect of financial innovation on money demand using the number of ATMs as a proxy for financial innovation and Ndirangu and Nyamongo (2015) who use currency outside banks/time deposit ratio. It has become even more important to revisit the stability of money demand in Kenya considering this unique innovation, mobile money. Kenya is of specific interest in this study because it was the first country to introduce mobile money and it has the largest number of mobile money users in the world. Davidson and Pénicaud (2012)'s worldwide mobile money survey indicates that 80 percent of 2011 mobile money transactions were processed in East Africa. Moreover, Kenya, Uganda, Madagascar and Tanzania have more registered mobile money users than bank accounts (Pénicaud, 2013).

While most research has yielded great insight to the money demand literature, a vital question that is worth investigating is whether the demand for money is still stable given the recent financial innovation developments in Kenya. Given the limited number of studies on mobile money and money demand, this paper contributes to the relevant literature by re-estimating the Kenyan money demand including not only the standard financial innovation proxies but also the country specific innovation, mobile money. This study hopes to shed some light on the relationship between this new innovation and money demand. Also, this study is likely to inform policy makers and guide their decision making particularly in terms of monetary policy. The rest of the paper is structured as follows. A review of the theoretical and empirical literature is given

[4] Central Bank of Kenya (CBK) conducts monetary policy based on monetary aggregate targeting, i.e. Net Domestic Assets and Net International reserves are used as the operational parameters and monitors M3 and private sector credit (CBK (2014b) Monetary Policy Statement). Therefore, stability of money demand plays a crucial role in monetary policy and instability due to new financial innovations could complicate monetary policy effectiveness.

in Section 2 followed by a brief overview of the Kenyan financial system and financial innovations in Section 3. Then, Section 4 presents the data, the model specification and the estimation method. Finally, the results and conclusions are discussed in sections 5 and 6 respectively.

2. Literature Review

In theory, the growth in financial innovation can improve efficiency in the banking sector through the reduction in transaction costs. However, it can also complicate the way monetary policy is conducted due to the instability of the money demand. To achieve the ultimate goal of price stability, Central Banks particularly those that target monetary aggregates require a stable money demand function. The stability of money demand plays a crucial role in the conduct of monetary policy especially in terms of the appropriate monetary policy actions (Sriram, 2000). To try to understand the implications of financial innovation on money demand, it is imperative to first comprehend the theory of the demand for money. Several theories that explain money demand have been developed over time. Older theories that are based on the quantity theory of money such as the classical economists, assume that the velocity of money is stable and that the primary determinant of money demand is income. This theory has advanced over time with the modification by the Keynesians who incorporate interest rate and refer to money demand theory as the liquidity preference theory. This includes three motives of holding money, namely, the transaction/business motive, the precautionary motive and the speculative motive (Serletis, 2007).

The transaction demand for money is associated with the level of income and money serves as a medium of exchange. Similarly, the precautionary demand for money is dependent on the level of income but it is associated with the level of uncertainty. However, the speculative demand for money mainly focuses on the level of interest rates. Money is considered a store of value and individuals could choose to hold either money or bonds. Therefore, bond prices are highly dependent upon the interest rate (Serletis, 2007 and Sriram, 1999). Interest rates are negatively associated with money demand according to Keynesians and as a result a rise in interest rates is not only associated with a reduction in money demand but a rise in velocity. Put differently, an increase in money demand could lead to a decline in velocity while a decrease in money demand could lead to an increase in velocity.[5] In other words, unlike the classical economists, the Keynesians argued that the velocity of money is not constant (Serletis, 2007).

New money demand theories "post-Keynes" were also developed; for instance, the transactions and portfolio theories (Sriram, 1999). The transactions theories such as the Baumol-Tobin model, the shopping time model and cash in advance model assume that money serves as a

[5] Income Velocity (V) = PY/M and QTM states MV=PY so (M/P)*V=Y, thus V=Y/ (M/P) For example an increase in interest rate will lead to a decrease in money demand and thus an increase in velocity. (see Serletis,2007)

medium of exchange while the portfolio theories such as Tobin's theory of liquidity preference and money and overlapping generations assume the role of money as a store of value (Serletis, 2007). Although Keynesians found that velocity is non-constant, Friedman argues that velocity is rather constant and predictable. Furthermore, the demand for money only depends on permanent income therefore, it is insensitive to interest rates, stable and accurately predictable. (Serletis 2007).

In terms of empirical work, money demand specification has received a lot of attention over the years partly due to the contradictory results regarding the stability of money demand. Although the older money demand theories seem to dominate the empirical literature, in recent years, the number of studies using different model specifications and estimation techniques have increased. For example Ireland (1995) uses the cash in advance theoretical model while Alvarez and Lippi (2009) and Attanansio et al (2002) use the Baumol-Tobin model to capture the role of financial innovation on money demand. While the quantity theory of money depicts a stable and predictable money demand, empirical evidence seems to depict mixed results. On the one hand studies such as Stock and Watson (1993) for USA, Suliman and Dafaalla (2011) for Sudan, and Bahmani-Oskooee and Gelan (2009), Hamori (2008) and most recently Salisu et al (2013) for Africa find a stable money demand. On the other hand some studies find no evidence of a stable money demand. For example, Bahmani-Oskooee and Bohl(2000) for Germany, Deckle and Pradhan (1997) for Asian countries, Kararach (2002) for Uganda and Bahmani-Oskooee and Barry(2000) for Russia. The results on the stability of demand for money are also mixed for the case of Kenya. Darrat (1985), Mwenga (1990), Adam (1992) and more recently Kiptui (2014) indicate a stable money demand function while the Sichei and Kamau (2012) and Nyamongo and Ndirangu (2013) find that money demand in Kenya is unstable.

There are various reasons that could lead to the instability of money demand such as changes in regulations, financial and monetary reforms or developments in financial innovation. Financial innovation could lead to instability of money demand and unpredictable velocity. Andersen (1985) highlights three sources of instability. These are, first a change in income velocity as a result of fluctuations in interest rates and other factors not related to income. Second, money stocks that may not correspond to money balances desired in the short run which could lead to unexpected changes in velocity. Third, a shift in the money demand function implying unstable parameters or new developments such as financial innovation. Instability of money demand may also be due to the inadequacy of the partial adjustment modelling technique or perhaps new financial innovation (Sriram, 1999). Financial innovation can lead to an increase in interest rate elasticity of demand and therefore variation in velocity of money (Gurley and Shaw, 1960).[6]

[6] In addition, financial innovation could weaken the interest rate channel and thus affect monetary policy (Misati et al 2010). Financial innovation could also affect other variables in the economy other than money demand for example, Melnik and Yashiv (1994) argue that financial innovation affects other macroeconomic variables especially through the bank asset side of the balance sheet in addition to its impact on money demand. The rationale for this lies on the fact that financial innovation allows consumers to change their portfolio allocation which affects bank's ability to lend and thus affects the interest rates.

Although, some studies such as Hafer and Hein(1984), and Lippi and Secchi(2009) find that financial innovation leads to lower interest rate elasticity.What is clear however, is that financial innovation is one of the main reasons for instability of the money demand.

As a result of the growth in financial innovation over the last few years, several empirical studies have started including financial innovation in the money demand specification.[7] Exclusion of financial innovation in the money demand function could lead to misspecification of the money demand through over estimation, commonly referred to as "missing money" (Arrau and De Gregorio, 1991). Empirical evidence suggests that financial innovation ought to be included in the money demand function to help solve some of the issues faced by money demand specification such as autocorrelated errors, persistent over prediction and implausible parameter estimates (Arrau et al, 1995). In addition, non-stationary processes such as financial innovation, could explain the failure of co-integration of the money demand but once financial innovation is accounted for, periods of "missing money" are eliminated (Arrau and De Gregorio, 1991).

Some of the studies that have accounted for financial innovation in the money demand specification such as Arrau and De Gregorio (1993), Ireland (1995), Attanasio et al (2002), Alvarez and Lippi(2009) and Nagayasu(2012) include mainly advanced and transition economies. This is partly due to the fact that most financial innovation in the last few decades occurred in the developed countries. However with new regulations, improved banking systems and financial markets as well as increased cell phone usage, there is a remarkable progress in financial innovation in the developing countries as well. Studies that have attempted to study the relationship between financial innovation and money demand in developing countries *inter alia* include Arrau et al (1995), Mannah-Blankson and Belyne(2004), Hafer and Kutan(2003) and Hye(2009).

Since measurement of financial innovation is not easy per se, a number of proxies have been used in the relevant literature such as number of ATMs, M3/M1, M2/M1, bank concentration and a dummy variable *inter alia* to capture financial innovation. For example, Hafer and Kutan (2003) and Augustina *et al* (2010) used a dummy variable to account for shifts in the money demand on account of financial innovation for the case of the Philippines and Nigeria respectively. Arrau and DeGregorio(1991) modelled financial innovation as shocks that follow a random walk that lead to permanent changes to the money demand not explained by the opportunity cost of holding money or income. Although stochastic or deterministic trends offer a plausible proxy for financial innovation that eliminates the misspecification in the traditional money demand function, Arrau et al (1995) argue that it may be too general to identify the

[7] Some studies attempt to capture the relationship between financial innovation and money demand by considering money as a medium of exchange. For example Ireland (1995) incorporates financial innovation into the cash in advance theoretical model while Alvarez and Lippi (2009) and Attanansio et al (2002) use the Baumol-Tobin model to capture the role of financial innovation on money demand. However, other studies have incorporated financial innovation to the traditional money demand function by directly using different proxies of financial innovation and these include inter alia Arrau et al (1995), Nagayasu (2012) ,Hafer and Kutan(2003), Arrau and De Gregorio(1993), Mannah-Blankson and Belyne(2004) and Sichei and Kamau(2012).

specific origin of the innovation. For developed countries, Fischer (2007) use the number of ATM concentration in Switzerland to proxy for financial innovation while Lippi and Secchi (2009) and Attanasio, et al (2002) also use ATM related data for Italy. However, Nagayasu (2011) considered several measures for his panel data analysis one of which included the bank concentration data. He measured bank concentration as a ratio of the number of banks to the total population which would be similar to using the number of ATMs captured by Fischer (2007). Other studies have used different proxies for financial innovation for example, Michalopoulos *et al* (2009) measure financial innovation as growth rate of private credit/GDP while Arrau et al (1995) use a time trend and a stochastic trend to measure financial innovation in developing countries.

Kenya is no exception to growth in financial innovation particularly now with the new innovation, mobile money, it has become even more vital to capture the relationship between financial innovation and money demand.[8] One attempt by Sichei and Kamau (2012) to account for financial innovation in the money demand function for Kenya found that ATM proxy for financial innovation only had an impact on M1 but no evidence was found for the other measures of money. Similarly, Ndirangu and Nyamongo (2015) also found no effect of financial innovation on money demand using currency outside banks/time deposit ratio as a proxy for financial innovation. However, Weil et al (2012) who use Safaricom data to compute M-PESA velocity find that mobile money has a minor systematic effect on monetary policy in Kenya due to the fact that mobile money is sufficiently small. They however argue that this conclusion may change in the future as mobile money progresses to more than a payment platform hence increasing the number and values of mobile money. While the Kenyan studies have yielded some insight into the relationship between financial innovation and money demand, they have not fully investigated the appropriate measures of financial innovation given the recent mobile money developments. Some attempts to capture financial innovation were done by Misati(2010) who measure financial innovation as bank assets/GDP and M3/M1 for the case of Kenya while Sichei and Kamau (2012) use the number of ATMs and Ndirangu and Nyamongo (2015) use currency outside banks/time deposit ratio as a proxy for financial development. The short coming of these Kenyan studies is that they fail to proxy financial innovation using mobile money usage in the money demand specification and yet it is one of the latest innovations that has been growing rapidly in Kenya.

In terms of the relationship between financial innovation and money demand, several studies find a negative effect. For example Lippi and Secchi (2009) and Attanasio, et al (2002). However some studies indicate a positive relationship between money demand and financial innovation such as Hye (2009) who find that there is a positive relationship between financial innovation and money demand in both the short run and long run in Pakistan. Similarly, Mannah-Blankson

[8] Instability of money demand in Kenya could be due to recent financial innovations such as the mobile money platforms (Central Bank of Kenya (CBK), 2014b). According to the June 2014 monetary policy statement, it has become more difficult to predict money demand due to unstable money multiplier and falling velocity.

and Belyne (2004) for the case of Ghana find that financial innovation has a positive effect on money demand using M1. However, with the use of M2, their results indicate a negative relationship. Trying to justify their results, the authors claim that with improved innovation in the payments systems, money demand is likely to be higher for more liquid monetary aggregates compared to the less liquid ones.

One of the main determinants of money demand, the interest rate is often negatively related to the money demand. The debate is mainly centred on the type of interest rate used whether long term or short term interest rates. For example, Bahmani-Oskooee and Bohl (2000) use the long-term government bond yield for Germany and Hafer and Kutan (2003) 91-TBILL rate for the Philippines. In developing countries particularly where financial markets are not well developed, it becomes harder to use interest rates. Some studies use expected inflation since developing countries do not often have well developed financial markets or well regulated interest rates or simply lack of data on interest rates (see Tahir, 1995, Sriram, 1999 and Bahmani-Oskooee and Gelan, 2009). A good example is Suliman and Dafaalla (2011) who use inflation as the opportunity cost of holding money for Sudan. For the case of Kenya, most studies have so far used the Treasury bill rate to capture the return on alternative assets and the deposit rate to capture the return on domestic asset[9]. These include Kiptui (2014), and Sichei and Kamau (2012). Earlier studies such as Adam (1992) use the discount rate for Treasury bill. These studies all depict a negative relationship between the opportunity cost of holding money and money demand. Based on the theory of the Bahmol-Tobin Model, the interest rate elasticity of money demand and income elasticity of money demand are both approximately 0.5. However, based on the quantity theory of money, income elasticity of demand is approximately 1 (Serletis, 2007). Majority of the studies find that income and money demand are positively related but the size of the income elasticity tends to vary among the studies.

Another determinant of money demand that has raised debate over the years is the exchange rate. An extension of the money demand specification in some studies usually includes the exchange rate to capture openness. Exchange rates have two effects on money demand a substitution effect and a wealth effect. A substitution effect occurs when a depreciation of the exchange rate leads to a reduction in the demand for money. This occurs due to the substitutability of domestic currency for foreign currency or bonds because there are higher returns from holding foreign money (sriram, 2000). A wealth effect occurs when a depreciation of the exchange rate leads to an increase in money demand. In other words, a depreciated exchange rate would imply an increase in foreign assets by domestic residents and thus a rise in wealth (Dobson and Ramlogan, 2001). For the case of Kenya, few studies have captured openness, however Kiptui (2014) who attempted to include the exchange rate in the money demand specification found a negative relationship. This implies that there is evidence of the substitution effect for the case of Kenya.

[9] Sichei and Kamau (2012) argue that the coefficient on the deposit rate is positive since there is less incentive to hold alternative money with higher own rate of return.

When it comes to econometric modelling of the stability of money demand, several cointegration methods have been used over time[10]. Starting with the Engel and Granger (1987) cointegration method which uses a two-step procedure to determine a stationary linear combination. Adam (1992) and Augustina et al (2010) use this method to determine cointegration of money demand and its determinants for the case of Kenya and Nigeria respectively. While this method may have been prevalent in earlier studies, there are some limitations with this two-step procedure. It can transfer errors from the first step to the second step. In addition, the fact that one variable is required to be on the left hand side and others are regressors, the variable selected for normalization affects the outcome and any change in the ordering of the equation could lead to different results (Enders, 2010).

The Johansen and Juselius (1990) rank test method for cointegration tries to improve on some of the limitations from the Engel and Granger by allowing for multiple cointegrating vectors. (Enders, 2010). Studies that have used the Johansen and Juselius rank test include Hoffman *et al* (1995), Bahmani-Oskooee and Bohl (2000), Sichei and Kamau (2012), Hafer and Kutan(2003), Mannah-Blankson and Belyne(2004), and Suliman and Dafaalla (2011). However, its main short coming lies in mandatory testing for stationarity prior to the cointegration test. In other words, one needs to know the order of integration, of which various studies have mainly focused on I (1) variables. The autoregressive distributed Lag (ARDL) model by Pesaran et al (2001) has an advantage over the Johansen and Juselius rank test in that it is more flexible in terms of the order of intergration. Testing for stationarity is not necessary for the ARDL method since both I (0) and I (1) variables can be used rather than focus on say I (1) variables. The ARDL method to cointegration may not be satisfactory in determining stability, therefore, applying stability tests such as the (CUSUM)[11] and (CUSUMSQ)[12] tests after cointegration could help determine stability of the coefficients (Bahmani-Oskooee and Gelan (2009). This is partly due to the fact that estimated elasticities could remain unstable after co-integration of the variables. Studies that have employed the ARDL approach to cointegration for Kenya include Bahmani-Oskooee and Gelan (2009), Kiptui (2014) and Ndirangu and Nyamongo (2015). However, one of the limitations in these studies is failure to account for financial innovation particularly mobile money in the money demand specification except for Ndirangu and Nyamongo (2015) who use the currency outside banks/time deposit ratio as a proxy for financial development. The current study overcomes this limitation by incorporating mobile money in the money demand specification using two separate measures of mobile money, a dummy variable to capture the period of mobile money usage and the number of mobile money transfers. Prior to the empirical analysis, it is useful to know the main features of the Kenyan financial system. This is done in the next section.

[10] Some studies such as Stock and Watson(1993), Nagayasu (2012)and Hoffman *et al* (1995) have used the dynamic OLS(DOLS) to determine cointegration while others such as Nagayasu (2012) and Hamori(2008) have considered the Fully modified OLS(FMOLS) .

[11] cumulative sum of recursive residuals

[12] cumulative sum of squares recursive residuals

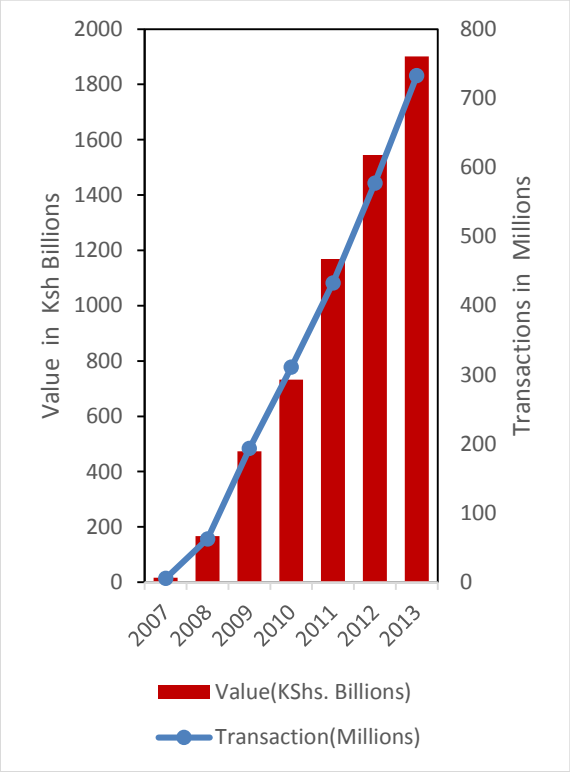
3. An Overview of the Kenyan financial system and financial innovations

In the last two decades, Kenya experienced several financial reforms to enhance the financial sector and boost economic growth. This could partly explain the development of various financial innovations and particularly, mobile money within the last decade. The deregulation in the 1990s and improved technology in the communications industry enhanced financial services. Kenya has transformed its payment system over time starting with the automation of the Nairobi clearing house in 1998, followed by the Electronic Funds Transfer (EFT) and the 2005 launch of the Kenya electronic payments and settlement system (KEPSS) which is a Real Gross Time Settlement (RTGS) system, improved management of liquidity in the banking system (Central Bank of Kenya, 2014a) and more recently mobile money adoption. Jack and Suri (2011) argue that mobile money provides enhanced financial services and was not necessarily designed to replace all payment systems. In addition to the reforms, Safaricom has maintained a good working relation with the Central Bank of Kenya that enabled it to develop the mobile money product that could suit the market and therefore facilitate the rapid growth in mobile money services (Mas and Radcliffe, 2011).

Since its introduction in 2007, mobile money has grown rapidly with 65 percent of Kenyan households using this product (Jack and Suri, 2011). In addition nearly 40 percent of the adult population had at least sent or received a text message through this system. Mobile money has continued to grow rapidly in Kenya. For example the total value of mobile money transactions rose from 16 billion Kenya shillings ($248 million) in 2007 to 1.9 trillion Kenya Shillings (US$22 billion) in 2013. Similarly, the total number of mobile money transactions rose from 5.47 million in 2007 to 733 million in 2013(see Figure1).

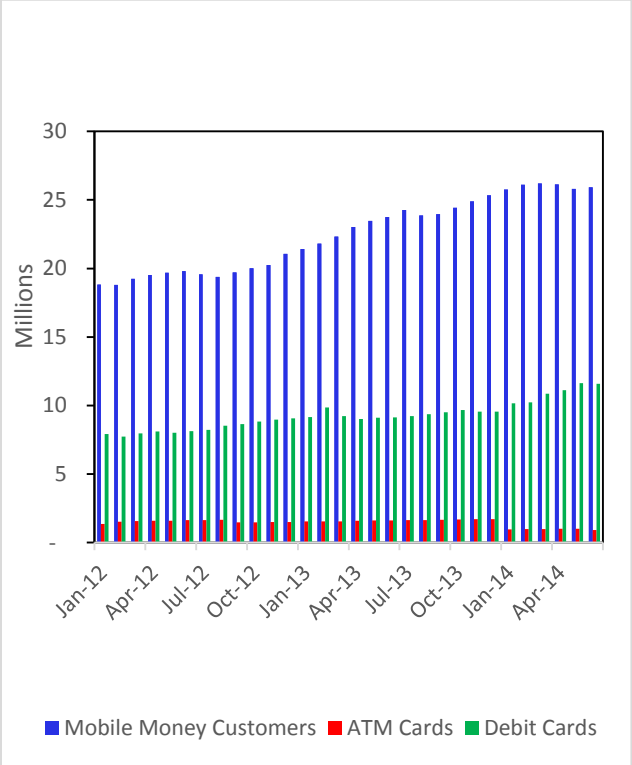
Within a short period of time, more Kenyans have had access to financial services through the use of this new technology mobile money. Indeed, the number of mobile money users currently surpass the number of ATMs and debit cards as indicated in figure 2. The number of registered customers in Kenya increased to 25.9 million by June 2014 compared to only 21,000 customers at the start of mobile money in March 2007. Since the population of Kenya stands at 45 million people (Central Intelligence Agency, 2014), it implies that the number of mobile money customers is higher than half the population of Kenya. More importantly, financial innovation is likely to have a larger effect on the financial system than other payment systems especially in terms of reaching out to the unbanked population that would otherwise not have been able to access financial services.

Figure 1: Trend in the Mobile Money values and number of transactions in Kenya (2007-2013)



Source: Central Bank of Kenya (2014a)

Figure 2: Comparison Between Mobile Money customers, ATMs and Debit Cards (2012-2014)



Source: Central Bank of Kenya (2014a)

Commercial banks are also increasingly working together with telecom companies to improve financial services despite the fact that a bank account is not needed for mobile money usage. For example, Safaricom's M-PESA account holders can easily transfer money between their M-PESA accounts and their bank accounts directly or through the use of an ATM (Jack and Suri 2011). Mobile money is continuously evolving. For example Kenya's largest telecom company, Safaricom, adopted M-shwari in 2012 in addition to M-PESA. M-shwari is a paperless bank account using the mobile phone. One can earn interest and get loans based on their credit history from M-PESA with no interest rate but with a one off loan facilitation fee of 7.5%. In addition, there is free movement of money from M-PESA to M-Shwari with no trip to the bank (Safaricom, 2014).This continuous growth in mobile money technology needs to be investigated to ensure monetary policy is not compromised by the fast evolving innovation.

4. Data, Model Specification and Estimation Method

4.1. Data

To investigate the relationship between financial innovation and money demand, quarterly data from a full sample (2000:q1-2014:q2) and a limited sample (2007:q1-2014:q2) are used. Money demand is captured using real monetary aggregates and the last month of each quarter is considered because money is a stock. To generate real money variables, monetary aggregates are divided by the consumer price index. Since financial innovation is more likely to have a bigger impact on liquid assets, real M1 (M1/CPI) is considered while real M2 (M2/CPI) and real M3 (M3/CPI) are used for robustness checks. M1 consists of currency in circulation, other deposits at CBK and demand deposits in banks, M2 comprises of M1, quasi-money in Banks and Non-Bank Financial Institutions (NBFIs) while M3 consists of M2 and foreign currency deposits according to the CBK (2014a) Depository Corporation Survey.

For CPI, exchange rate (NER), the 91-Treasury bill rate (TBILL) and deposit rate (DRATE), monthly averages were taken to generate quarterly data. Kenya recently (i.e. in 2014) rebased their GDP quarterly numbers to 2009 from 2001 base year and the new series are available from 2009 to 2014 (KNBS, 2014). Therefore, the pre-2009 GDP series were rebased and a chained index was formed in order to have a consistent data series from 2000-2014 based on 2009 weights.

The variable of interest in this study is financial innovation. Three proxies for financial innovation are considered for this full sample (2000:q1- 2014:q2) and these include M2/M1, M3/M1 and a dummy variable that takes on a value of 1 onwards for the period of mobile money and 0 otherwise (DUM). These types of measures are selected mainly following the literature and data availability. To further understand the impact of mobile money on money demand, a limited sample is also considered from 2007:q2 to 2014:q2. The rational for this is to capture the impact of mobile money on money demand using the number of mobile money transactions[13] (MOB) as a financial innovation proxy measure rather than exclusively relying on the dummy variable in the full sample. This could also act as a robustness check to ensure that the dummy variable is not capturing any other financial reform or shock other than mobile money. The monthly mobile money transactions were summed up to get quarterly mobile money transactions.

[13] This measure is only available for the limited sample since that is the period of mobile money innovation. The number of transactions were used to capture mobile money rather than the value of transactions because the value is directly part of M1. Therefore, the closest measure to capturing mobile money is the number of mobile money transactions because it is not directly part of M1.

Finally, interaction variables between mobile money and Tbill rate (MOBTB) and mobile money and GDP (MOBGDP) are also considered for the limited sample. This captures any indirect effect of mobile money on money demand. In other words, the effect of mobile money on interest rate and GDP and as a result money demand. Mobile money transactions, monetary aggregates, Treasury bill rate, and the nominal exchange rate were acquired from the Central Bank of Kenya (2014a) while the Real GDP and CPI were retrieved from the Kenya National Bureau of Statistics (2014). Details of the variable description with the variable name, abbreviation and variable source can be found in Appendix B, Table (I).

The evolution of all the variables used in this study is essential in deciding whether to add a trend and or constant for the stationarity tests. The summary statistics in Appendix B, Table (II) indicate that 58 observations were used for the full sample while 29 were considered for the limited sample. What's more, all the variables used in this study were logged in order to determine their elasticities except the 91-day TBILL rate (TBILL), the deposit rate (DRATE), M2/M1, M3/M1) and the mobile money dummy variable (DUM). In terms of the variables in levels, Appendix A , Figure (I) indicates some non-linearity in the variables as well as outliers for example, the depreciation of the exchange rate(NER) in 2008 which was probably due to the onset of the global financial crisis and the 2007/2008 Kenyan election crisis. In addition, there is a spike in the TBILL and DRATE during the period of 2012. The rise in interest rates corresponds to the high inflation rate during the same time period. Although M2/M1 and (M3/M1) broad measures of financial innovation appear to have been declining, they started to pick up in 2007 coinciding with the introduction of mobile money. Furthermore, mobile money has continued to trend upwards since 2007. The monetary aggregates, GDP and MOB also seem to depict an upward trend. The next section provides the model specification and estimation method.

4.2. Model Specification and Estimation Method

A traditional money demand equation is used following Hamori (2008) with inclusion of financial innovation as depicted below.

$$\ln(M)_t = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 TBILL_t + \beta_3 FINOV_t + \varepsilon_t \quad (1)$$

Initially, this equation is estimated over the full sample period with different proxies of financial innovation (FINOV). Specifically M2/M1, M3/M1 and a dummy variable (DUM) that takes on a value of 1 onwards during the period of mobile money and 0 otherwise for the full sample.

Following the recent Kenyan literature on money demand(see Kiptui(2014), Sichei and Kamau(2012) and Ndirangu and Nyamongo(2015)), we modify equation (1) to include the deposit rate (DRATE) and the nominal exchange rate (NER) as well depicted in equation 2.

$$\ln(M)_t = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 TBILL_t + \beta_3 FINOV_t + \beta_4 DRATE_t + \beta_5 \ln(NER)_t + \varepsilon_t \quad (2)$$

The coefficient of interest β_3 which represents the effect of financial innovation on money demand is expected to be negative according to most of the literature on financial innovation (see Arrau *et al* (1995), Lippi and Secchi (2009) and Attanasio *et al* (2002)) although a few studies such as Hye (2009) and Mannah-Blankson and Belyne (2004) do indicate a positive relationship. The coefficients on income β_1 and the Treasury bill rate β_2 are expected to be positive and negative respectively as money demand theory predicts. The coefficient on the deposit rate is expected to be positively related to money demand while the coefficient on the nominal exchange rate is expected to have either a positive or negative sign depending on whether wealth effects(Dobson and Ramlogan, 2001) or substitution effects (sriram 2000) are greater respectively.

Equation (1) is also estimated over the limited sample period 2007:q1 to 2014:q2 (period of mobile money usage) using the number of mobile money transactions (MOB) as a proxy for financial innovation. This replaces the mobile money dummy in the full sample as depicted in equation 3.

$$\ln(M)_t = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 TBILL_t + \beta_3 \ln(MOB)_t + \varepsilon_t \quad (3)$$

To capture the indirect relationship between mobile money and its determinants, we introduce interaction variables in equation 3 between mobile money and interest rate (MOBTB) and mobile money and GDP (MOBGDP) as shown in equation (4)

$$\ln(M)_t = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 TBILL_t + \beta_3 \ln(MOB)_t + \beta_4 MOBTB_t + \beta_5 MOBGDP_t + \varepsilon_t \quad (4)$$

For equation (4) the marginal effects are analysed. For example the marginal effect of money demand with respect to the treasury bill i.e. $\partial M^d / \partial TBILL = \beta_2 + \beta_4 * MOB$ where MOB is the mean of the log of mobile money transactions in the limited sample depicted in the summary statistics in Appendix B, Table (II).This specification allows for technology to not only affect money demand but interest rate elasticity and income elasticity of demand. The additional regressors i.e. the nominal exchange rate and the deposit rate that were included in the full sample were excluded in the limited sample due to loss in the degrees of freedom.

The Pesaran et al (2001) autoregressive distributed Lag (ARDL) bounds approach is used in this estimation procedure. For example, equation (1) can be re-written as an ARDL model depicted below in equation (5). The stability tests post cointegration such as the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares recursive residuals (CUSUMSQ) tests are also applied.

$$\Delta \ln(M)_t = a_0 + \sum_{i=1}^{k1} \alpha_i \Delta \ln(M)_{t-i} + \sum_{i=1}^{k2} \beta_i \Delta \ln(GDP)_{t-i} + \sum_{i=1}^{k3} \theta_i \Delta TBILL_{t-i} + \sum_{i=1}^{k4} \omega_i \Delta FINOV_{t-i} + \delta_1 \ln(M)_{t-1} + \delta_2 \ln(GDP)_{t-1} + \delta_3 TBILL_{t-1} + \delta_4 FINOV_{t-1} + \mu_t \quad (5)$$

The Δ represents first differences while the $\boldsymbol{\mu_t}$ is the error term. The bounds test used to determine the presence of cointegration among the variables is based on an F-statistic test (Pesaran *et al*, 2001). The null hypothesis of no cointegration regardless of whether the regressors are I(1) or I(0) against the alternative hypothesis is as follows:

$H_O: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$

$H_A: \delta_1 \neq 0,\ \delta_2 \neq 0, \delta_3 \neq 0, \delta_4 \neq 0$

Cointegration exists if the null hypothesis is rejected. In other words, if the F-statistic is greater than the upper bound I(1) critical value. However if the null is not rejected, i.e. F-statistic is smaller than the critical values of the lower bound I(0), then co-integration does not exist. What's more, if the F-test is between the I(0) and I(1) critical values then the result is inconclusive (Pesaran et al, 2001). If cointegration is established, then long run results and short run results can be generated. The short run results include the error correction term that shows how much disequilibrium is eliminated in each short run period. For cointegration to exist, the error correction term is expected to be negative and significant.

5. Results

Although stationarity tests are not necessary per se for the ARDL method, an Augmented Dickey Fuller (ADF) test and a Phillips-Perron test were carried out. This was done to ascertain the order of integration of the variables since Pesaran *et al* (2001) ARDL tests display only I(0) or I(1) critical values. These results in Appendix B Table (III) and Table (IV) provide the stationarity tests of the variables with and without a time trend respectively. These tests show that some of the variables are I(1) while others are I(0). In some cases, it is difficult to identify with full certainty if a variable is strictly I(0) or I(1) or mutually integrated because it depends on the type of test used and whether or not a trend was added. The only variables that are strictly I (1) include (M2/CPI), (M3/CPI), the nominal exchange rate and the financial innovation proxy (M3/M1). Mobile money transactions is the only strictly I(0) variable. The rest of the variables are either I(0) or I(1) therefore some other methods used for cointegration such as Johansen Juselius and Engle and Granger may not be easily implemented without certainty of the order of integration. But since the order of integration does not matter for the ARDL i.e. regardless of whether the variable is I(0) or I(1) , ARDL is the most appropriate method for this analysis. The ARDL bounds test to cointegration results based on the full dataset indicate that there is evidence of a long run relationship between money demand and its regressors as shown in Table 1.

The null hypothesis of no cointegration in models 1 and 2, is rejected with an F-statistic significant at a 5% level (see Appendix B, Table (V) for all the ARDL cointegration model results for the full sample)[14]. This is true for the models that include a mobile money dummy variable as a proxy for financial innovation. However, there is no evidence of a long run relationship when either financial innovation is excluded or when it is included and captured by the typical proxies (M2/M1 and M3/M1). [15] What's more, when the broad measures of the dependent variable (M2/CPI) and (M3/CPI) were used, again no evidence of cointegration was found. Hence, only Eq1 and Eq2 with (M1/CPI) as the dependent variable and a mobile money dummy as the regressor of interest were considered for the full dataset analysis along with the other explanatory variables.

Having established cointegration, the results based on the estimated long run models in table 1 are consistent with the money demand theory *a priory* predictions except for the mobile money dummy variable. The mobile money dummy variable is positive and significant. This implies that periods with mobile money had a positive impact on money demand compared to periods without mobile money. These results are different from the studies on Kenya such as Ndirangu and Nyamongo (2015) who find a negative relationship between financial innovation and money demand using currency outside banks/time deposit ratio as a proxy for financial development while Sichei and Kamau (2012) find a negative relationship using number of ATMs. However, other studies such as Hye (2009) for Pakistan and Mannah-Blankson and Belyne(2004) for Ghana find a positive relationship between financial innovation and money demand.

One possible explanation for the positive relationship between mobile money and money demand is due to the fact that mobile money is backed up in commercial banks as deposits. With financial innovation, individuals tend to move away from more liquid assets (M1) to less liquid assets (M2 or M3) and as a result the demand for money is reduced. However, mobile money is an alternative form of cash i.e. e-money and not necessarily an alternative form of asset other than cash. Therefore, as mobile money usage increases, so does the demand for M1. Individuals who would otherwise not have had access to financial services now do so with easier access through an alternative form of cash.

The coefficient on GDP is positive and significant in both models and slightly higher than unity while the TBILL rate coefficient is negative, small and significant as expected. The results of income elasticity greater than unity are similar to most literature like Darrat (1985), Adam

[14] Several models were tested for cointegration using the specific to general approach, starting with the simple specification with only GDP and TBILL as the explanatory variables. All measures of financial innovation discussed in the model specification and money demand measures along with other explanatory variables were also included. Eq 1 and 2 which contain mobile money as the proxy for financial innovation were the only specifications found to be cointegrated and thus further analysis was done.

[15] One explanation for the lack of evidence of cointegration of the standard proxies of financial innovation could be due to the fact that despite all the new financial innovations in place, none has had a bigger impact on Kenya more than mobile money.

(1992), Sichei and Kamau(2012), and Ndirangu and Nyamongo(2015) although some coefficients are significantly larger than unity in comparison to our results in Table 1.

Table 1: Full Sample Regression Results (2000Q1-2014Q2)

ARDL Bounds Test to Cointegration		
	F-statistic	Models
F((M1/CPI)|GDP, TBILL , DUM)[4]	4.95**	1 ARDL(1,2,0)
F((M1/CPI|GDP), TBILL , DUM, DRATE, NER,)[2]	4.35**	2 ARDL(1,2,0,0,0)
Long Run Coefficient Estimates Using ARDL	**Eq1**	**Eq2**
GDP	1.30 (0.09)***	1.44 (0.08)***
TBILL rate	-0.02 (0.00)***	-0.01 (0.00)***
Mobile Money Dummy	0.10(0.03)***	0.07(0.03)**
Deposit rate	----	-0.01(0.01)
Nominal Exchange rate	----	-0.23(0.10)**
Constant	-9.17(1.18)***	-9.91(0.94)***
Short Run Coefficient Estimates Using ARDL		
ΔGDP	0.53(0.13) ***	0.67(0.13)***
ΔGDP[-1]	-0.43 (0 .11) ***	-0.51(0.12)***
Δ TBILL rate	-0.01(0.00)***	-0.01(0.00)***
Mobile Money Dummy	0.06(0.02) **	0.05(0.02) **
Δ Deposit rate	----	-0.01(0.01)
Δ Nominal Exchange rate	----	-0.16(0.07)**
Constant	-5.25(1.03) ***	-6.96(1.34)***
ecm[-1]	-0.57(0.09) ***	-0.70(0.18)***
Diagnostic Tests		
F-stat [a]	9.94***	8.80***
R-squared	0.51	0.57
LM test of residual Serial Correlation: $\chi^2_{(4)}$	5.96	1.2
Ramsey's RESET: $\chi^2_{(1)}$	0 .92	0.05
Normality: $\chi^2_{(2)}$	1.40	1.35
Heteroskedasticity: $\chi^2_{(1)}$	0.37	0.52
CUSUM	unstable	Stable
CUSUMSQ	stable	Stable

*p-value<0.10, **p-value<0.05, ***p-value<0.01. (.) represent the standard errors. [.] represents the number of lags used based on the Schwarz Bayesian Criterion(SBC) for optimal lag length determination. [a] represents $F(5, 48)$ for Eq1 and $F(7, 48)$ for Eq2. ecm represents the error correction term.

The interest rate elasticity results are also similar to other empirical studies such as Mwega (1990) who estimates interest rate elasticity at -3.7 percent while Sichei and Kamau, and Ndirangu and Nyamongo (2015) find that the interest elasticity is negative and greater than 1. In terms of Eq2 results that incorporate additional regressors, the exchange rate is significant and negatively related to money demand implying that for the case of Kenya the substitution effect is more evident than the wealth effect. Put differently, a depreciation of the exchange rate is likely to lead to higher demand for foreign bonds which substitute domestic money for foreign bonds and thus a decline in demand for money. Although the results differ from Ndirangu and Nyamongo (2015) who find evidence for wealth effects, other studies such as Kiptui (2014) and

Bahmani-Oskooee and Gelan(2009) find strong evidence of the substitution effect for the case of Kenya. The Deposit rate is insignificant implying it does not have an effect on money demand. These results are not in line with other Kenyan studies such as Kiptui (2014), Sichei and Kamau (2012) and Ndirangu and Nyamongo (2015) who find a significant and positive relationship.

Mobile money is also positive and significant in the short run for both Eq1 and Eq2. This result is similar to Hafer and Kutan(2003) who used a dummy variable to capture financial innovation and established that financial innovation led to an increase of real M1 in the short run in the Philippines. All other short run results have similar signs as those in the long run in both models. But, most importantly, the error correction terms are significant and less than 1 justifying the existence of cointegration. The error correction term measures the speed of adjustment back to equilibrium and in Eq1, 57 percent of the disequilibrium is eliminated in each short run period while 70 percent is eliminated in Eq2. In other words, the speed of adjustment to equilibrium for Eq2 is faster and smoother because it only takes a little over one quarter to return to equilibrium while Eq1 takes approximately 2 quarters.

Both models seem to perform well according to the diagnostic tests. Ramsey test suggests that the models are well defined while there is no indication of heteroskedasticity or serial correlation. The F-test indicates that the models are statistically significant with all the variables jointly significant. To check for the stability of the coefficients for both models, the CUSUM and CUSUMSQ tests are employed as depicted in Appendix A Figures (II) and (III) for equations 1 and 22 respectively. The stability tests for Eq1 suggest the coefficients are unstable. The CUSUM test lies outside the 5% confidence bands indicating instability. However, the CUSUMSQ appears to be stable although it slightly touches the upper bound. This could imply that the instability was very short lived as the test is within the 5 percent bounds thereafter. For Eq2 however, all the coefficients appear to be stable with both CUSUM and CUSUMSQ tests lying within the 5% confidence bands. Although both models were found to be cointegrated, only Eq2 that includes additional explanatory variables appears to be stable.

The results from the full dataset indicate that there is no evidence of cointegration regardless of the measure of money used except when a particular measure of financial innovation is added to the model. In this case, a dummy variable capturing mobile money. These results are rather interesting in the sense that there is not only evidence of a long run equilibrium between real M1 and its determinants but that mobile money affects money demand positively. This finding is explored further in the limited sample by using a continuous variable measure of mobile money, i.e. mobile money transactions and by including interaction variables to investigate its effect on interest rate and income elasticity of demand as well.

The ARDL bounds test to cointegration results based on the limited dataset (2007:q1- 2014:q2) indicate that there is evidence of a long run relationship between money demand (real M1) and its regressors as shown in Table 2. The null hypothesis of no cointegration in equation 3 and 4, is rejected at a 5% level of significance. However, there is no evidence of cointegration when

financial innovation is captured by the typical proxies (M2/M1 and M3/M1) or when broad money variables (M2 or M3) are used to capture money demand. (See Appendix B, Table (VI) for all the ARDL cointegration model results for the limited sample)[16].

Table 2: Limited Sample Regression Results (2007q2 -2014q2)

ARDL Bounds Test to Cointegration		
	F-Statistic	Models
F(M1/CPI)|GDP, TBILL, MOB)[4]	51.19**	3. ARDL(1,2,0,0)
F((M1/CPI)|GDP, TBILL, MOB, MOB*TBILL, MOB*GDP)[1]	4.02**	4. ARDL(1,1,0,1,0,1)
Long Run Coefficient Estimates Using ARDL	**Eq3**	**Eq4**
GDP	1.26(0.31)***	-4.68(3.11)
TBILL rate	-0.02(0.00) ***	-0.41(0.17)**
Mobile Money Transactions	0.04(0.04)	-13.99(7.48)*
Mobile Money*TBILL	---	0.08(0.03)**
Mobile Money*GDP	---	1.00(0.55)*
Constant	-8.55(3.99)**	73.82(42.48)*
Short Run Coefficient Estimates Using ARDL		
ΔGDP	0.27(0.16)	0.91(0.75)
ΔGDP[-1]	-0.39(0.15) **	----
ΔTBILL rate	-0.01(0.00) ***	-0.13(0.04)***
ΔMobile Money Transactions	0.02(0.02)	2.51(2.12)
ΔMobile Money*TBILL	---	0.03(0.01)***
ΔMobile Money*GDP	---	-0.20(0.16)
Constant	-3.86(2.16)*	23.84(10.46)**
ecm[-1]	-0.45(0.11)***	-0.32(0.10)***
Diagnostic Tests		
F-stat [a]	7.98***	7.98***
R-squared	0.69	0.73
LM test of residual Serial Correlation: $\chi^2_{(4)}$	8.78*	7.56
Ramsey's RESET: $\chi^2_{(1)}$	0.10	5.59**
Normality: $\chi^2_{(2)}$	1.56	0.20
Heteroskedasticity: $\chi^2_{(1)}$	0.39	0.18
CUSUM	stable	stable
CUSUMSQ	stable	stable

*p-value<0.10, **p-value<0.05, ***p-value<0.01. (.) represent the standard errors. [.] represents the number of lags used based on the Schwarz Bayesian Criterion(SBC) for optimal lag length determination. [a] represents $F(5, 19)$ for Eq3 $F(6, 21)$ for Eq4. ecm represents the error correction term.

In contrast to the full dataset results, the mobile money coefficient in Eq3, (see Table 2) is insignificant although it has the same positive sign as the results in Eq1, Table 1. However with addition of the interaction variables in Eq4, it becomes negative and significant. The interest rates coefficients are negative and significant as expected in both models. GDP is only significant in Eq 3, with addition of interaction variables in equation 4, it becomes insignificant. These direct effects are not as important per se because we have interaction variables therefore, marginal effects would be more informative in comprehending the effect of mobile money on money demand and interest rate elasticity for Eq 4.

[16] Similar to the full sample, several models were tested for cointegration using the specific to general approach, starting with the simple specification with only GDP and TBILL as the explanatory variables. All measures of financial innovation discussed in the model specification and money demand measures along with other interaction variables were also included. Equation 3 and 4 (table2) were found to be cointegrated and thus further analysis was done. Results for the other models that were found to be cointegrated were not presented here to save space.

Since GDP is insignificant, only the marginal effects of mobile money and interest rate elasticity are analysed in Eq4, table2. The marginal effect of money demand with respect to the TBILL rate is approximately -0.086. In other words the results in Eq4 indicate that $\partial M^d/\partial TBILL$ = -.4095 + (0.0821*3.938) = -0.086 derived from $\partial M^d/\partial TBILL = \beta_2+\beta_4 * MOB$. This suggests that the marginal effect with respect to the TBILL rate is not only negative as expected but also much smaller than the direct effect of interest rate on money demand -0.41. Further investigation also shows this decrease in interest rate elasticity of demand as a result of financial innovation to be true. For example, if the mean of mobile money was to increase from say 3.94 to 4.5, the marginal effect of money demand with respect to the Treasury bill rate would reduce to -0.040.

This is an indirect effect of mobile money on money demand through the interest rate elasticity of demand. The results of a decline in interest rate elasticity of demand due to financial innovation are in line with studies such as Lippi and Secchi(2001) and Hafer and Hein(1984) who argue that financial innovation has led to a decline in interest rate elasticity of demand. However, these findings differ from Gurley and Shaw(1960) who argued that financial innovation leads to an increase in interest rate elasticity of demand. In terms of the marginal effect of money demand with respect to mobile money ($\partial M^d/\partial MMONEY$) for Eq4, the coefficient is 0.29. These results are similar to the positive coefficient on mobile money in Table I with the full sample.

Although inclusion of financial innovation i.e. mobile money yields insignificant results in both the long run and short run in Eq3, the marginal effect in Eq4 depicts a positive relationship between mobile money and money demand. More importantly, mobile money also affects money demand indirectly through the reduction of the interest rate elasticity. To further justify the presence of cointegration, the error correction terms in both models are significant and negative with Eq3 depicting a faster speed of adjustment to equilibrium of 45 percent compared to 32 percent in Eq4.

In terms of the diagnostic tests, no evidence of serial correlation or heteroskedasticity was found at a 5% level of confidence. Although there is some serial correlation in Eq3, it is only at a 10% level. The models seem to perform well with the F-test indicating that the models are statistically significant with all the variables jointly significant. The R-square is relatively higher for Eq4 probably due to interaction variables compared to Eq3. When it comes to the stability of the coefficients, the CUSUM and CUSUMSQ tests indicate that they are within the 5% level for both models as depicted in Figures (IV) and (V) in Appendix A. This suggests that the coefficients of both models are relatively stable.

6. Conclusions

The findings of the investigation into the relationship between financial innovation and money demand suggest that mobile money not only has a positive effect on money demand but also

leads to a decrease in the interest rate elasticity of demand. A possible explanation for the positive relationship could be due to the fact that mobile money is backed up in commercial banks as deposits and because mobile money is an alternative form of cash i.e. e-money and not necessarily an alternative form of asset other than cash. There is an incentive to hold onto this new alternative form of cash rather than other assets and as a result demand for money increases.

The results also suggest that there is a long run relationship between money demand and its determinants with inclusion of mobile money. This is only true with the use of real M1 as a measure for money demand since no evidence of a long run relationship was found using broad money or the standard proxies of financial innovation. Perhaps, lack of a long run relationship with addition of other measures of financial innovation could imply that mobile money seems to have affected the Kenyan financial sector more than the standard measures of financial innovation.

In terms of policy implications, although there is evidence of stability of money demand with inclusion of financial innovation, it is only evident for narrow money i.e. M1 and not broad money (M2 or M3). Moreover, CBK's operational target is net domestic assets (NDA) and monitors M3. With the growing trend in mobile money usage and improvements to this technology, it may continue to affect the stability of money demand. The stability of money demand is essential for monetary policy, however with growing financial innovations, targeting monetary aggregates becomes much more difficult for the Central Bank. Especially because it is difficult to predict how fast mobile money is likely to grow and influence monetary aggregate targeting.

One major shortcoming of this analysis was the limited data especially in terms of the proxies for broader measures of financial innovation available. Longer time series usually generate better precision of the long run results.

Although mobile money technology could complicate monetary policy, it is expected to improve efficiency in the banking sector through the reduction in transaction costs and improve people's livelihoods. For further research, it would be interesting to use micro level data to investigate whether use of mobile money leads to improved livelihoods as a result of a reduction in transaction costs.

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Appendix A: Figures

Figure (I): Variables in Levels

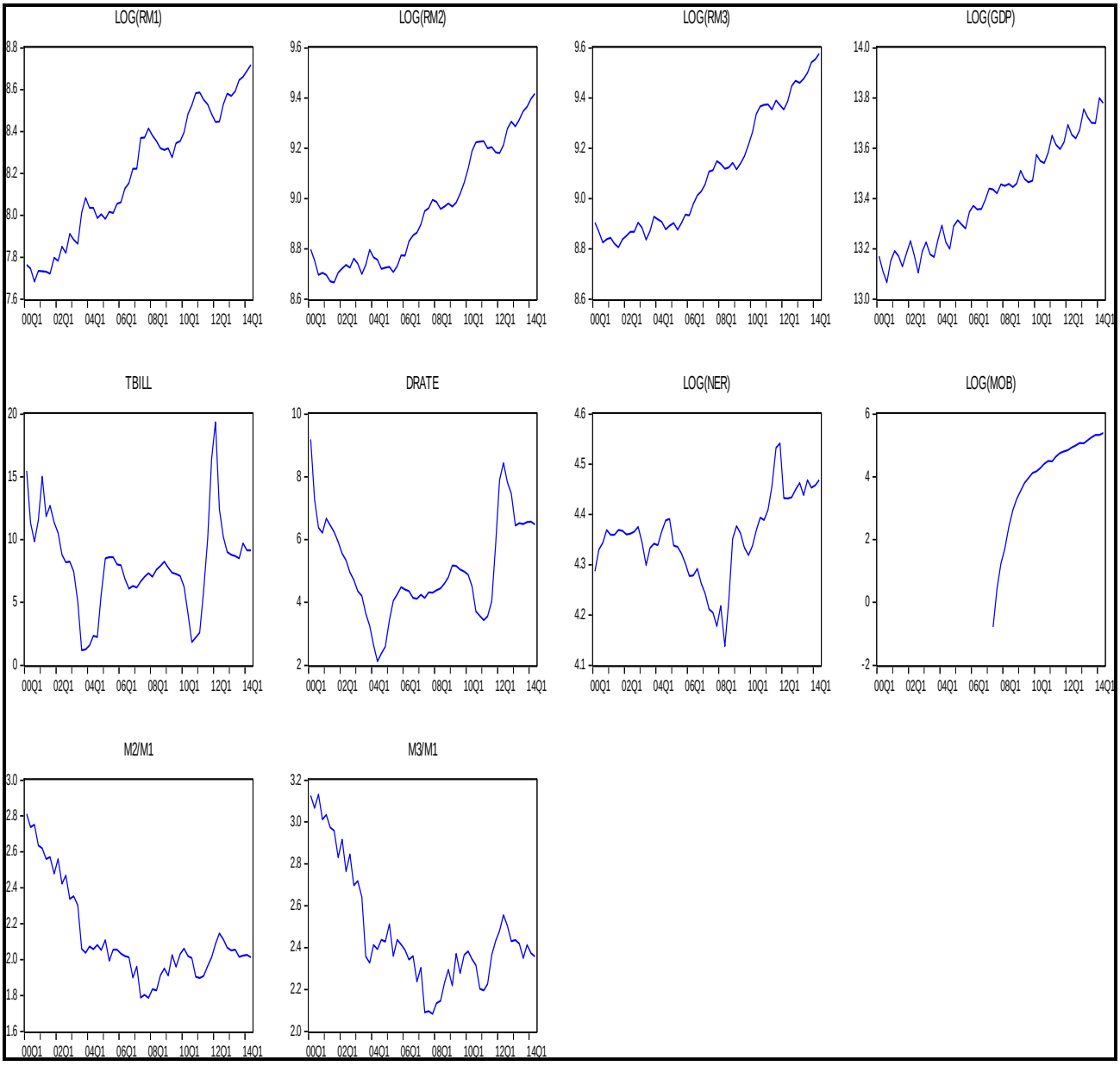


Figure (II): CUSUM and CUSUMSQ EqI- Full Sample

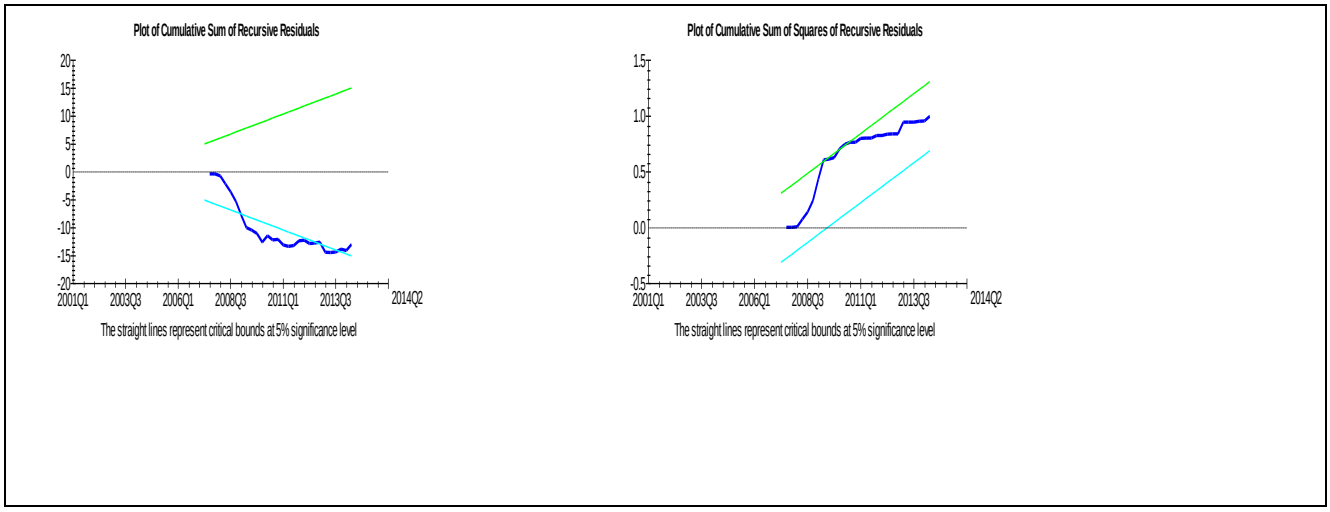


Figure (III): CUSUM and CUSUMSQ Eq2- Full Sample

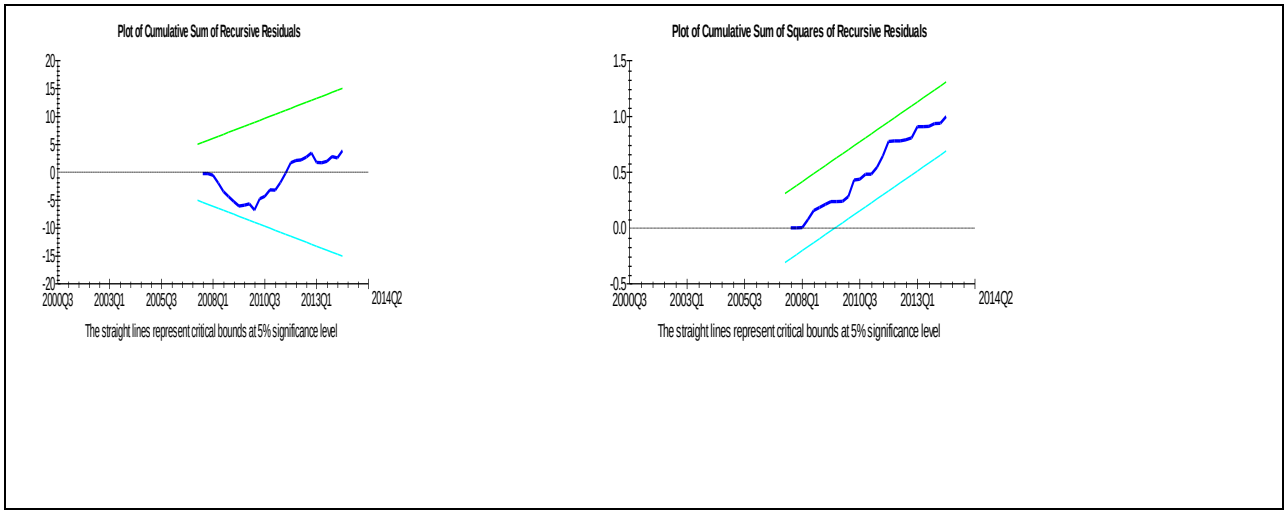


Figure (IV): CUSUM and CUSUMSQ Eq3- Limited Sample

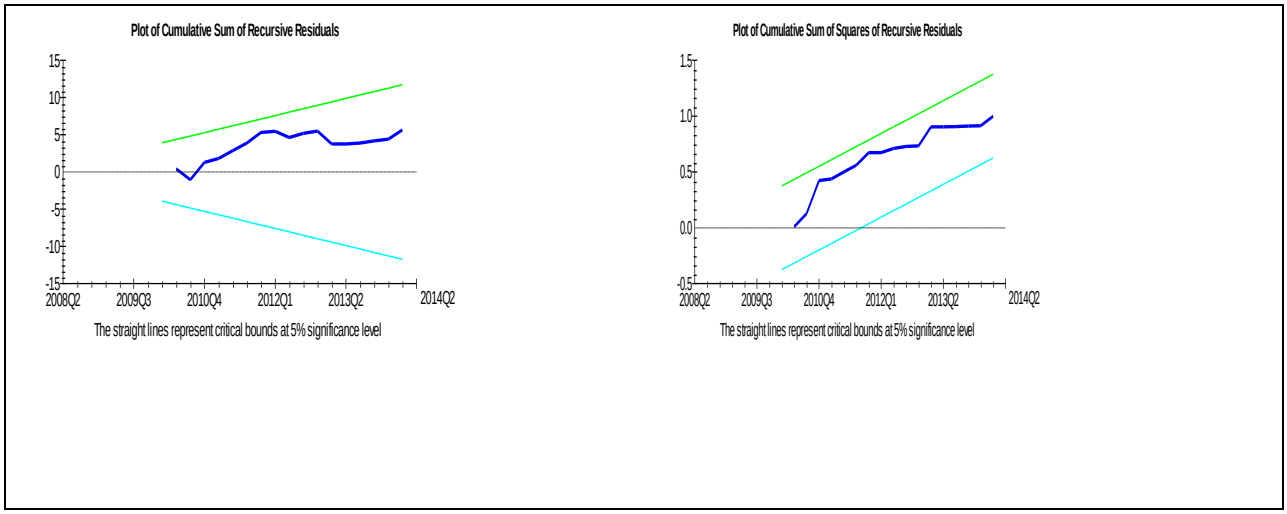
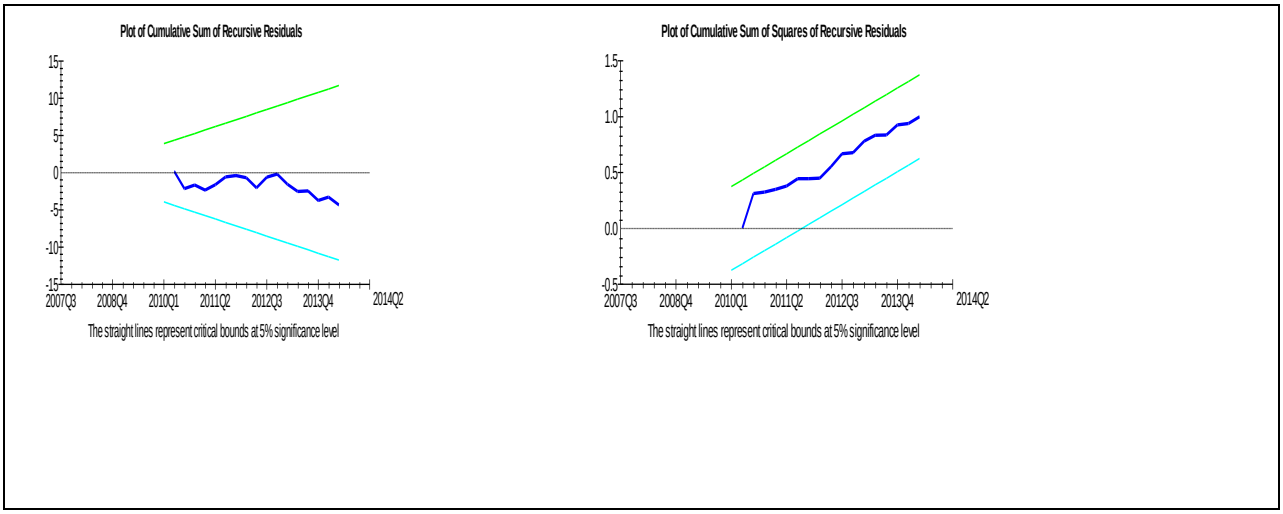


Figure (V): CUSUM and CUSUMSQ Eq4- Limited Sample



Appendix B: Tables

Table (I): Variable Description

VARIABLE NAME	DESCRIPTION	ABBREVIATION	SOURCE
Money demand(Real M1, M2,M3)	Monetary aggregates in Ksh. Millions divided by CPI(M/CPI)	RM1, RM2, RM3	CBK, 2014a and KNBS,2014a for CPI
Real Gross Domestic Product	GDP at constant 2009 prices- Kshs. Millions	GDP	KNBS, 2014a
Treasury Bill Rate	91-Tbill rate	TBILL	CBK, 2014a
Deposit Rate	Deposit rate	DRATE	CBK, 2014a
Nominal Exchange rate	US dollar/Kenya Shilling Bilateral nominal exchange rate	NER	CBK, 2014a
Dummy variable for mobile money	1 for mobile money 0 otherwise	DUM	
Mobile money Transactions	number of mobile money transactions per quarter-Millions	MOB	CBK, 2014a
Financial innovation(M2/M1)	M2/M1	M2/M1	CBK, 2014a
Financial innovation(M3/M1)	M3/M1	M3/M1	CBK, 2014a
MOB*GDP	Interaction variable between mobile money transactions and GDP	MOBGDP	
MOB*TBILL	Interaction variable between mobile money transactions and interest rate	MOBTB	

Table (II): Summary Statistics for Logged Variables

Summary Statistics-Full Sample(2000:q1 - 2014:q2)				
	Mean	Max	Min	Observations
Log(M1/CPI)	8.21	8.72	7.68	58
Log(M2/CPI)	8.95	9.42	8.67	58
Log(M3/CPI)	9.11	9.58	8.81	58
Log(GDP)	13.41	13.80	13.07	58
TBILL Rate	8.01	19.35	1.18	58
Deposit Rate	5.06	9.19	2.13	58
Log(Nominal Exchange rate)	4.35	4.54	4.14	58
Mobile money Dummy	0.50	1	0	58
Financial innovation(M2/M1)	2.13	2.81	1.79	58
Financial innovation(M3/M1)	2.48	3.13	2.08	58
Summary Statistics-Limited Sample(2007:q2 - 2014 q2)				
	Mean	Max	Min	Observations
Log(M1/CPI)	8.48	8.72	8.28	29
Log(M2/CPI)	9.16	9.42	8.95	29
Log(M3/CPI)	9.32	9.58	9.11	29
Log(GDP)	13.58	13.80	13.42	29
TBILL Rate	8.13	19.35	1.82	29
DRATE	5.37	8.45	3.44	29
Log(Nominal Exchange rate)	4.37	4.54	4.14	29
Log(Mobile money Transactions)	3.94	5.40	-0.79	29
Financial innovation(M2/M1)	1.97	2.15	1.79	29
Financial innovation(M3/M1)	2.31	2.56	2.08	29

Table (III): Stationarity Tests (with Trend)

	ADF Test		Phillips-Perron Test		
Variables	levels	1st Difference	levels	1st Difference	Result
Log(M1/CPI)	-2.87	-7.50***	-3.20*	-7.50***	I(1) or I(0)
Log(M2/CPI)	-2.7	-5.77***	-3.00	-5.77***	I(1)
Log(M3/CPI)	-2.92	-6.31***	-2.92	-6.24***	I(1)
Log(GDP)	-3.39*	-3.96**	-5.91***	-14.80***	I(0)
TBILL Rate	-3.23*	-5.25***	-2.89	-5.09***	I(0) or I(1)
Deposit Rate	-2.5	-4.40***	-3.13	-4.55***	I(1)
Log(Nominal Exchange rate)	-1.74	-6.48***	-1.83	-6.57***	I(1)
Log(Mobile money Transactions)	-7.18***	-5.72***	-49.15***	-5.19***	I(0)
Financial innovation(M2/M1)	-1.97	-10.38***	-1.97	-10.10***	I(1)
Financial innovation(M3/M1)	-1.88	-10.17***	-1.88	-9.92***	I(1)

*p-value<0.10, **p-value<0.05, ***p-value<0.01

Table (IV): Stationarity Tests (without Trend)

	ADF Test		Phillips-Perron Test		
Variables	levels	1st Difference	levels	1st Difference	Result
Log(M1/CPI)	-0.25	-7.56***	-0.24	-7.57***	I(1)
Log(M2/CPI)	1.45	-5.52***	1.12	-5.50***	I(1)
Log(M3/CPI)	1.45	-6.04***	1.45	-6.03***	I(1)
Log(GDP)	0.72	-3.84***	0.81	-13.77***	I(1)
TBILL Rate	-3.26**	-5.31***	-2.70*	-5.17***	I(0)
Deposit Rate	-2.37	-4.56***	-2.87**	-4.66***	I(0) or I(1)
Log(Nominal Exchange rate)	-1.47	-6.51***	-1.57	-6.53***	I(1)
Log(Mobile money Transactions)	-16.44***	-7.40***	-14.66***	-7.42***	I(0)
Financial innovation(M2/M1)	-2.86*	-9.60***	-2.86*	-9.32***	I(0)
Financial innovation(M3/M1)	-2.42	-9.76***	-2.42	-9.48***	I(1)

*p-value<0.10, **p-value<0.05, ***p-value<0.01

Table (V): ARDL Bounds Test for Cointegration-Full Sample (All Models)

		10%		5%		
Model	F-Statistic	I(0)	I(1)	I(0)	I(1)	Cointegration
F((M1/CPI)| GDP, TBILL rate)[4]	2.28	3.17	4.14	3.79	4.85	no
F((M2/CPI)| GDP, TBILL rate)[4]	2.35	3.17	4.14	3.79	4.85	no
F((M3/CPI)| GDP, TBILL rate)[4]	2.35	3.17	4.14	3.79	4.85	no
F((M1/CPI)|GDP, TBILL rate, M2/M1)[4]	2.08	2.72	3.77	3.23	4.35	no
F((M2/CPI)|GDP, TBILL rate, M2/M1)[4]	1.66	2.72	3.77	3.23	4.35	no
F((M3/CPI)|GDP, TBILL rate, M2/M1)[4]	2.15	2.72	3.77	3.23	4.35	no
F((M1/CPI)|GDP, TBILL rate, M3/M1)[4]	2.27	2.72	3.77	3.23	4.35	no
F((M2/CPI)|GDP, TBILL rate, M3/M1)[4]	1.72	2.72	3.77	3.23	4.35	no
F((M3/CPI)|GDP, TBILL rate, M3/M1)[4]	2.21	2.72	3.77	3.23	4.35	no
F((M1/CPI)|GDP, TBILL rate, Mobile Money Dummy)[4]	4.95	3.17	4.14	3.79	4.85	yes
F((M2/CPI)|GDP, TBILL rate, Mobile Money Dummy)[4]	2.04	3.17	4.14	3.79	4.85	no
F((M3/CPI)|GDP, TBILL rate, Mobile Money Dummy)[4]	1.87	3.17	4.14	3.79	4.85	no
F((M1/CPI)|GDP, TBILL rate, Mobile Money Dummy, Deposit rate, Nominal Exchange rate)[2]	4.35	2.45	3.52	2.86	4.01	yes
F((M2/CPI)|GDP, TBILL rate, Mobile Money Dummy, Deposit rate, Nominal Exchange rate)[2]	1.45	2.45	3.52	2.86	4.01	no
F((M3/CPI)|GDP, TBILL rate, Mobile Money Dummy, Deposit rate, Nominal Exchange rate)[2]	2.05	2.45	3.52	2.86	4.01	no

Bounds test for unrestricted intercept and no trend found on pg 300 Pesaran et al (2001) [.] represents the number of lags used based on the Schwarz Bayesian Criterion (SBC) for optimal lag length determination. Cointegration exists if the null hypothesis is rejected. In other words, if the F-statistic is greater than the upper bound I(1) critical value. However if the null is not rejected, i.e. F-statistic is smaller than the critical values of the lower bound I(0), then co-integration does not exist. However, if the F-test is between the I(0) and I(1) critical values then the result is inconclusive (Pesaran et al, 2001)

Table (VI): ARDL Bounds Test for Cointegration-Limited Sample (All Models)

Model	F-Statistic	10%		5%		Cointegration
		I(0)	I(1)	I(0)	I(1)	
F((M1/CPI)| GDP, TBILL rate)[4]	9.23	3.17	4.14	3.79	4.85	Yes
F((M2/CPI)| GDP, TBILL rate)[4]	0.62	3.17	4.14	3.79	4.85	no
F((M3/CPI)| GDP, TBILL rate)[4]	1.05	3.17	4.14	3.79	4.85	no
F((M1/CPI)|GDP, TBILL rate, M2/M1)[4]	2.81	2.72	3.77	3.23	4.35	inconclusive
F((M2/CPI)|GDP, TBILL rate, M2/M1)[4]	1.47	2.72	3.77	3.23	4.35	no
F((M3/CPI)|GDP, TBILL rate, M2/M1)[4]	1.6	2.72	3.77	3.23	4.35	no
F((M1/CPI)|GDP, TBILL rate, M3/M1)[4]	3.95	2.72	3.77	3.23	4.35	yes (but insignificant ecm)
F((M2/CPI)|GDP, TBILL rate, M3/M1)[4]	1.25	2.72	3.77	3.23	4.35	no
F((M3/CPI)|GDP, TBILL rate, M3/M1)[4]	1.13	2.72	3.77	3.23	4.35	no
F((M1/CPI)|GDP, TBILL rate, Mobile Money transactions)[4]	51.19	2.72	3.77	3.23	4.35	yes
F((M2/CPI)|GDP, TBILL rate, Mobile Money Transactions)[4]	1.61	2.72	3.77	3.23	4.35	no
F((M3/CPI)|GDP, TBILL rate, Mobile Money Transactions)[4]	6.25	2.72	3.77	3.23	4.35	yes(but explosive error term>1)
F((M1/CPI)|GDP, TBILL rate, Mobile Money transactions, Mobile Money*TBILL, Mobile Money*GDP)[1]	4.02	2.26	3.35	2.62	3.79	yes
F((M2/CPI)|GDP, TBILL rate, Mobile Money transactions, Mobile Money*TBILL, Mobile Money*GDP)[1]	4.46	2.26	3.35	2.62	3.79	yes
F((M3/CPI)|GDP, TBILL rate, Mobile Money transactions, Mobile Money*TBILL, Mobile Money*GDP)[1]	3.12	2.26	3.35	2.62	3.79	inconclusive

Bounds test for unrestricted intercept and no trend found on pg 300 Pesaran et al (2001) [.] represents the number of lags used based on the Schwarz Bayesian Criterion (SBC) for optimal lag length determination. Cointegration exists if the null hypothesis is rejected. In other words, if the F-statistic is greater than the upper bound I(1) critical value. However if the null is not rejected, i.e. F-statistic is smaller than the critical values of the lower bound I(0), then co-integration does not exist. However, if the F-test is between the I(0) and I(1) critical values then the result is inconclusive (Pesaran et al, 2001)