Empirical Analysis of Real Money Demand Function in Kenya: 2000 – 2016

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DECLARATION

This academic research paper is my original work and has not been presented for any academic award in any other university.

Signature_____ Date_____

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This academic research paper has been submitted for examination with my approval as university supervisor.

Signature_____ Date_____

Dr. Owen Nyang'oro

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May God Bless you all.

Dedication

This research paper is dedicated to my parents, Simion Kombo and the late dear mum, Marcella Gesare, whose passion for my success was pivotal; my siblings Dolyvine, Duke, and Naomi; and Yvonne for their prayers, support and inspiration to achieve this milestone.

Thus far the Lord has brought us.

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Abbreviations and Acronyms

ADF: Augmented Dickey Fuller

ARCH: Autoregressive Conditional Heteroscedasticity

ATM: Automated Teller Machines

CBK: Central Bank of Kenya

CBR: Central Bank Rate

CDS: Central Depository System

ECM: Error Correction Model

FEVD: Forecast Error Variance Decomposition

GDP: Gross Domestic Product

KNBS: Kenya National Bureau of Statistics

NSE: Nairobi Securities Exchange

OECD: Organisation for Economic Co-operation and Development

USD: United States Dollar

Definition of Operational Terms

Demand for money refers to the amount of money that an economic agent holds on average over a period of time with the intention of completing various financial transactions.

Gross Domestic Product (GDP) is the monetary value of all the final goods and services produced within a country's borders within a specific period of time.

Monetary policy refers to the decisions and actions that a monetary authority (the Central Bank) makes with the aim of ensuring that supply of money in an economy is consistent with the government's economic growth and price goals. Thus the key objective of monetary policy is to sustain price stability in an economy by maintaining low and stable levels of inflation.

Real money refers to the amount of money measured in constant currency. This is equivalent to nominal money divided by the prevailing price levels in a country and they therefore measure what the money can buy.

Abstract

Demand for money is one of the fundamental considerations in effective formulation and performance of monetary policy. Central Bank of Kenya highly dependent upon the stability of the demand for money function to achieve efficient policy formulation. In the past decade, Kenya has experienced rapid financial innovations in payment systems which provide alternatives to cash money. Certainly, these innovations affect monetary policy transmission channels and financial sector players and hence the effectiveness of monetary policy.

The main objective of this study is to empirically establish the real money demand function in Kenya and analyse its stability. Empirical analysis has been carried out using quarterly time series data from 2000q1 to 2016q4 based on Engle-Granger Two-Step approach to cointegration analysis. The empirical analysis establishes cointegration and shows that there are structural breaks in Kenya's real money demand function while CUSUM and CUSUMSQ stability tests, show that real money demand function is not stable. The impulse response analysis shows significant changes in real money demand as a result of shocks in the explanatory variables. We find that interest rate are not significant in the short-run.

We conclude that the instabilities in money demand function in Kenya, and lack of significance in interest rates could be attributed to financial developments and innovations in Kenya. We recommend use of alternative monetary policy frameworks that are not based on money supply aggregates to achieve monetary policy goals. Specifically, we recommend the use of the nominal GDP targeting, alone or in combination with others, to offer effective conduct of monetary policy in Kenya.

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

An efficient financial system is key in expanding an economy's long run economic prospects and plays the following roles. First, it provides investment information; second, it enables mobilisation and pooling of savings and allocation of capital; third, it ensures monitoring of investments and corporate governance on debt capital; fourth, it facilitates the trading, diversification and management of risk; and finally, it eases exchange of goods and services.

Kenya's financial system players include the Central Bank of Kenya (CBK), which acts as the principal and system regulator; commercial banks; and non-bank financial institutions. CBK is majorly responsible for formulation and implementation of monetary policy, and ensuring adequate liquidity, solvency and an efficient market-based financial system. In addition, it is involved in supporting economic growth and ensuring currency stability.

Over the past two decades, the financial system in Kenya has undergone a number of major and rapid financial innovations. These innovations have been attributed to technological progress and financial sector competition and the need to reduce risks and lower transaction costs. This progress has significantly changed the functioning of the financial system by providing new money transfer services, and other alternatives to cash which could have possible implications on monetary policy formulation.

CBK's monetary policy framework consists of measures of money aggregates that are based on an inflation target of 5% with an aim of ensuring that there is price stability. This is signalled by movements in the Central Bank Rate (CBR), which is the base for monetary policy formulation. The CBR is used to coordinate changes in short-term interest rates. Its movement, in terms of its direction and its magnitude, mirror the changes in the country's monetary policy stance. Table 1.1 shows average annual CBR operational in Kenya.

Table 1.1: Average Central Bank Rates in Kenya (2006-2016)

Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
CBR (%)	9.93	9.23	8.84	7.96	6.42	8.40	15.75	8.83	8.50	10.27	10.68

Source: Central Bank of Kenya

The Central Bank of Kenya, similar to other Central Banks worldwide, operates and uses various instruments and targets to formulate and implement policies to achieve inflation, output and financial stability goals. These instruments indirectly work through various but specific channels of monetary policy transmission to bring about effects to the economy. The Central Bank of Kenya uses the interest rates and reserve money as instruments of monetary policy which target monetary aggregates such as broad money supply, expected inflation, credit, and exchange rates.

The channels of monetary policy transmission refer to the mechanisms and/or process through which changes brought about by monetary policy decisions; which influence nominal stock of money and nominal short-term interest rates, affect real economic aggregates. Mishkin (1996) has identified a set of six channels which include commercial interest rates, asset prices, exchange rates, bank lending rates, firm balance sheets, and expectations.

Expansionary monetary policy reduces the real interest rate, i.e. decreases in cost of capital, thus stimulating investment and ultimately increases aggregate demand and output. Expectations of variations in nominal exchange rate usually determine differences in the local and foreign levels of interest rates. As a result, variabilities in the exchange rate will have an effect on the comparative price of domestic goods vis-à-vis the price of foreign goods, consequently affecting net exports and domestic output.

The bank-lending mechanism together with the balance-sheet mechanism forms the credit channels. In this regard, a monetary contraction gives rise to a decline in bank reserves and deposits, and as a consequence reduces the available bank loans. This ultimately leads to a higher cost of external debt finance therefore affecting the net worth of businesses. Thus, a constrained monetary policy reduces the level of lending/credit, reduces investment, and ultimately lowers the level of an economy's output.

The asset price channel is founded upon a major assumption that a monetary contraction will cause an increase in the discount rates and thus decrease the asset prices. This will discourage investments in the real estate which will adversely affect the real economy. The expectations channel is important to the operation of all the other channels. This is because expectations of future variations in monetary policy rate, will instantly lead to an effect on the interest rates, prices and money wage-setting behaviour, and future actual inflation. As a result, this can affect the future path of real economic activities.

Financial innovation basically refers to introduction of new instruments and services into the financial system. It also refers to alterations in both the depth and structure of financial markets, changes in the objectives and roles of financial institutions, changes in the ways and means through which financial products and services are delivered, and the advancement of new processes, financial instruments, institutions, financial practices and markets. Resina (2004), Ignazio (2007) and Misati *et al.* (2010) confirm and argue that financial developments increases the number of financial market institutions and players.

Since the late 1990s, there has been a tremendous growth in financial innovations in Kenya, especially in the payment systems. This involves the introduction of Kenya Electronic Payment and Settlement System (KEPSS). There has also been a significant rise in the number of Automated Teller Machines (ATMs), a rise in the usage of credit and debit cards, and a growing need for point of sale machines. For instance, in 2013, the number of operational cards grew by 7.5%; to 11.5 million from 10.7 million in the previous year. Table 1.2 shows a summary of payment cards usage in Kenya in the last six years of the study.

Table 1.2: Payment Cards Usage (2011 – 2016)

YEAR	Total No. of Cards (Millions)	No. of ATMs	No. of POS Terminals	No. of Transactions (Millions)	Transacted Value (Millions)
2010	7.7	2,091	18,179	92.5	517,324
2011	10.1	2,205	16,604	122.4	577,852
2012	10.7	2,381	18,478	224.6	1,009,758
2013	11.5	2,487	21,089	338.1	1,532,778
2014	13.9	2,613	17,511	265.0	1,265,261
2015	13.2	2,718	22,230	229.9	1,348,215
2016	14.8	2,656	30,133	216.2	1,396,522

Source: Central Bank of Kenya

Other financial developments include the introduction of Central Depository System (CDS) accounts, automation systems such in the Nairobi Securities Exchange (NSE) market in 2009, and many other Information and communication technology (ICT) sector advancements that have led to increased usage of electronic money and reliance of e-money balances as opposed to cash money. As a result, this incessant growth in access and reliance on alternatives to holding money has the potential of reducing demand for cash money or eventually disrupting the nature of demand for money.

Kenya's main disruptive financial innovation occurred in March 2007 when M-Pesa, a mobile money transfer services was introduced by Safaricom. This was followed by other telecommunications service providers in providing similar but differentiated services. Since then the services have rapidly grown placing Kenya at the top of financial revolution and ultimately expanding the level of financial inclusion in the country. Table 1.3 shows summary statistics of the mobile money service performance as at the end of December of each respective year.

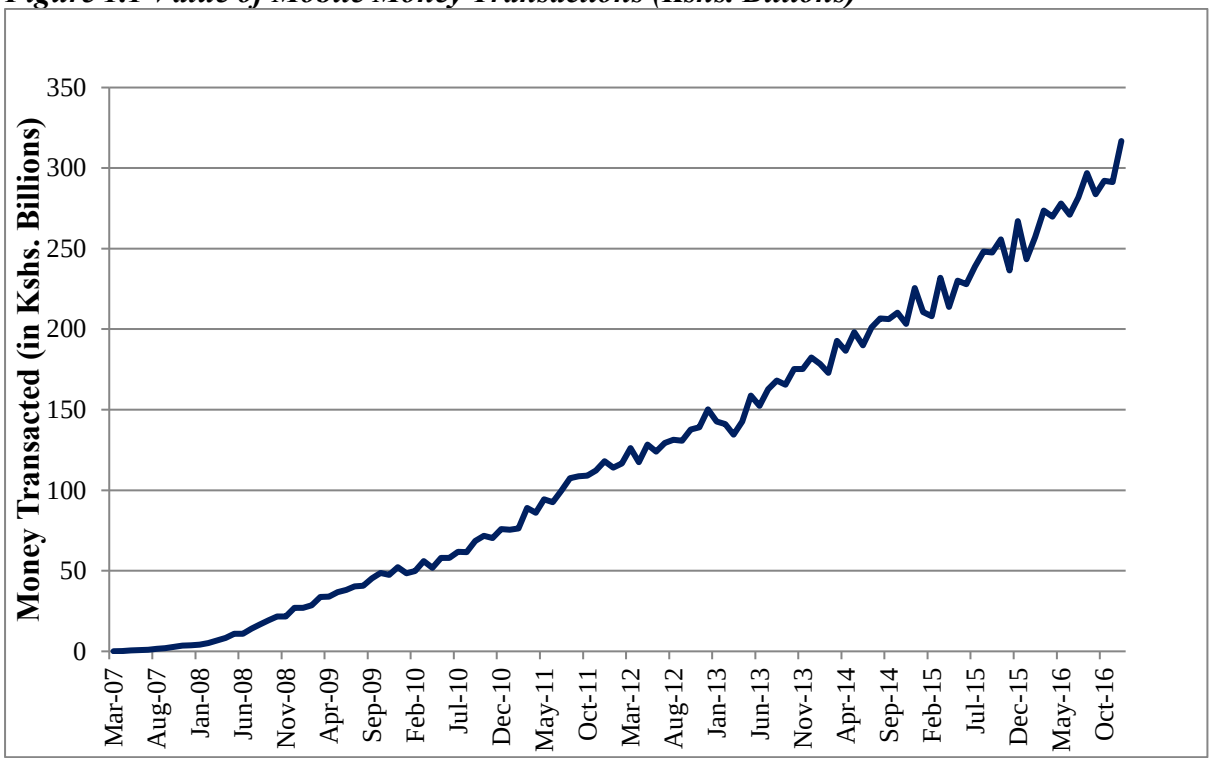
Table 1.3: Mobile Money Transfers

	No. of Agents	**No. of Customers (Millions)**	**No. of transactions (Millions)**	**Money transferred (Billions.)**	**Average transfer value**
2007	1,582	1.3	2.50	14.83	5,941.89
2008	6,104	5.1	62.74	166.57	2,654.89
2009	23,012	8.9	193.50	473.41	2,446.56
2010	39,449	16.4	311.05	732.22	2,354.06
2011	50,471	19.2	433.00	1,169.15	2,700.13
2012	76,912	21.1	577.37	1,544.81	2,675.58
2013	113,130	25.3	732.60	1,901.56	2,595.64
2014	123,703	25.2	911.34	2,371.79	2,602.54
2015	143,946	28.6	1,114.18	2,816.10	2,527.52
2016	165,908	35.0	1,526.15	3,355.58	2,198.72

Source: Central Bank of Kenya

The mobile money innovation has evolved into more sophisticated financial services including banking functions such as provision of mobile phone-based loans. It has also provided an opportunity for banks to reach and link customer accounts to cell phone numbers. This has led to more financial inclusion and at the same time also augmented the use of cashless transaction systems in Kenya. The growth of mobile money transfers is signalled by the steady graph as shown in Figure 1.1. This indicates a reduction in reliance on cash money for economic transactions.

Figure 1.1 Value of Mobile Money Transactions (Kshs. Billions)



Data Source: Central Bank of Kenya; Graph generated by the Author

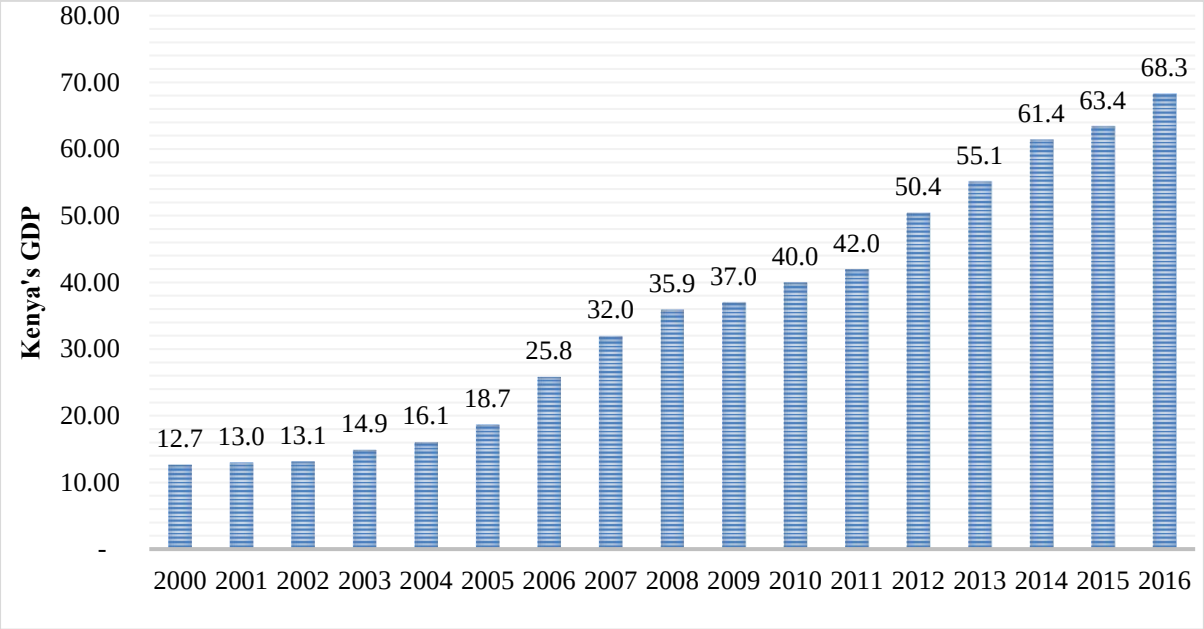
According to Akhtar (1983), Kogar (1995), Resina (2004), Ignazio (2007), Misati et al. (2010), and Ho (2006), financial developments affects effectiveness of monetary policy through the monetary transmission channels. Financial innovations have also been linked to improved financial market integration, superior allocation of resources which ensures diversification of risks, and a reduction in transaction costs. This leads to structural changes that could have diverse effects on financial stability and adequacy of monetary policy, and possibly create new risks.

To a large extent, it is still not yet clear how financial innovations affect how monetary policy is conducted in Kenya, especially after the rapid financial innovations. How developments in the payments systems that have proliferated affect the monetary policy transmission mechanisms is of utmost importance to avert the dangers of financial system instability which can otherwise cause havoc in an economy.

Financial innovations generally develop in three main economic frontiers. First, they lead to proliferation of alternative means of payments. Second, they increase the range of investment products available to economic agents. Finally, the innovations alter financing options. All these frontiers provide alternatives to cash money, and change the information content of asset prices and the borrowing options and thus affecting the interest rates.

A general outlook on Kenya's economy shows that the country has experienced a positive growth rate over time. Figure 1.2 represents the country's GDP measurements in United States Dollar (USD). Economic projections from the most recent World Bank report (Kiringai, *et. al.;* 2016) further indicate that the economic growth rate for Kenya is expected to continue growing. Notably the report says that economic growth rate is projected to increase from the 2015 figure of 5.6% to 5.9% in 2016, and increase further to 6% in the year 2017.

Figure 1.2: Kenya's GDP (in USD. Billion).



Data Source: World Bank, World Development Indicators. Graph Generated by the Author

Statistics from the World Bank presented in Table 1.4, show that Kenya's GDP growth rate was at its lowest level of 0.6% in 2000, while in 2001 it stood at 3.8%. This is a period that was marked by booms in the export sectors and food supply. The GDP growth rate generally fluctuated between the year 2001 and 2011. But in 2007, the growth rate hit a peak mark of 6.9%. Unfortunately, in 2008, Kenya suffered a combination of internal and external shocks whose effects sunk the country's economic activities. The major and notable economic disruptions include post-election violence, the global economic slump and financial crisis experienced in the year, a persistent increase in oil prices and high food prices which were driven by food shortages.

Table 1.4: Annual percentage GDP growth rate

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Annual growth rate (%)	2.3	0.6	3.8	0.5	2.9	5.1	5.9	6.5	6.9	0.2	3.3	8.4	6.1	4.6	5.7	5.3	5.6	5.9

Source: World Bank, World Development Indicators

1.2. Statement of the Problem

Growth of electronic money, one of the financial innovations, has been prevalent in Kenya, progressively driving the country into a cashless economy. This has led to introduction of alternatives to holding cash which affects the general demand for money and other financial structural changes. Most financial developments occur in sectors which are not directly regulated by the central bank, for example, the telecommunications and the IT sectors.

Financial innovations develop in a non-regular pattern though they require regular and prompt regulatory response. This creates uncertainty, complicates and adversely affects the effectiveness of monetary framework. This will therefore require central banks to regularly revise and develop new procedures and instruments in order to realize efficient monetary policy. Otherwise, a lack of proper regulatory framework could threaten the country's financial stability and eventually lead to failure to achieve macroeconomic goals and targets.

A stable demand for money function is a fundamental considerations in effective formulation and performance of monetary policy. However, if the relationship is not stable, aggregate monetary targeting might not be an effective policy option for ensuring price stability. Thus, the problem of this study is to examine the long-run and short-run determinants of money demand and its stability in Kenya. This is because understanding Kenya's real money demand function is critical in understanding the appropriate monetary policy applicable in Kenya.

1.3. Research Questions

This research study seeks to address one general question and various specific questions. In general, what is the nature of money demand in Kenya and how does it affect monetary policy? The next section outlines the specific questions.

1.3.1 Specific Questions

The following are the specific research questions;

1. What is the long run and short run relationship between real demand for money and its determinants in Kenya?
2. Is the demand for real money function in Kenya stable?
3. How should policy makers respond to effects of financial innovations?

1.4. Objectives of the Study

The main objective of this research paper is to empirically examine and establish the demand for real money function and its stability in Kenya for the period 2000 – 2016. The specific objectives of the research are:

1. To empirically investigate the long-run and short-run determinants of real money demand in Kenya.
2. To evaluate the stability of real money demand function in Kenya during the period under study.
3. To provide policy recommendations based on conclusions from the research results.

1.5. Significance of the Study

The empirical findings of this study are crucial in informing economic policy makers and other stakeholders, on the appropriate policies to undertake to ensure there is effective monetary policy controls. This will ensure optimal balance between monetary policy decisions and a country's towards achieving economic growth and development goals. The study has used a more recent data series in order to provide new insights to the field of monetary policy. This is significant to researchers, and scholars in providing an understanding of the determinants of money demand in an environment with major and rapid financial innovations, such as Kenya.

Finally, as major financial innovations from Kenya such as mobile money take a global dimension, this research work will provide insights to local policy makers and those in other monetary policy regimes. This will therefore ensure domestic and global financial stability and prudence. This study therefore seeks to bridge the research gaps identified in previous studies to ensure appropriate regulatory framework in the global financial sector which will help to avert financial crises.

1.6. Organization of the Research Paper

The remaining parts of this research paper have been constituted in the following structure. Chapter Two incorporates the literature review that covers theoretical review, empirical review and the overview of the literature. Chapter Three covers and describes the methodology adopted in this research paper. The chapter covers the model specification and the proposed estimation techniques. Chapter Four covers the data analysis, research results and interpretation of research findings while Chapter Five presents the research summary, conclusions and policy recommendations based on the empirical research outcome.

CHAPTER TWO
LITERATURE REVIEW

This chapter evaluates the literature on various approaches to demand for money, financial innovations, and formulation of monetary policy decisions. The review focuses on growth of financial innovations and channels of monetary policy transmission; and innovations and demand for money. The following sections provide a theoretical and empirical literature review on financial innovations and its relation to the formulation of monetary policy.

2.1 Theoretical Review

The theoretical considerations on demand for money emphasize three key motives for holding money. The three major reasons advanced for demand for money focus on the transactions, precautionary, and speculative motives. Various theories have been formulated to address the role of money in the economy. The Quantity Theory of Money, which encompasses the classical formulation of this theory, Friedman's restated version and Cambridge version, forms the major models in the study of demand for money. We have also considered other theories such as Keynes' liquidity preference, and Baumol–Tobin's transactions demand for money model.

The classical quantity theory of money is built on principles of the equation of exchange which was advanced by Irving Fisher in 1911 (Fisher, I. and Brown, H., 1922). This classical relationship contends that there exists a one-to-one link between the volume of money and the general domestic level of prices. It also argues that people hold money for the sole purpose of meeting their transactions. The theory assumes that both velocity and volume of transactions are constant in the short-term. However, this assumption has been criticized with modifications which show that velocity of money actually depends on spending impulses which are not constant and thus it is not expected to be constant.

Whereas the classical theory of money demand emphasizes on the transactions motive, Keynes focused on the speculative motive. He introduced the liquidity preference theory that considers the function of money as a store of value. The theory argues that demand for money is determined by interest foregone by holding non-interest bearing assets. It is based on the argument that the more quickly an asset can be converted into money the more liquid it is. Thus, cash money is the most liquid asset that people can hold. In this theory, Keynes notably argues that people hold their assets exclusively as either money or bonds.

The Cambridge cash balance approach to demand for money was put forward by Pigou (1917) and Marshall (1923). The theory considers money as a store of value. It argues that people hold a proportion of nominal income in form of cash balances. They assumed that interest rate, wealth, expected prices and interest rates are constant. Demand for money is thus considered as a mathematical relationship that involves the proportion of income held in the form of real cash money balances, and the level of prices.

Baumol (1952) and Tobin (1956)'s inventory approach focused on the transactions motive for demand for money. Their analysis is founded on the inventory control techniques and argues that people hold money to facilitate individual and business transactions. Thus money is considered as a convenient means of purchasing goods and services. In this case, the opportunity cost incurred in holding money is the interest income which is forfeited by not holding interest generating assets.

In his restatement of the quantity theory of money, Friedman (1956) did not examine any motives for holding money. Instead he introduced a range of factors into the demand for money function which were essential in restating the classical quantity theory of money. He considers money as a type of asset which people can keep as part of their wealth portfolio while firms can consider it as a factor of production. He considers bonds, equities and/or shares, consumable goods, human capital and physical capital as other forms of assets that people can hold.

He argues that demand for money is a function which is determined by factors that generally influence demand of any other asset. He applied the asset demand theory to money and formulated a function where demand for money depends on an individual's permanent income (y), ratio of human capital to total wealth (w), level of prices (P), rate of return on money (r^m), return on equities (r^e), rate of interest on bonds (r^b), and institutional factors (u). He therefore developed the following nominal demand function (M^d) for money. The function can easily be transformed into a model of demand for real money balances as shown in equation 2.1 where $[\frac{1}{p}.\frac{\partial p}{\partial t}]$ is the expected rate of return on real assets, which is measured by the rate of price change over time.

$$\frac{M^d}{P} = f\ (y,\ w,\ r^m,\ r^b,\ r^e,\ \frac{1}{p}.\frac{\partial p}{\partial t},\ u) \tag{2.1}$$

The portfolio choice theory introduced by Tobin (1958) and Markowitz (1952) argues that people hold a combination of assets in form of interest bearing and non-interest earning assets. High risky assets will usually be associated with high returns. However, as opposed to Keynes' theory, people will be unwilling to hold all risky assets although they offer higher average returns. Depending on their attitude towards risk, they will seek to have both safety and reasonable returns through diversification to achieve an optimal combination (portfolio) of secure and risky assets.

The optimal portfolio consists of a mix of money; a safe and low risk (riskless) asset associated with low returns, and a set of high risk/high return assets such as bonds and shares. The choice of this portfolio and as a result, the demand for money, is influenced by the trade-off between expected risk in assets and their expected returns. Thus, more risk averse people are expected to have a bigger share of money in their portfolio. Likewise, higher expected returns will lead people into preferring risky assets to holding money. Tobin-Markowitz agree with Keynes's speculative theory that there exists an inverse association between nominal interest rates and demand for money. Some assets such as treasury bills have a positive return but zero risk, and therefore dominate money (M1). Hence the speculative demand for money is almost zero.

In consideration of the foregoing theories, it is noteworthy that Keynes' theory is limited by the argument that people hold all their assets exclusively as either money or bonds. This limitation was addressed by Tobin-Markowitz's approach which can also be applied to the problem of alternative asset from a set of several assets. Tobin-Markowitz also tackled Keynes' erroneous assumption that interest rates move in a specific direction by advancing the fact that individuals are not certain how the interest rate will change. Similar to Keynes, Tobin and Baumol advance the concept that transactions demand for money is a function of interest rates.

Further, we note that the Cambridge theory, Friedman's re-statement of the quantity theory of money, and Tobin-Markowitz's approaches are more robust since they introduce the influence of various micro and macro-economic variables. Baumol and Tobin clearly show the existence of a direct link between income and transactions demand for money. In general, these theories agree with Keynes that demand for money is associated with the nominal interest rate in a negative relationship.

Precautionary demand for money argues that economic agents hold money to meet expenses relating to unplanned or unforeseeable circumstances. The amount of precautionary money balances that the people want to hold is influenced by the level of income, accessibility to credit, and the level of interest rates. Considering that the volume of transactions is proportional to the level of income, then if income increases, the precautionary money balances will also rise. On the other hand, if credit is easily available, then precautionary demand for money will be lower. Finally, we note that in general, a higher interest rate implies a high opportunity cost of holding money (inclusive of precautionary demand for money). This is similar to arguments by Baumol (1952) and Tobin (1956, 1958) in the inventory approach, which leads to the conclusion that precautionary demand for money is inversely related to the interest rates.

From the foregoing approaches, we establish that demand for money can be presented by a mathematical function that encompasses an association between real money balances and factors that determine demand for money such as interest rates, income, price changes, and exchange rates. It is in this regard that Odularu and Okunrinboye (2009) argue that the stability of the elasticities in this relationship is a very important consideration in establishing suitability and efficiency of monetary policy decisions.

2.2 Empirical Literature Review

Studies by Resina (2004), Ho (2006), Noyer (2007), and Ignazio (2007) show that financial innovations create new cost effective opportunities, new financial market players, and changes in the range of financial services and payment options. They also agree with Kuang (2008) that innovations alter the extent and speed by which monetary policy decisions are transmitted. In addition, they also alter how the economy reacts to monetary policy framework, and makes the link between non-monetary and monetary components more volatile and unsteady. Other studies have been undertaken to determine the nature and strength of the link between interest rate; monetary policy and financial development. The studies show diverse effects and implications.

Considering demand for money and monetary policy, we note that various studies have also been done with the specific focus on estimating and investigating the stability of a money demand function. Previous studies in Kenya which we have reviewed include Adam (1992), Sichei and Kamau (2012) and Kiptui (2014). Previous studies from other countries in this review include; Awad (2010), Halicioglu and Ugur (2005), Narayan and Narayan (2008), Odularu and Okunrinboye (2009), Onafowora and Owoye (2011), Oyelami and Yinusa (2013).

According to Ho (2006), innovations can negatively affect the effectiveness of monetary policy channels by replacing traditional forms of money. Financial innovations affects the amount of money held in various ways. This works through bank deposits, the automatic transfers between fixed and saving deposits, ATM balances, and credit cards. In general, financial innovations reduce money demand in an economy. Noyer (2007) further shows that innovations reduce information asymmetries by increasing dissemination and incorporation of information into the financial system. This enhances the interest rate channel but the wider access to credit weakens the credit channel. Sukudhew et al. (2007) using Engle-Granger two-step technique shows that financial innovations strengthen the asset price channel but weakens the lending channel.

Misati et al. (2010), using 2SLS and data from Kenya, conclude that financial innovations stifle the interest rate channel. But Ndirangu and Nyamongo (2014) using data from 1998 to 2012 conclude that financial innovations have positive effects and improve the interest rate channel. They also establish a structural break in the trend after 2007, similar to earlier findings by Weil, et al. (2012), a study that also finds velocity of mobile money to be lower than that of cash but increasing over time. It is noted that the post-2007 period is associated with instabilities in income velocity of money, money demand, and the money multiplier. This can be associated to mobile money transfers which were introduced into the financial system in early 2007.

In studying the demand for money function, Goldfeld (1976) points out the possibility that rapid growth of financial innovations could end up in a scenario where the orthodox features of money supply are no longer in application. He attributes this to possibility of excluding new financial instruments and variables from the definition of money. This could consequently compromise the traditional constitution of the demand for money function. He referred to this as “the case of the missing money” and concludes that it explains the instability observed in his study.

In a study on the effects of various methods of payment on demand for money, Helmut (2004) noticeably finds out that alternative payments affect the usage of cash money. The study shows that with the introduction of alternative payments, the share of cash payments declined by about 6% to 7% in the period between the year 2000 and 2002. He attributes this change to the increase in the number and value of debit card transactions. He therefore concludes that the intensified usage of cashless payment methods has an enormous influence on demand for cash money.

Onafowora and Owoye (2011) investigated the effects of various financial changes on the money demand stability in Nigerian. Their empirical findings show that there is a long-run relationship between the real broad money and various macroeconomic variables. They used recursive residuals (CUSUM and CUSUMSQ tests) to test for the stability of both the short- and long run parameters of the estimated function for real money demand in Nigeria. They find that the parameters are stable and therefore conclude that the central bank is justified to use broad money supply as monetary policy targets to manage inflation and other economic goals. They further note that in the presence of currency substitution, a central bank may lack total control over money supply, and this can undermine its ability to sustain monetary targets, and highly limit its ability to design and implement effective monetary policy.

In the context of Kenya, Adam (1992) carried out an estimation of the money demand function in the period between 1973 and 1989 and established that the function was stable during that time. Similarly, in a bid to estimate and measure the stability of a demand for money function for Egypt, Awad **(**2010) used quarterly data for a period of 12 years starting in 1995. The study carried out stability tests, to check for any effects of structural changes, by using the Chow test criteria, and found out that the demand for money function, during the period of study was not stable. The author therefore concludes that following these findings, the central bank may not able to achieve its price stability goal based on the aggregate monetary targeting.

Using a cointegration methodology as proposed by Pesaran et al. (2001) and stability tests based on CUSUM and CUSUMSQ, Halicioglu and Ugur (2005) empirically investigated the stability of the money demand function for Turkey, one of the developing OECD countries, whose monetary policy is based on aggregate monetary targeting. The paper notes that for aggregate monetary targeting to be effective, the presence of a stable long-run and short-run relationship in the money demand function is very essential. This is because a stable function ensures that the impact of money supply on other macroeconomic variables is predictable. They found out that the function is stable and concluded that as a result, monetary targeting is an appropriate monetary policy target for Turkey. Damian (2011) also makes a similar argument and concludes that monetary policy strategy cannot be optimal if the money demand function is not stable.

Narayan and Narayan (2008) estimated the money demand function for Fiji between the year 1971 and 2002 by using a bound testing approach to cointegration. They note that this methodology can be used regardless of whether the variables in consideration are stationary or non-stationary. The estimation employs the use of a time trend and applies various lags ranging from 1 to 3. Their study finds no cointegration among the variables. However, on further analysis based on the Bai and Perron (1998) procedure, they confirm that there are structural breaks in the function. They therefore conclude that instabilities in Fiji's demand for money could be associated to various factors taking place in Fiji such as political coups, various macroeconomic policies and other international trade policies.

Odularu and Okunrinboye (2009) studied the effects financial innovations on demand for money balances in Nigeria. They used an Engle-Granger Two-Step technique, and their analysis shows that there was a one-on-one association between national income and demand for money. The study however shows a negative relationship with interest rates. In conclusion, contrary to the findings by Onafowora and Owoye (2011) which indicate instabilities, the study notes that financial innovations had insignificant effects on demand for money.

However, a more recent study by Oyelami and Yinusa (2013) which focused on the effects of alternative payment systems in Nigeria differs with the conclusions by Odularu and Okunrinboye (2009). The analysis used a VECM technique and monthly data for the period between 2008 and 2010. The analysis found that some innovations replace the demand for real money balances while others complement its demand. In conclusion, they note that innovations in the payment system diminish the effectiveness of monetary policy. They therefore warn that this might lead to severe implications on monetary policy.

A recent study by Mbugua and Karume (2013) notes that there is an increasing usage of digital financial products in Kenya which involves e-money, automation of the national payment system, debit and credit cards, mobile money, mobile-based financial products, and many others. The study also notes that commercial banks are now integrating internet and mobile banking into their services. The study concludes that digital financial products such as mobile money have led to financial deepening by looping in many people into the financial system.

Sichei and Kamau (2012) investigated demand for money in Kenya based on different monetary aggregates. Their study establishes that the money demand functions are not stable and conclude that as a result, monetary targeting policy framework, which is currently in use, may not be inappropriate. They attributed the instabilities in the demand for money to various factors, among them financial innovations. This is contrary to Kiptui (2014) who has also re-considered the stability of the money demand relationship by using the ARDL Model. He finds out that real income estimates and the interest rate elasticities are within the expected theoretical and empirical ranges. He thus concludes that demand for money has in the past been stable and therefore monetary policy measures have been effective. However, he notes that the developments in the financial system call for an in-depth analysis to determine if they have had any effects in monetary policy formulation and their implications.

2.3 Overview of the Literature Review

In general, there is a low number of studies focusing on financial innovations and monetary policy in Kenya since this is a new and evolving issue. Literature shows that financial innovations and monetary aggregates are indirectly related to one another. Studies also show that financial innovations affect the demand for money, and monetary policy transmission mechanisms. Most of the available studies have focused on the factors influencing uptake and growth of financial innovations, increased consumer welfare, the risks associated with these innovations, and the general qualitative effects on economic growth.

Financial innovations have diverse implications on the demand for money, effectiveness of channels of monetary policy transmission and consequently, the effectiveness of monetary policy. Some studies show that innovations enhance channels of policy transmission while others argue that the innovations dampen the channels. The studies further show that financial innovations affect the general stability of demand for money which, as earlier discussed, is part of the important considerations in monetary policy decisions. Financial innovations also create new financial products, services and structures into the financial system. Noting that the stability of the money demand function is essential for the operation of monetary targets, various studies argue that in the presence of instability, the aggregate monetary target is not an appropriate tool (measure) for the conduct of monetary policy.

Despite the above studies, little research has been done in Kenya to understand the role and the effects of financial innovations in the formulation of monetary policy. The little literature available does not cover most current data and hence have not captured mobile money which has greatly transformed Kenya's financial sector. As a result, due to lack of sufficient empirical studies, it is not yet clear how innovations affect monetary policy formulation and how best to incorporate them in policy formulation. We also note that specific studies in Kenya have recommended an in-depth analysis of the effects of financial innovations to determine if they may have had an effect in monetary policy formulation. This study seeks to bridge the information gap in this subject.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

Different methods have been used in previous studies to analyse the implications of financial innovations in monetary policy formulation. Majority of these studies have focused on the correlation between transmission mechanisms and macroeconomic variables. Various studies have analysed a combination of monetary policy channels and their relationship to inflation, output, and other aggregate economic variables. Conversely, other studies such as Misati *et. al.* (2010), and Ndirangu and Nyamongo (2014) have specifically considered one or two channels in their analysis. As noted in the literature review, various studies have considered the stability of a money demand function, in various countries, using diverse approaches. This paper therefore adopts its research design based on the insights, conclusions and recommendations from previous studies.

3.2 Research Design

This research study has used the conventional approach to analyze the stability of money demand function in Kenya. This has been done by measuring the equilibrium relationship between real money balances and its determinants; and determining whether there are any changes to real money demand vis-à-vis financial innovations. Consequently, the standard money demand function was analysed by employing a logarithmic regression of money demand against logarithms of determinants of demand for money. We have used quarterly data for the period of 2000 – 2016 similar to the methodology used by Awad (2010).

Empirical analysis has been conducted using an error correction method, to establish both the long-run and short run elasticities of macroeconomic variables used in the research. This has been done to determine the direction, magnitude and speed of changes in real demand for money. We have used the parameter tests with a specific focus on the use of CUSUM and CUSUMSQ stability test methods, proposed by Brown, *et. al.* (1975), to measure relationship stability. This analysis has been used to determine the nature of Kenya's demand for money function and as a result provided a clear understanding of the implications on monetary policy.

It is essential to take cognizance of the fact that the period of study considered in this research paper is 2000 to 2016. This period was appropriately selected for this research in order to incorporate a time frame within which Kenya's major disruptive financial innovations took place. These include the introduction of the main disruptive financial innovations such as mobile money, digitization of various financial services and products, and introduction various forms of cashless transactions in Kenya.

3.3 Theoretical Framework

The general theoretical framework on demand for money considers the three key classical motives for holding money. These include the transactions motive which argues that agents hold money to facilitate the normal day-to-day transactions. The second motive is the precautionary where people hold money to meet emergency expenditures, and finally the speculative motive which focuses on demand for financial assets based on the expected future returns from such assets. As a result, there are assets that take dominance over money and in that case demand for money becomes zero.

The basic theory is built on the exchange equation (Equation 3.1) which provides a functional connection in the long-run demand for money. However, Keynes liquidity approach modifies demand for real money balances arguing that there exists a negative relationship involving interest rates and real money balances as shown in Equation 3.2. As a result, demand for real money balances can be represented as a mathematical relationship involving economic activity (Y) and nominal interest rate (*i*) as shown below.

$$MV = PY \tag{3.1}$$

$$M/P = f(i, Y) \tag{3.2}$$

Further, considering other theories such as Friedman's restatement of the quantity theory of money, and Cambridge version of quantity theory of money, together with the inventory approach and portfolio choice theory we can generate determinants of money demand. From these factors, we can therefore specify a general function for real demand for money which incorporates real income, exchange rate, interest rates on a 91-day Treasury bills, and expected inflation as shown in Equation 3.3.

$$(M/P)_t = f(Y_t, E_t, i_t, \pi_t) \tag{3.3}$$

3.4 Model Specification

The standard demand for money function is expressed as shown in Equation 3.4. A measure of inflation *(π_t)* is incorporated in the model to measure the observed rate of inflation.

$$(M3/P)_t = \beta_0 + \beta_1 Inf_t + \beta_2 ExR_t + \beta_3 intR_t + \beta_4 Y_t + \varepsilon_t \quad \ldots\ldots (3.4)$$

where;

M3 = Broad Money Supply

P = the general level of prices, (measured by CPI)

Y = National Income (measured by real GDP)

ExR = Exchange rate

intR = Interest rate (91-day Treasury bill rate)

Inf = Inflation level

ε = Error term

The study has used a log linear regression technique as the general estimation technique which enables us to investigate the stability of money demand function in Kenya. As a result, in this research paper, we have used a log-linear formulation of the money demand model developed as shown in Equation 3.5.

$$ln(^{M3}/_{P})_t = \beta_0 + \beta_1 lnInf_t + \beta_2 lnExR_t + \beta_3 lnintR_t + \beta_4 lnY_t + \varepsilon_t$$

$\ldots\ldots\ldots$ (3.5)

This logarithmic transformation of the standard money demand function provides an appropriate way of changing the highly skewed and inter-dependent variables into those that are more approximately normal without losing the linear characteristics of the model. It is a significant step which allows us to consider and interpret estimated coefficients as elasticity values, thus allowing us to analyse the percentage changes between two variables. According to Niyimbanira (2013) the transformation also helps to reduce heteroscedasticity. Finally, it's an effective method to decrease nonlinearity and seasonal trends that could be in the sample data.

In this regard β_1 measures the inflation elasticity of money demand, β_2 measures the foreign exchange rate elasticity of money demand, while β_3 measures the interest rate elasticity of money demand, and β_4 is the measure for income elasticity of money demand. β_0 is a constant parameter controlling for the fixed parameters in the model.

3.4.1 Assumptions and Expected Signs

Based on theoretical foundations involving the variables used in the model, it is expected that the signs of explanatory variables are β_1, β_2 and $\beta_3 < 0$ and $\beta_4 > 0$, such that demand for money is expected to exhibit a positive relationship with the level of economic activity, while foreign exchange rate, interest rate, and the rate of inflation are expected to be negatively related with demand for money. The expectation on foreign exchange rate (β_2) is based on the theoretical assumption that when domestic currency appreciates, the demand for domestic currency also rises[1].

3.5 Data and Sources

The study has used time series data collected from secondary sources and aggregated on a quarterly interval. The data sources include CBK, Kenya National Bureau of Statistics (KNBS), International Monetary Fund (IMF), World Bank Development Indicators and other sources covering the period 2000 to 2016. The research data set consists of quarterly measures of extended broad money supply (M3), economic activity measured by real GDP, general price levels (measured by CPI), average exchange rate (in Kshs. per US Dollar), and inflation levels.

3.6 Pre-Estimation Tests

Various pre-estimation and diagnostic tests have been undertaken to determine how to treat the variables and the appropriate model to use in estimating both the short-run and the equilibrium relationships in the research variables. A general two-way data plot has been carried out to determine if the variables have a trend. The diagnostic tests carried out involve a two-way data plot, tests for stationarity, integration order, and tests for cointegration.

3.6.1 Unit Root and Integration Order Tests

Stationarity of the variables has been tested using the Augmented Dickey Fuller (ADF) (1979, 1981) criterion. The test has been founded on the regression model expressed in Equation 3.6.

$$\Delta \ln X_t = \mathrm{C} + \beta X_{t-1} + \lambda T + \sum_{j-1}^{\rho} \gamma_j \Delta X_{t-j} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots \quad (3.6)$$

This equation tests for a possible presence of a unit root in X_t; where X represents each of the variables in the model, t = 1... T is the index representing time, while ΔX_{t-j} represents the lagged first differences which is meant to control for serial correlation in the disturbances, ε_t.

[1] *This assumption is based on studies which argue for theory of currency substitution effect of exchange rate changes. However, based on analysis of empirical studies, Sahadudheen (2011) argues that exchange rate changes can also have wealth effects leading to different expectations in the sign.*

In this test, the null hypothesis argues that a variable follows a unit root process (i.e. a unit root exists). On the other hand, the alternative hypothesis is set such that the variable that is being considered is said to be stationary (i.e. has no unit root).[2] The hypotheses can therefore be represented as follows;

Null Hypothesis: $H_0: \beta = 0$ (unit root exists)

Alternative Hypotheses: $H_1: \beta < 0$ (No existence of a unit root)

Further pre-estimation tests have been carried out to establish the degree of integration for the non-stationary variables identified. The test method follows the ADF criteria where the non-stationary variables are differentiated *d*-times to establish the number of differentials at which they become stationary; which is the order of integration.

3.6.2 Lag Order Selection

The optimal lag length lag order, ρ, underlying the VAR model can be determined by use of various methods such the sequence of Likelihood Ratio (LR) test, the Final Prediction Error Criterion (FPE), Akaike Information Criterion (AIC), Hannan and Quinn information criterion (HQIC), and the Schwarz Bayesian Information Criterion (SBIC).

3.6.3 Test for Cointegration

The unit root test is carried out to check on the stationarity of the research variables. If we establish that the variables are non-stationery, a cointegration test is then carried out to establish whether there exists a long-term relationship among the non-stationary variables.

The test of cointegration is based on the Granger representation theorem which tests the null hypothesis of no cointegration among the time series by checking for existence of a unit root in the OLS residual. This is determined by ADF tests on the residuals, with the MacKinnon (1991) critical values adjusted for the number of variables in the model.

[2] *We reject the null hypothesis when the p-value of the test statistic is equal to or less than the specified significance level.*

3.7 Econometric Model

Pre-estimation tests on the research model have established that all the research variables are non-stationary, and they are cointegrated with the same degree of integration. We have also established that there are at least one cointegrated relationships among the non-stationary variables. As a result, the most appropriate method to carry out the empirical analysis is by use of an error correction model (ECM), so that we can estimate and analyze both the short-term and the long-term relationship parameters. Rossana (2004) notes that this model is more appropriate because it ensures that higher degrees of integration do not affect resulting cointegrating matrices obtained from lagged levels of the time series data.

The basic structure of an ECM which is equivalent to a Vector Autoregressive (VAR) model can be formulated as shown in Equation 3.7.

$$(L)\Delta X_t = \alpha_0 + \alpha\beta' X_{t-1} + \alpha_i(L)\Delta X_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.7)$$

where X represents the set of the variables in the research model, such that;

$X = \begin{bmatrix} RM \\ Inf \\ ExR \\ intR \\ Y \end{bmatrix}$, α is a vector of constants, and $\beta' = \begin{bmatrix} 1 \\ -\beta_\pi \\ -\beta_E \\ -\beta_i \\ -\beta_Y \end{bmatrix}$ is the cointegrating vector.[3]

The beta, β, from the error correction model represents a matrix of the cointegrating vectors, where β can be considered as an error correction element. Similarly, α is a matrix of coefficients representing the estimated adjustment parameters from the error correction model and they are used to measure the speed of adjustment towards equilibrium.

The error correction model in this study has therefore been derived as shown in Equation 3.8. This constitutes the error correction model through which our study's empirical analysis has been done. Therefore, the general vector error correction representation, with r cointegrating vectors can be written as follows;

[3] $\left({}^{M3}/_{P}\right)$ *has been formulated as the definition of real money balances, RM.*

$$\Delta lnx_t = \alpha + \Pi lnx_{t-p} + \sum_{i=1}^{p-1} \Gamma_i \Delta lnx_{t-i} + \varepsilon_t ; \quad (0 < r \leq k)$$

…… (3.8)

where

x_t is a vector representing k variables as used in the system, Δ is a differencing operator, such that $\Delta x_t = (x_t - x_{t-1})$; α is a vector of constants, while Π is the long run (equilibrium) multiplier matrix such that $\Pi = \alpha\beta'$ where α and β represents a set of $k \times n$ matrices of rank n; Γ_i represents a square $(k \times k)$ matrix which describes the short-run system dynamic effects, and ε_t is the vector of independently and identically distributed error terms.

From Equation 3.8 above, Πlnx_{t-1} forms the error correction mechanism that measures the long-run (equilibrium) relationship between variables, and the short run adjustments that underlie the long run relationship. The next part describes the short run adjustments which shows the process through which the system re-adjusts, in case of occurrence of a disequilibrium in the previous period.

In this dynamic stochastic model, all variables are treated as endogenous variables and they can therefore be presented in lagged values against the lagged measures of all the other variables used in the research model. Consequently therefore, the error correction model which we have estimated in this study can be expressed as follows;

$$\Delta \ln RM_t = \alpha_0 + \alpha_1 \Delta lnInf_t + \alpha_2 \Delta lnExR_t + \alpha_3 \Delta lnintR_t + \alpha_4 \Delta lnY_t + \alpha_5 ECM_{t-1} + \varepsilon_t \quad \text{…… (3.9)}$$

where ECM represents the error correction term in this study.

According to Sriram (2001) the error correction model is superior over other econometric techniques. This is founded on the fact that the model provides for the possibility of analysing both short-run dynamics and the equilibrium relationship between money demand and its functional explanatory variables.

CHAPTER FOUR
EMPIRICAL RESULTS

4.1 Introduction

This chapter discusses the empirical results and findings for this study. The section starts by introducing the summary statistics of the research data, then the chapter presents a summary and analysis of empirical results from the estimation conducted.

The research data comprising of 68 observations on a quarterly basis from 2000q1 to 2016q4, used in this study can be summarized in Table 4.1, which shows a summary characteristics of the research data.

Table 4.1: Summary Statistics of the Variables

	No. Obs.	Mean	Std. Dev.	Min	Max
Real Money, (RM)	68.00	3043.99	952.97	1984.24	4869.94
Inflation, (Inf)	68.00	8.17	4.58	1.22	19.19
Exchange Rates, (ExR)	68.00	80.73	9.20	63.41	102.98
Interest Rates, (intR)	68.00	8.23	3.55	1.18	19.35
Real GDP, (Y) in Billions	68.00	571.52	316.06	229.92	1094.62

Source: Generated by the Author

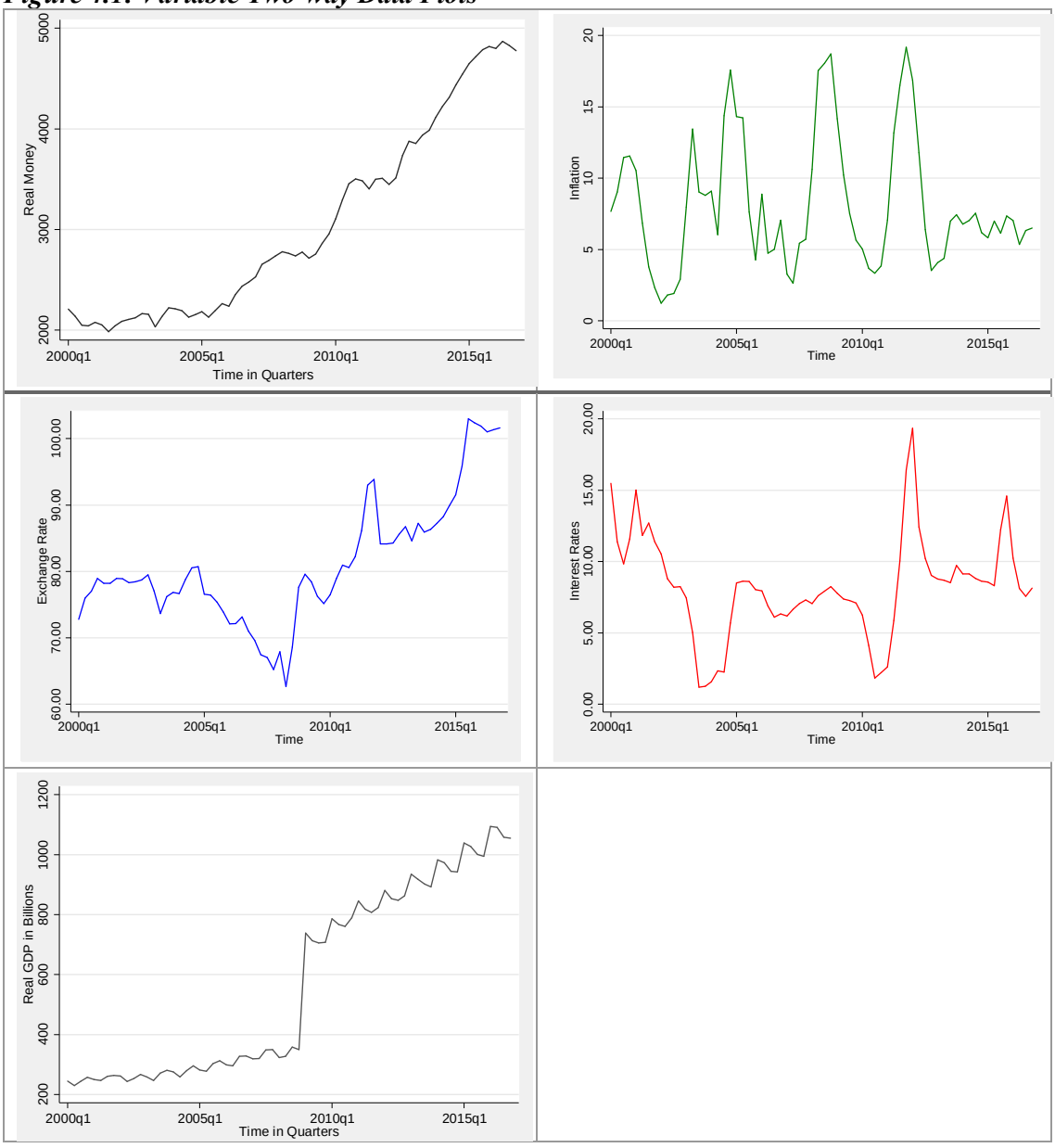
4.2 Pre-Estimation Tests

This section describes the results from the diagnostic tests that have been carried out as part of the research methodology. They involve general two-way data plots, unit root (stationarity) tests of the variables, integration order tests, and tests for cointegration. As previously discussed, these tests have provided important insights in this research paper's model specification and estimation approach.

4.2.1 Data Plot

A general two-way data plots have been fitted as presented in Figure 4.1. The plots for real money balances, and economic activity show an upward trend while those for interest rates and inflation rates do not follow a trend, but exhibit random tendencies over the time series. The exchange rates follow both a random pattern and an upward trend. Since the variables are non-stationary, it is important to difference them during the empirical analysis. These plots are, in part, similar to the plots by Weil, et al. (2012). Real GDP has a sudden spike in 2009 due to rebasing.

Figure 4.1: Variable Two-way Data Plots



Source: Generated by the Author

4.2.2 Unit Root and Integration Order Tests

The presence of unit roots in the variables has been tested using the Augmented Dickey Fuller criterion, based on the general regression equation, and criteria explained in Section 3.6.1 of this paper. The test results for the research variables are summarized as shown in Table 4.2. The results clearly indicate that we should not reject the null hypothesis (that the variables are non-stationary) for all the variables at confidence levels of 1%, 5% and 10%.

Further tests have also been carried out to establish the degree of integration for these non-stationary variables. This test follows the ADF criteria, where the non-stationary variables are differentiated *d*-times to establish the number of differentials at which they become stationary (which describes the order of integration). The results from the test for presence of unit roots show that all the research variables are integrated of order 1, while all the first difference variables are I (0).

Table 4.2: Augmented Dickey-Fuller Test for Unit Roots[4]

Level Variables	***Test Statistic Z(t)***	***P-value***	***Degree of Integration***	***Differenced Variables***	***Test Statistic Z(t)***	***P-value***	***Degree of Integration (differenced variables)***
lnRM	1.100	0.995	I(1)	***D1lnRM***	–6.224	0.000	I(0)
lnInf	–2.788	0.060	I(1)	***D1lnInf***	–6.368	0.000	I(0)
lnExR	–0.562	0.879	I(1)	***D1lnExR***	–6.857	0.000	I(0)
lnintR	–2.486	0.119	I(1)	***D1lnintR***	–5.611	0.000	I(0)
lnY	–0.572	0.877	I(1)	***D1lnY***	–9.161	0.000	I(0)
Critical Values: 1% (–3.556); 5% (–2.916); 10% (–2.593)				Critical Values: 1% (–3.558); 5% (–2.917); 10% (–2.594)			

Source*: Generated by the Author*

[4] *Tests on the level variables also show similar unit root test results within all the critical confidence levels.*

4.2.3 Lag Order Selection

Before estimating and analysing our research model, it is important to establish the lag order, (ρ) of the unrestricted VAR. After this, the optimal lag length can then be incorporated into cointegration test and the subsequent econometric model. The lag length can be determined by using the sequence of Likelihood Ratio (LR) test, the Final Prediction Error Criterion (FPE), Akaike Information Criterion (AIC), Hannan and Quinn information criterion (HQIC), and the Schwarz Bayesian Information Criterion (SBIC) as shown in Table 4.3.

Table 4.3: Lag Order Selection

Selection-order criteria

Sample: 2001q1 – 2016q4 **Number of obs = 64**

lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	–33.008				2.30e-06	1.188	1.254	1.356
1	321.696	709.41	25	0	7.60e-11	–9.116	–8.717*	–8.103*
2	352.890	62.388	25	0	6.30e-11	–9.309	–8.578	–7.454
3	392.346	78.912	25	0	4.20e-11	–9.761	–8.698	–7.062
4	423.587	62.482*	25	0	3.7e-11*	–9.956*	–8.561	–6.414

Source: Generated by the Author

There are various arguments for the criteria to use in the choice of the optimal lag order. Ivanov and Kilian (2005) argue that SBIC could be appropriate when working with any number of observations for quarterly data on vector error correction model. Pesaran *et al.* (2001) also argues that the SBIC is superior to the rest of the model specification criteria for the reason that it has more parsimonious specifications. Furthermore, a study by Lütkepohl (2005) notes that the SBIC and the HQIC criteria alike, offer more reliable estimates for the true lag order.

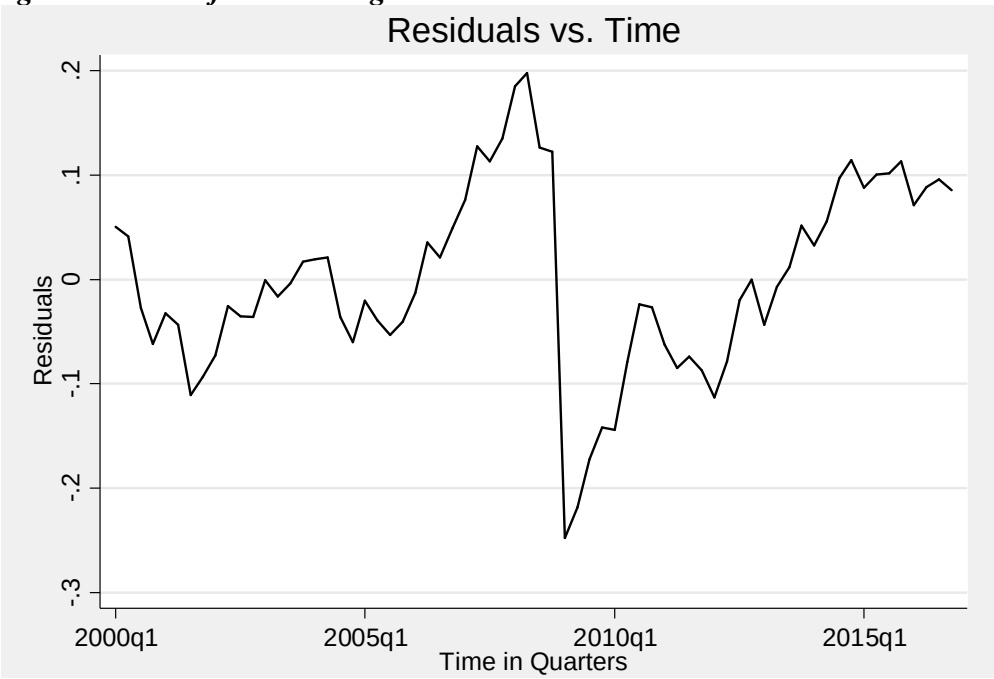
Based on the results from the lag order selection presented in Table 4.3, we note that there are various lag orders based on different test criteria. As a result, the maximum lag length ρ underlying the VAR model which we have applied to the dependant variable in the long-term relationship empirical estimation has been determined to be a lag length of 4, ($\rho = 4$). The research variable lag selection test results are presented in Appendix 1; Table A1–A5.

According to Paulsen (1984), Tsay (1984), and Nielsen (2001), the established lag-order selection criteria can also be used to determine the lag length of both the VAR model and the underlying error correction model. We have incorporated the lag dynamics into the econometric model to ensure that the empirical results are free from spurious characteristics.

4.2.4 Test for Cointegration

In our pre-estimation tests, we have established the presence of unit roots in the variables and we have noted that all the level variables are integrated on degree one, i.e. they are I (1), it is important to test whether the data series are cointegrated. As a result, this study has used the Engle-Granger two-step procedure to test for cointegration. This criteria is simpler and offers a robust alternative to the Johansen tests for cointegration[5]. It involves Ordinary Least Squares (OLS) regression, calculation of the error term, u_t and then carrying out a unit root test on the residual to establish if it is stationary. A plot of the residuals along the study time line can be plotted as shown in Figure 4.2 below.

Figure 4.2: Plot of Residuals against Time

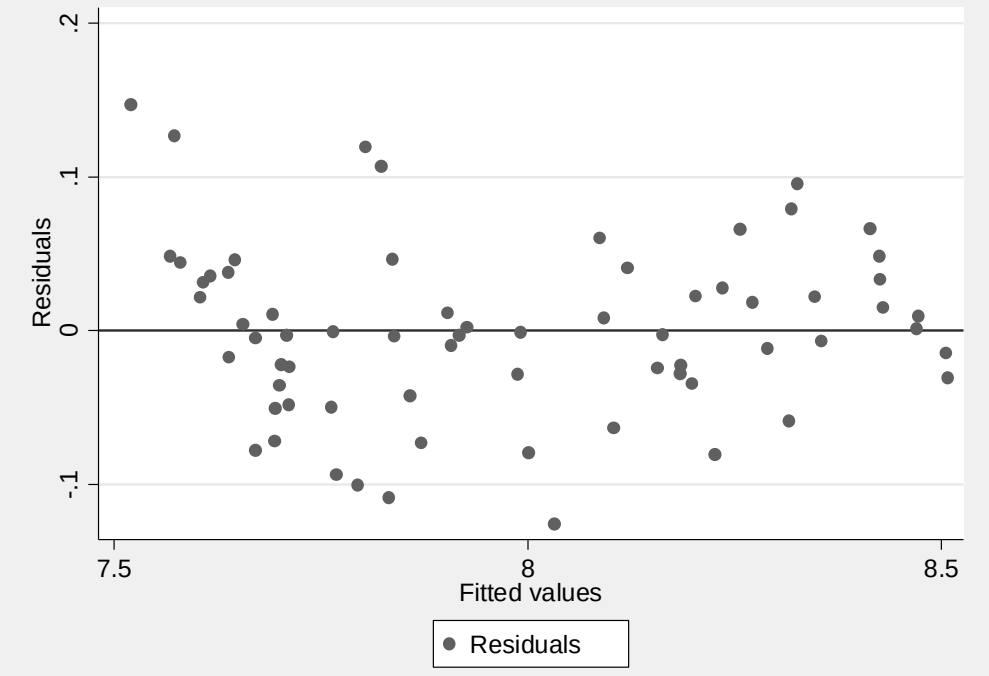


Source: Generated by the Author

The plot of the residuals against the fitted values can also be given in Figure 4.3. The plot shows that the residuals do not indicate a particular pattern/distribution when plotted against the fitted values. The lack of a pattern indicates that there is no violation of the assumptions underlying ordinary least-squares.

[5] *The Engle-Granger test is based on fewer distributional assumptions and does not need identification of the cointegrating rank (i.e. number of cointegrating vectors).*

Figure 4.3: Plot of Residuals against the Fitted Plot



Source: Generated by the Author

Engle and Granger (1987) points out that non-stationary I(1) time series will in effect cancel-out each other to yield a stationary, I(0) residual and as a result the data series will therefore be cointegrated on the condition that the residual is stationary. The Engle-Granger cointegrating test based on the residual (u_t), which has inherently been generated from OLS estimation, have been carried out and are presented in Table 4.4. In this residual based cointegration test, we have used critical values provided by Engle and Yoo (1987) as opposed to the ordinary ADF test values.

Table 4.4: Engle-Granger Cointegration Test Results

				Number of Obs. = 67
	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	*–4.933*	*–4.959*	*–4.419*	*–4.133*
p-value for Z(t) = 0.0000				

Source: Generated by the Author

From this test results, we reject the null hypothesis which argues that there is a unit root in the residual (u_t) series. The rejection of the null hypothesis is evidence that the residual is stationary, implying that the series are actually cointegrated i.e. a long-term relationship exists among the research variables.

4.2.5 Test for Structural Breaks

Relationships among economic variables may change over time. Thus, testing for structural breaks is extremely important when analysing long time series. This is because, Perron (1989) argues, the structural breaks could lead to biased/inconsistent test results. We can have structural breaks in the cointegrating space and also in the level variables. We have carried out the Wald tests to determine if there are unexpected shifts in the time series, at an unknown break dates. The test results are presented in Table 4.5. The results show that the individual variables experienced a structural change in different times. However, the long run regression model for real money demand function experienced a structural break in 2009.

Table 4.5: Structural Break Test Results

Variable	*Test Statistic*	*p-value*	*Estimated break date*
lnRM	18.712	0.002	2005q3
lnInf	4.487	0.644	2003q1
lnExR	14.460	0.014	2008q3
lnintR	17.625	0.005	2003q4
lnY	72.148	0.000	2004q3
Regression Model	248.082	0.000	2009q1

Source: Generated by the Author

Hungnes, (2010) shows that we can control for the structural breaks by including a dummy variable in the empirical analysis, which assumes zero until the structural break, and one thereafter.

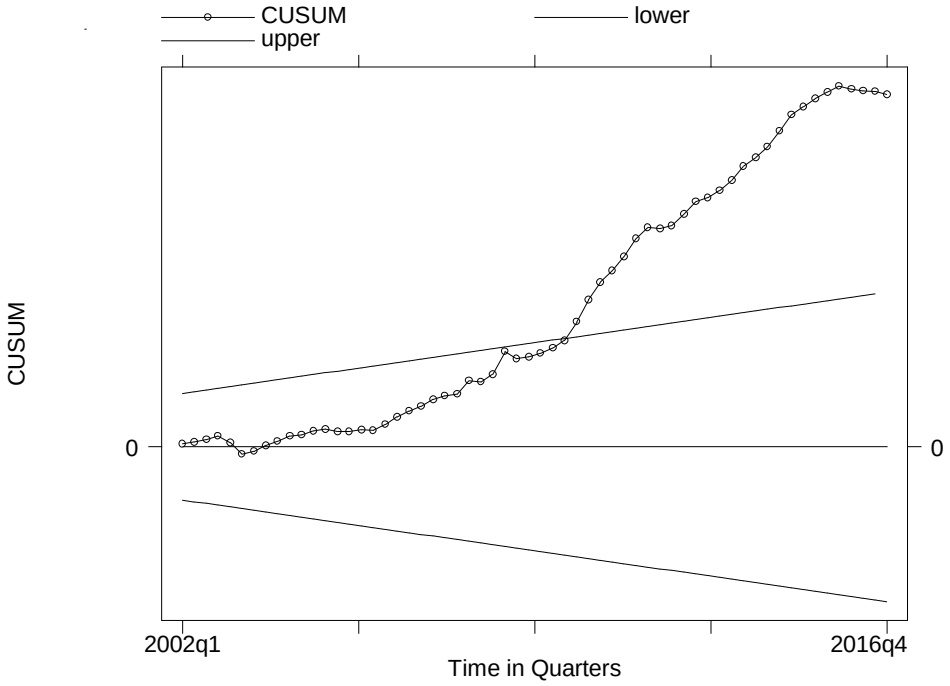
4.2.6 Model Stability Test

The existence of cointegration among the variables does not necessary suggest that the long-run model is stable. Although pre-estimation tests indicate that the model has been well specified, we note that some long-run coefficients are not significant. We have carried out parameter stability test to check if lack of significance is due to existence of instabilities in the money demand function. This will help us to assess the effects of financial innovations on money demand stability in Kenya.

To achieve this goal, we have applied the recursive stability tests as proposed by Brown, *et. al.* (1975). The tests are based on cumulative sum of recursive residuals (CUSUM), and the cumulative sum of squares of recursive residuals (CUSUMSQ) tests to the residuals of the estimated long-run econometric model. This tests for the stability and constancy of the estimated coefficients which can also determine if there are structural breaks in the money demand function.

In the stability analysis, the estimated parameters are considered to be stable if they fall inside the critical bounds within the 5% critical lines. The use of this bound testing approach to establish whether the demand for money function in Kenya is stable, is superior over the Chow test because we do not have *priori* knowledge whether there exists structural breaks in the function and the exact time of a structural break. Figure 4.4 and Figure 4.5 show the results for parameter stability test in the long-run model, based on the CUSUM and CUSUMSQ methods.

Figure 4.4: CUSUM Test Result



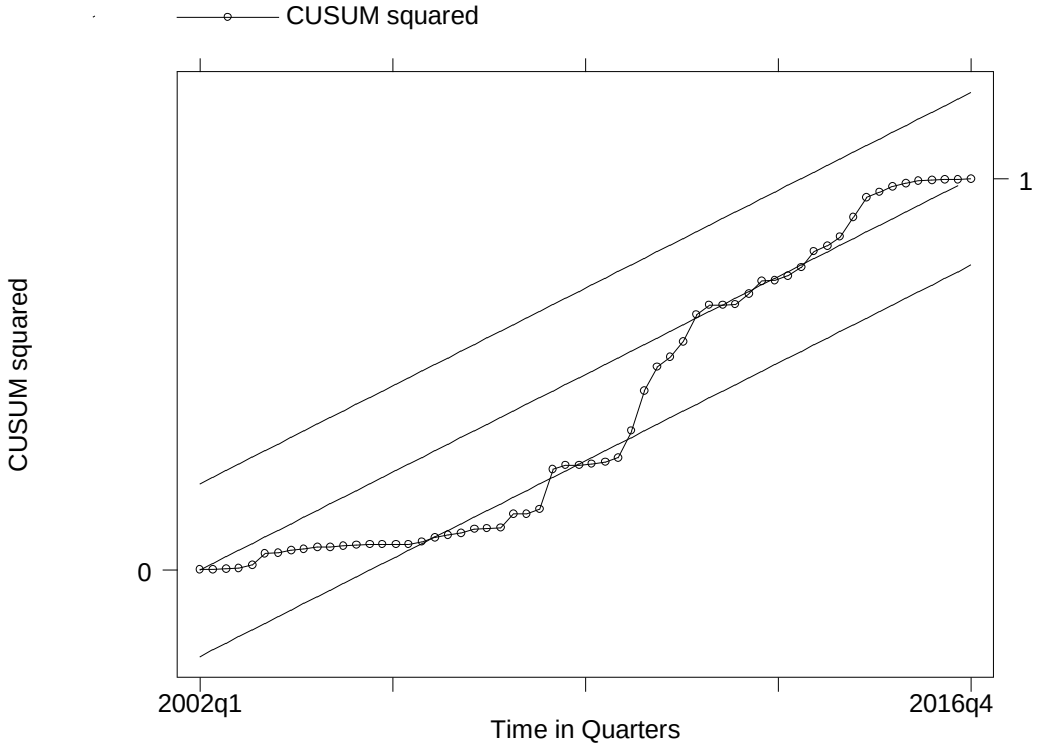
Source: Generated by the Author

The above CUSUM graph shows that parameter stability may have encountered a structural break leading to instabilities in the money demand function. The parameter instability seems to be present in the model, as from the year 2009. This result is consistent to Wald tests on the model as present in Table 4.5. Prior to 2009q1, the CUSUM plot is noted to drastically start developing a unique change from its relatively low to a sharp positive slope. This divergence

continues until the curve moves out of the critical bounds, within the 95% confidence level, and remains unstable to the end of the research period.

The CUSUMSQ plot shown in Figure 4.5 can be interpreted in a similar way to the CUSUM plot. However, this plot uses cumulative sum of squares of recursive residuals and is essential in measuring parameter constancy. From the plot in the CUSUMSQ graph, we notice a movement of some of the estimations outside the boundaries of stability (critical lines) and thus indicating lack of parameter or variance stability and constancy in the model.

Figure 4.5: CUSUMSQ Test Result



Source: Generated by the Author

The findings in this research paper are similar to most recent findings in studies by Weil, et al. (2012), and Ndirangu and Nyamongo (2014) which established that there are instabilities in money demand, especially after the year 2007. These studies also found out that there is a structural break in the financial system and attributed this to mobile money transfers which had been introduced in March 2007. Sichei and Kamau (2012) also established instabilities in the money demand function and a structural break in 2003 which they attributed to changes in both the fiscal and monetary regimes. However, these recent studies are in contrast to earlier findings by Adam (1992) who had established that demand for money function for Kenya was stable from 1973 to 1989. This difference could be due to the changing financial environment over the period, such as financial sector development, including financial innovations.

4.3 Long-Run Econometric Model

The cointegration test has established that there is a long-term relationship among the variables. The establishment of cointegration implies that there exists a valid error correction representation of the series. Thus, the Error correction model (ECM) is the most appropriate method for our analysis in order to measure both the short-run dynamics and long-run parameters of the model. The long-run relationship is presented in Table 4.6. This estimation has been based on OLS regression, and therefore the residuals measure disequilibrium in the long-run relationship[6]. We have incorporated a time dummy variable (dt) to control for the observed structural break in the model. We have also applied determined optimal lag levels for the variables. This regression constitutes the 1st-step of Engle-Granger Two-Step approach to Error correction model.

Table 4.6: Long-run (equilibrium) equation estimation Results[7].

Number of obs	=	64	
F(6, 56)	=	627.91	
Prob > F	=	0.000	
R-squared	=	0.973	
Root MSE	=	0.048	

lnRM	**Coef.**	**Std. Err.**	**T**	**P>|t|**	**[95% Conf. Interval]**	
lnInf	–0.036	0.011	–3.28	0.002	–0.057	–0.014
lnExR	0.493	0.103	4.81	0.000	0.288	0.698
lnintR	0.019	0.008	2.31	0.024	0.002	0.035
lnY	0.938	0.054	17.39	0.000	0.830	1.046
dt	–0.638	0.057	–11.26	0.000	–0.751	–0.524
_cons	0.303	0.374	0.81	0.422	–0.446	1.052

***Source**: Generated by the Author*

From the 1st-step long-run regression results, we note that the p–value for F-test is zero and this implies that the regression model is statistically significant at all significance levels. Consequently, the model has explanatory power in our empirical analysis. The model has a coefficient of determination (R-squared) of 0.973, which implies that the independent variables (inflation, exchange rates, interest rates, and the level of economic activity) explain 97.3% of the variability in the dependent variable (demand for real money).

[6] *Since cointegration holds, then the OLS estimator in this regression is super-consistent.*
[7] *We have also specified robust standard errors to control for autocorrelation and heterogeneity.*

The long-term elasticities show that the income elasticity of real money demand in Kenya is less than unity (0.938) and has the correct expected sign. This implies that changes in real GDP induce a less than proportional rise in demand for real money balances in the long term. According to Sichei and Kamau (2012), the close to unity elasticity can be attributed to monetization and economic development. The result is slightly different from previous studies by Sichei and Kamau (2012), Ndung'u (1994), and Ndele (1991) which had established an elasticity of 1.46, 1.7, and 1.92, respectfully. We also note that inflation elasticity, and exchange elasticity have the expected signs and are statistically significant. However, the coefficient for interest rate does not show the expected sign and is also different from the findings by Ndung'u (1994) who got an interest rate elasticity of -1.97.

4.4 Error Correction Model Estimation

We have carried out the ECM model estimation based on Engle-Granger Two-Step Approach to cointegration analysis. This is based on the robustness of this method over other methods. The error correction model will also incorporate dummy variables to control for the structural breaks identified in the model variables.

4.4.1 Engle-Granger Two-Step Representation

The EG 2-step ECM results, presented in Table 4.7, show the behaviour of the research variables in the short run in relation to the long run cointegrating relationship.

Table 4.7: Engle-Granger* 2-Step *ECM Estimation Results

Source	SS	df	MS
Model	0.014	6	0.002
Residual	0.026	56	0.000
Total	0.040	62	0.000

Number of obs	= 63
F(6, 56)	= 4.89
Prob > F	= 0.000
R-squared	= 0.344
Adj R-squared	= 0.274
Root MSE	= 0.022

LD.lnRM	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnInf LD	–0.022	0.007	–3.11	0.003	–0.036	–0.008
lnExR LD	0.245	0.083	2.94	0.005	0.078	0.412
lnintR LD	–0.003	0.009	–0.29	0.770	–0.020	0.015
lnY LD	0.133	0.064	2.08	0.042	0.005	0.260
dt	–0.104	0.051	–2.04	0.047	–0.207	–0.002
ECT-1	–0.171	0.073	–2.34	0.023	–0.318	–0.025
_cons	0.010	0.003	3.49	0.001	0.004	0.016

Source: *Generated by the Author*

The empirical results from the Engle-Granger 2-step ECM estimation, show that the error correction term coefficient, for the model, which measures the speed at which the variables adjust towards equilibrium is statistically significant and has the expected theoretical sign (it is negative). This is consistent with theory and previous empirical studies, and therefore implies that there is convergence towards equilibrium level in long run. We also note that all the variables have the expected signs, and are significant except for interest rates. This therefore implies that interest rates do not affect demand for real money balances in the short run.

From the generated Engle-Granger 2-step ECM estimation results, we have therefore reformulated equation 3.9 and incorporated the coefficients to generate the error correction model. The formulated error correction mechanism, which represents the short-run model, can be presented as shown in Equation 4.0 below.

$$\Delta \ln RM_t = 0.010 - 0.022\Delta lnInf_t + 0.245\Delta lnExR_t - 0.003\Delta lnintR_t - 0.133\Delta lnY_t - 0.171ECT_{t-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4.0)$$

The ECM results represent the elasticities of various variables that determine demand for money function for Kenya. From the results, the inflation rate elasticity of demand for money is 0.022, while exchange and interest rate elasticities of demand for money are 0.245 and 0.003 respectively. The results also show that the response of real money demand to changes in output is 0.133. From the error correction term coefficient of –0.171, we can conclude that about 17.1% of the overall system changes are corrected in the period after the disturbance. This implies that the system converges towards the long term equilibrium at a rate of 17.1% per quarter.

From the EG 2-step ECM results, we note that all the coefficients for the real money demand function have the expected coefficient signs as presented in section 3.4.1 of this research paper. Furthermore, considering the *p-values* for the *t-statistics* presented in Table 4.6, we note that, apart from the interest rate coefficient, all the other coefficients are statistically significant. The statistical significance of the dummy variable implies that the structural breaks in the money demand function have strong effects on money demand. The lack of statistical significance for the interest rate coefficient could be due to model misspecification, or instabilities in the process, or other factors which may not have been controlled for in the model.

4.5 Post-Estimation Tests

It is important that Engle-Granger 2-step ECM estimation results be interpreted when the econometric model is stationary and properly specified. This section describes the various post-estimation diagnostic tests undertaken. Among others, Enders (2004), identifies three major diagnostic tests which can be carried out to determine whether the estimated model is appropriately specified. These include serial correlation tests to determine if the residuals approximate white noise; granger causality, and innovation accounting (impulse–response and variance decomposition analysis) tests to determine interactions among the research variables. In addition, we have also tested for existence of autoregressive conditional heteroscedasticity (ARCH) effects.

4.5.1 Test for Autocorrelation

In the post-estimation tests we have also carried out tests for autocorrelation in the residuals from the error correction model. We have used Durbin's alternative test and Breusch-Godfrey methods to test for serial correlation. The test results for these two tests are presented in Table 4.8 and 4.9. From these test results, we do not reject the null hypothesis, which states that there is no serial correlation, at all lag levels. This provides strong evidence to conclude that the econometric model is properly specified.

Table 4.8: Durbin's Alternative Test for Autocorrelation Results

lags(p)	chi2	Df	Prob> chi2
1	1.266	1	0.261
2	1.597	2	0.450
3	5.975	3	0.113
4	6.767	4	0.149
H_0: No Serial Correlation			

Source: *Generated by the Author*

Table 4.9: Breusch-Godfrey LM test for autocorrelation

lags(p)	chi2	Df	Prob> chi2
1	1.410	1	0.235
2	1.799	2	0.407
3	6.363	3	0.095
4	7.231	4	0.124
H_0: No Serial Correlation			

Source: *Generated by the Author*

4.5.2 Granger Causality Test

It is important to note that although regression analysis refers to the dependence of one variable on other variables, it does not then entail causation. This means that existence of long-run relationship between variables should not be taken to prove causality or any direction of influence. This argument has been clearly explained by Gujarati (2004: 696). This therefore implies that establishment of long-run money demand function may not be sufficient for formulation of policy decisions. As a result, it is essential to analyse the direction of causality, and determine whether a variable is useful in forecasting another.

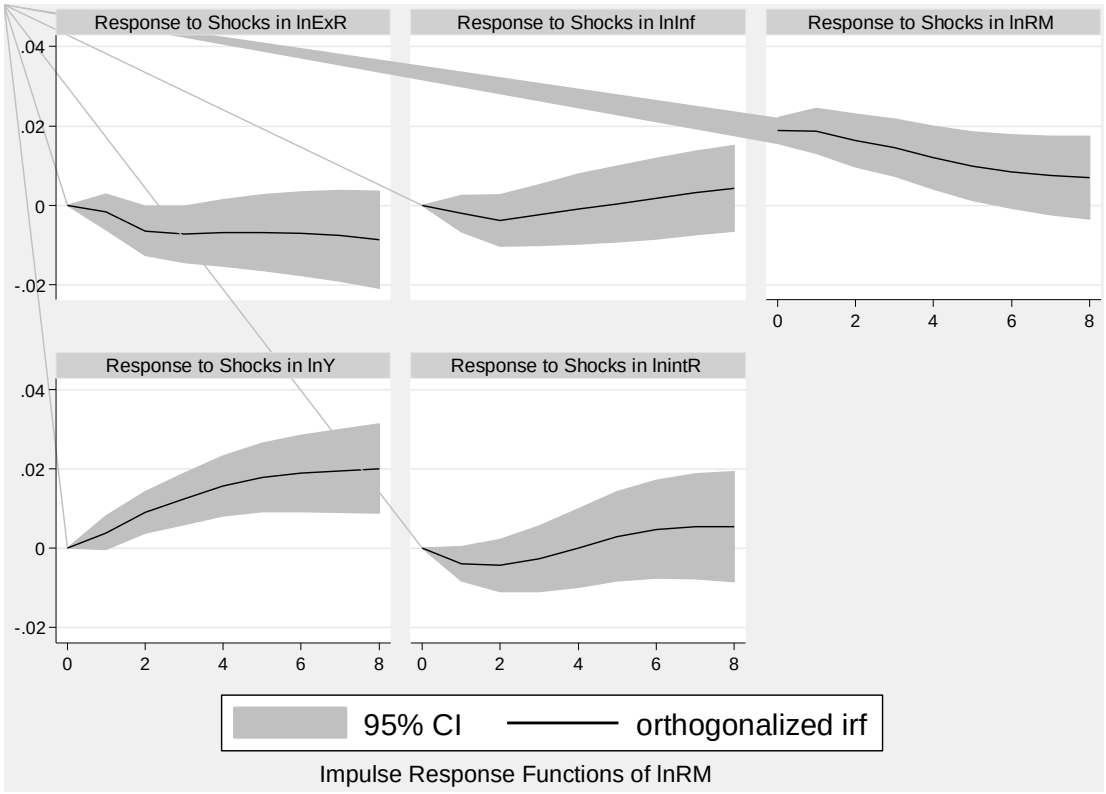
This test determines whether a given time series is useful in forecasting time series. It can establish whether there is causal relationship between variables. The Wald-type Granger causality test checks for non-zero correlation between the error processes of cause and effect variables. It tests that the coefficients on all the lags of an endogenous variable are jointly zero. For each equation, the tests check the hypotheses that each of the other endogenous variables does not Granger-cause the dependent variable in that equation. The null hypothesis, $H_{0,}$ states that the Lagged variable *[Excluded]* does not cause the *Equation Variable*. Appendices 2 presents a summary of Granger Causality Wald Tests at various lag specifications.

From the test results with a specification for the optimal lag level, we note that all variables jointly granger cause lnRM but individually lnInf, and lnintR do not granger cause lnRM within 5% confidence level. We also note that only lnRM, lnintR, and all variables jointly granger cause lnExR. Only lnintR, and jointly all the variables granger cause lnInf. With a specification of 3 and 4 lags, lnRM, lnInf, and jointly all the variables granger cause lnintR. Finally, the results show that only lnExR and all variables jointly granger cause lnY.

4.5.3 Impulse Response Functions

Impulse Response Functions (IRF) measures the effect of a one percent change to an endogenous variable on itself or on another endogenous variable over time. To help us measure how real money demand responds to changes in other variables, Inflation rate, Exchange rate, Interest rate, and Income were set as the impulse variables, and real money demand as the response variable. The impulse response function graphs show the path in which the response variable diverges from or converges to its equilibrium position within a given timeframe as shocks occur. The IRF summary graphs are presented in Figure 4.6, while the impulse response tables are presented in Appendix 6 (Tables 6A-6E).

Figure 4.6: Impulse Response Function Graphs

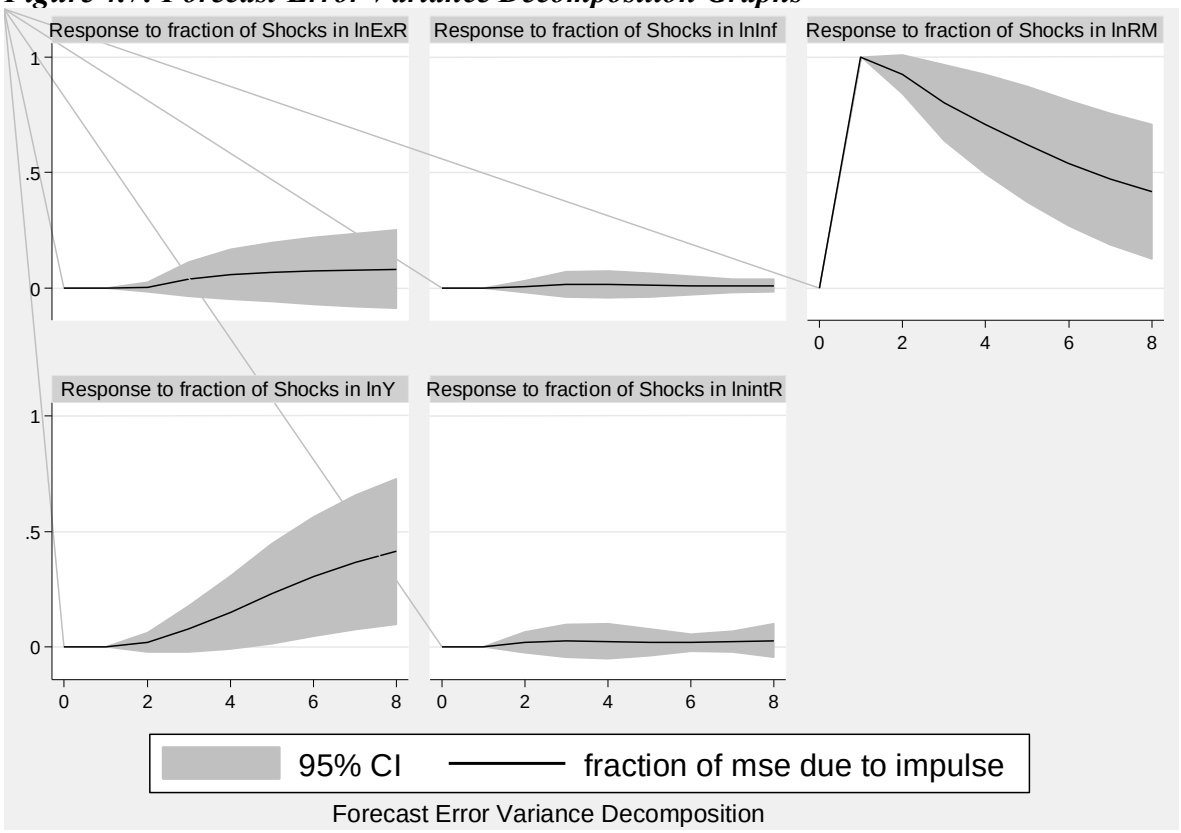


Source: *Generated by the Author*

A one percent orthogonal rise in real money demand leads to an immediate 1.89% increase in itself and further series of decreasing changes. A one percent orthogonal rise in inflation rate and exchange rate increases demand for real money balances by about 0.21% and 0.16% respectively in the first quarter followed by a series of insignificant reductions. A change in interest rate reduces demand for real money balances by 0.39% in the first quarter, stabilizes after three quarters but creates further insignificant increases. However, a one percent change in real income increases money demand by 0.38% in the following quarter and a series of increases of over 2% after two years.

The variance decomposition gives useful insights on the forecast errors which enable us to analyze the interaction between real money demand and the research variables. It gives the proportion of the movements in real money demand due to a shock to itself and to shocks in the other variables. The forecast error variance decomposition (FEVD) graphs are presented in Figure 4.7. A tabulation of the test results are presented in Tables 6A-6E in Appendix 6.

Figure 4.7: Forecast-Error Variance Decomposition Graphs



Source: *Generated by the Author*

The variance decomposition results shows various scenarios. The fraction of the variance on forecast errors in real demand for money due to a shock on itself is unity in the quarter after the shock, followed by a series diminishing proportion of variances. However, the share of the variance of forecast errors due to changes in other variables is zero in the first quarter, but generally increases thereafter. For instance, the result shows that about 2.4% of changes in real money demand are explained by 1% change in interest rates in the first year, a fraction that rises to 2.8% in the second year. Similarly, 1.9% of changes in real demand for money are explained by a 1% increase in income and this fraction rises to 41.4% in the second year. These high and significant changes will definitely have significant impacts in monetary policy.

4.5.4 Test for Autoregressive Conditional Heteroscedasticity (ARCH)

We have carried out Engle's Lagrange multiplier (LM) test for the existence of autoregressive conditional heteroscedasticity. The null hypothesis states that the regression disturbances are normally distributed. Table 4.11 presents the test results for ARCH (1), ARCH (2), ARCH (3), and ARCH (4) effects. Based on these results, we do not reject the null hypothesis, and we therefore conclude that the error term does not contain ARCH effects.

Table 4.10: LM Test for ARCH

lags(*p*)	chi2	df	Prob > chi2
1	0.462	1	0.4965
2	2.034	2	0.3618
3	3.219	3	0.3590
4	3.020	4	0.5544

H0: no ARCH effects *vs.* H1: ARCH(*p*) disturbance

Source: *Generated by the Author*

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter gives a summary of the study findings, the study conclusion, policy recommendations, and suggestions for further studies. The chapter comprises of three sections. Section 5.2 presents and discusses the summary of the empirical research findings. The next section constitutes the research conclusions while section 5.4 elaborates the policy implications based on the research findings, discusses the various monetary policy alternatives, and subsequently makes policy recommendations in consideration to the research findings. Finally, section 5.5 provides recommendations areas of further research on this paper's subject.

5.2 Summary of Findings

The main objective of carrying this research was to determine and investigate the stability of the real money demand function in Kenya. We have therefore tried to empirically establish the long-run and short-run relationships for the money demand function in the period between 2000:Q1 to 2016:Q4. We have tested whether the money demand function is stable over the period of study and whether there is any structural break over the period of study.

To achieve this goal, we have used the Engle-Granger two-step procedure to estimate the long-term relationship between demand for money and its determinants. Additionally, using the Engle-Granger two-step representation, we have estimated the error correction model for money demand. Based on the parameters of the estimated long-run relationship, we have investigated the stability of the money demand function and constancy of the estimated parameters for the period between 2000:Q1 to 2016:Q4.

Results from the Engle-Granger two-step procedure indicate that there is a long-term relationships between real money demand and its determinants. The error correction term (ECT) which measures the speed of adjustment for the real money function in Kenya is established to be –0.1715. From the estimated error correction model, we note that all the coefficients have the expected signs and apart from interest rates they are statistically significant within 5% significance level.

Post-estimation tests carried out have shown that the model is properly specified. However, parameter stability checks based on the CUSUM and CUSUMSQ tests, proposed by Brown, *et. al.* (1975) show instabilities and lack of parameter constancy. This therefore shows that real money demand function for Kenya is not stable during period under study. Further tests have confirmed that there is a structural break in the money demand function during the period; the estimated structural break date being 2009q1.

Granger causality tests show that all variables jointly granger cause lnRM, but individually lnInf does not granger causes lnRM. On the other hand, lnRM granger causes lnExR and lnintR within a specification of 4 lags. The impulse response function analysis shows that the orthogonalized IRFs do not change significantly. The forecast errors variance decomposition analysis shows that relatively high, significant and increasing changes in real money demand can be attributed to shocks in the explanatory variables. However, with a shock on itself, the proportion of variation is unity in the following quarter but diminishes in the course of time.

The lack of real money demand stability has various implications in the monetary policy, notably it can be a source of uncertainty in the financial system. This could as a result weaken the credibility and ability of achieving CBK's goals and monetary policy targets. As a result, monetary aggregates may not be appropriate for use as targets in the conduct of monetary policy. Mishkin and Savastano (2001) argues that monetary targeting may not be a viable strategy in emerging market economies due to the likelihood of instabilities in the money demand function. This may present a similar policy scenario to Kenya, as shown in our research findings. Hence, there is need to explore more and alternative monetary policy strategies for application in the presence of instabilities in the money demand function. Section 5.4 offers analysis of alternative strategies and this paper's policy recommendations for consideration.

5.3 Conclusion

Based on the findings of this research, we have made various research conclusions. Similar to various studies such as Weil, et al. (2012), Sichei and Kamau (2012), and Ndirangu and Nyamongo (2014), we conclude that there is a long-term relationship between real money balances and its determinants in Kenya. Secondly, based on the recursive stability tests, we conclude that the money demand function for Kenya is not stable in the period under study. We also conclude that there is a structural break in the money demand function, estimated to have occurred in the first quarter of 2009. Finally, based on FEVD analysis, the significant changes in real money demand due to changes in interest and income imply that domestic asset holders prefer to invest in interest earning financial assets instead of holding cash money balances. This can be attributed to the evolving financial development and innovations in Kenya.

We take cognizance that Kenya's major financial disruption, mobile money, was introduced in 2007, and note that this financial innovation could be the cause of instabilities observed in the real money demand function. As shown in Table 1.2 and 1.3, mobile money and other cashless systems' growth in Kenya continue to provide alternatives to the demand for cash money balances. This concurs with Ireland (1995) who notes that instabilities in the standard money demand function can be attributed to financial innovations in the private sector, among other factors.

5.4 Policy Implications and Recommendations

A stable money demand function is an appropriate way of ensuring that monetary policy decisions have a predictable effect on other economic variables. Notably, monetary policy which is anchored on monetary targeting calls for consistent quantitative estimates of money demand. However, in this study we have found that money demand function in Kenya is not stable. This implies that the current monetary stance, which is based on monetary, and inflation targeting, may not be effective. As a result, this calls for consideration of alternative monetary policy frameworks that can be employed to achieve desired economic goals.

Monetary targeting allows custom–policies that fit into the domestic environment and enables selection of inflation goals that can react to fluctuations in output. It also passes immediate signals to the economy in regard to monetary policy stance. However, this framework is only appropriate and reliable when there is a strong and stable money demand relationship. Inflation targeting, which also allows a focus on the domestic environment, allows some flexibility and

discretion, and a focus on long-run effects. Monetary policy however suffers in that it incurs huge economic costs in a bid to eradicate inflation. Secondly, inflationary targets are also not achieved immediately to ensure economic stability. It also runs the risk of discretionary monetary manipulation which could be dangerous to the economy.

Exchange rate targeting is another alternative monetary policy strategy which the Central Bank of Kenya can take into consideration in the conduct of monetary policy. In exchange rate targeting, the Central Bank ensures nominal exchange rate stability in relation to a stable low inflation foreign currency. Thus price stability is achieved through direct foreign exchange interventions and interest rate variations. This ensures that domestic inflation is therefore kept under control. The framework also provides immediate responses which can help to diminish time-inconsistency problems. Finally, it is simple and clear to the general public.

However, this framework requires maintenance of an adequate level of international reserves, suitable economic policy blend that ensures low inflation gap in relation to the anchor country. It also calls for the presence of strong institutional systems (legislative framework and political stability), and overall credibility to ensure its success. The framework also involves a trade-off between price stability and competitiveness. Furthermore, it can lead to loss of independence of monetary policy for the targeting country, and leads to transmission of economic shocks from the anchor economy to the targeting country. As a result, exchange rate targeting has the potential of leading to higher output volatility.

Finally, the Central Bank can also consider Nominal GDP targeting in the conduct of monetary policy. This strategy ensures that expenditure is maintained at a rate that ensures that inflation is close to the preferred level but at the same time reducing the fluctuations in real cyclical aggregates. The strategy has various advantages over other frameworks in that it enables policy makers to directly target fluctuations in output, and it is also less volatile compared to the level of prices. Additionally, the strategy takes into consideration the volatile financial innovations, which have been, and continue to be experienced in Kenya's financial system.

Considering the foregoing alternative monetary policy strategies, this research study recommends that the Central Bank of Kenya considers the use of a mix of targets, including the nominal GDP targeting in its conduct of monetary policy.

5.5 Recommendation for Further Study

In closing, this research study cannot be considered to have a final and irrefutable position for research on issues relating to Kenya's demand for money function. The research findings and conclusions made herein cannot be considered to be the final authority on this topic. However, it is our consideration that this research work will provide a basis to policy makers, and researchers in expanding research work on Kenya and other economies' money demand function, and monetary policy stance.

This research paper therefore calls for further studies that incorporate other factors which this paper may not have included in the model specification. Specifically, this study recommends further studies including a wide range of determinants of money demand, use of other methodologies such as fractional cointegration analysis and/or the nonlinear cointegration analysis to confirm the robustness of this research paper's results. We also recommend advanced studies that formulate research models which can directly include a financial innovations variable or its proxy and other factors which can unduly influence unit root tests.

There is also a need for more studies on the application of the various alternative monetary policy strategies in Kenya. A specific focus on the nominal GDP targeting will be beneficial to policy makers on particularly on how effective it could be implemented to achieve the desired goals. This will ensure that any challenges of moving to an alternative monetary policy framework is well informed, and it is effectively and efficiently implemented.

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APPENDICES

Appendix 1: ***Individual Variable Lag-Order Selection***

Table A1: Lag-Order Selection for lnRM

Selection-order criteria
Sample: 2001q1 - 2016q4 Number of obs = 64

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-12.9697				.090598	.436552	.449841	.470285
1	149.101	324.14	1	0.000	.00059	-4.59691	-4.57033	-4.52945*
2	150.367	2.5311	1	0.112	.000586	-4.60521	-4.56534	-4.50401
3	151.305	1.8773	1	0.171	.000587	-4.60329	-4.55014	-4.46836
4	153.486	4.3606*	1	0.037	.000566*	-4.64018*	-4.57373*	-4.47151

Table A2: Lag-Order Selection for lnInf

Selection-order criteria
Sample: 2001q1 - 2016q4 Number of obs = 64

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-58.9771				.381521	1.87428	1.88757	1.90802
1	-28.436	61.082	1	0.000	.151567	.951126	.977704	1.01859
2	-23.7154	9.4412	1	0.002	.134936	.834857	.874724	.936054
3	-22.0379	3.3551	1	0.067	.132122	.813683	.866839	.948613
4	-14.6616	14.752*	1	0.000	.108269*	.614425*	.68087*	.783088*

Table A3: Lag-Order Selection for lnExR

Selection-order criteria
Sample: 2001q1 - 2016q4 Number of obs = 64

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	47.9096				.013517	-1.46592	-1.45264	-1.43219
1	123.806	151.79*	1	0.000	.001301	-3.80643	-3.77985*	-3.73897*
2	124.843	2.0738	1	0.150	.0013*	-3.80759*	-3.76772	-3.70639
3	125.549	1.4116	1	0.235	.001312	-3.79839	-3.74524	-3.66346
4	125.75	.40328	1	0.525	.001345	-3.77344	-3.707	-3.60478

Table A4: Lag-Order Selection for lnintR

Selection-order criteria
Sample: 2001q1 - 2016q4 Number of obs = 64

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-55.8778				.346302	1.77743	1.79072	1.81116
1	-15.0853	81.585	1	0.000	.099864	.533915	.560493	.60138
2	-7.3835	15.404*	1	0.000	.080999*	.324484*	.364351*	.425682*
3	-6.88613	.99474	1	0.319	.082289	.340191	.393347	.475122
4	-6.82017	.13191	1	0.716	.084739	.36938	.435825	.538043

Table A5: Lag-Order Selection for lnY

Selection-order criteria
Sample: 2001q1 - 2016q4 Number of obs = 64

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-55.0611				.337575	1.75191	1.7652	1.78564
1	54.7523	219.63*	1	0.000	.011262*	-1.64851*	-1.62193*	-1.58104*
2	55.2308	.95699	1	0.328	.011447	-1.63221	-1.59234	-1.53101
3	55.6275	.7934	1	0.373	.011666	-1.61336	-1.5602	-1.47843
4	55.7296	.2043	1	0.651	.012	-1.5853	-1.51886	-1.41664

Table A6: Lag-Order Selection for dummy

Selection-order criteria
Sample: 2001q1 - 2016q4 Number of obs = 64

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-46.4506				.257937	1.48283	1.49612	1.51657
1	43.2569	179.42*	1	0.000	.016129*	-1.28928*	-1.2627*	-1.22181*
2	43.2569	0	1	.	.016642	-1.25803	-1.21816	-1.15683
3	43.2569	0	1	.	.017172	-1.22678	-1.17362	-1.09185
4	43.2569	0	1	.	.01772	-1.19553	-1.12908	-1.02686

Appendix 2: ***Granger – Causality Wald Tests – 1 to 4 lag specifications***

		4 lags		3 lags		2 lags		1 lags	
Equation	**Excluded**	**chi2**	**Prob> chi2**	**chi2**	**Prob> chi2**	**chi2**	**Prob >chi2**	**chi2**	**Prob> chi2**
lnRM	**lnInf**	1.45	0.84	0.51	0.92	0.78	0.68	2.17	0.14
lnRM	**lnExR**	14.47	0.01	20.92	0.00	6.49	0.04	7.35	0.01
lnRM	**lnintR**	8.91	0.06	4.41	0.22	3.95	0.14	0.07	0.80
lnRM	**lnY**	15.66	0.00	21.34	0.00	14.02	0.00	16.60	0.00
lnRM	**ALL**	55.47	0.00	47.07	0.00	24.13	0.00	22.46	0.00
lnInf	**lnRM**	7.23	0.12	5.56	0.14	4.20	0.12	6.17	0.01
lnInf	**lnExR**	6.68	0.15	1.06	0.79	1.18	0.56	0.21	0.64
lnInf	**lnintR**	30.41	0.00	13.44	0.00	9.26	0.01	5.09	0.02
lnInf	**lnY**	1.34	0.86	2.57	0.46	2.59	0.27	4.77	0.03
lnInf	**ALL**	40.65	0.00	19.68	0.07	14.84	0.06	10.51	0.03
lnExR	**lnRM**	16.35	0.00	13.34	0.00	13.65	0.00	3.85	0.05
lnExR	**lnInf**	9.10	0.06	4.81	0.19	4.18	0.12	0.58	0.45
lnExR	**lnintR**	16.58	0.00	4.75	0.19	3.85	0.15	1.38	0.24
lnExR	**lnY**	3.88	0.42	1.89	0.60	1.43	0.49	0.96	0.33
lnExR	**ALL**	45.98	0.00	26.48	0.01	21.18	0.01	8.41	0.08
lnintR	**lnRM**	16.68	0.00	10.83	0.01	0.65	0.72	0.16	0.69
lnintR	**lnInf**	16.42	0.00	12.45	0.01	0.46	0.80	1.82	0.18
lnintR	**lnExR**	6.24	0.18	2.81	0.42	7.25	0.03	1.87	0.17
lnintR	**lnY**	4.31	0.37	3.19	0.36	1.01	0.60	0.29	0.59
lnintR	**ALL**	35.40	0.00	27.47	0.01	10.56	0.23	4.82	0.31
lnY	**lnRM**	7.48	0.11	3.74	0.29	1.55	0.46	3.05	0.08
lnY	**lnInf**	8.85	0.07	8.91	0.03	4.49	0.11	3.07	0.08
lnY	**lnExR**	56.96	0.00	45.10	0.00	11.06	0.00	0.02	0.89
lnY	**lnintR**	9.21	0.06	7.06	0.07	0.97	0.62	0.02	0.90
lnY	**ALL**	75.89	0.00	60.04	0.00	20.28	0.01	5.66	0.23

Source: *Generated by the Author*

Appendix 3: ***Impulse Response Analysis Tables***

Table 6A: Impulse Response of lnRM to a Shock in itself

step	(1) oirf	(1) Lower	(1) Upper	(1) fevd	(1) Lower	(1) Upper
0	.018905	.01568	.02213	0	0	0
1	.018693	.01306	.024326	1	1	1
2	.016341	.009697	.022985	.92414	.839964	1.00832
3	.014569	.007342	.021797	.801499	.6361	.966897
4	.012061	.004148	.019973	.709027	.494514	.923541
5	.009871	.001251	.018491	.621463	.371185	.871741
6	.008415	-.000851	.017681	.5398	.266768	.812833
7	.007492	-.002338	.017322	.471874	.186112	.757636
8	.006983	-.003396	.017363	.416629	.124453	.708805

Table 6B: Impulse Response of lnRM to a Shock in lnInf

step	(2) oirf	(2) Lower	(2) Upper	(2) fevd	(2) Lower	(2) Upper
0	0	0	0	0	0	0
1	-.002101	-.006749	.002548	0	0	0
2	-.003801	-.010263	.002662	.00577	-.019848	.031389
3	-.002443	-.010144	.005259	.015522	-.038956	.069999
4	-.000937	-.009672	.007798	.01484	-.044746	.074425
5	.000249	-.009306	.009805	.011996	-.040951	.064943
6	.001672	-.008468	.011811	.009733	-.031833	.051298
7	.003121	-.007421	.013662	.008985	-.020262	.038232
8	.004269	-.006605	.015143	.010255	-.015978	.036488

Table 6C: Impulse Response of lnRM to a Shock in lnExR

step	(3) oirf	(3) Lower	(3) Upper	(3) fevd	(3) Lower	(3) Upper
0	0	0	0	0	0	0
1	-.001684	-.006116	.002749	0	0	0
2	-.006453	-.012642	-.000264	.003706	-.015798	.023211
3	-.00731	-.014447	-.000174	.036607	-.03817	.111384
4	-.006958	-.015277	.001361	.058535	-.050015	.167084
5	-.006905	-.016384	.002574	.068296	-.061017	.197608
6	-.007088	-.017609	.003433	.073285	-.071157	.217727
7	-.00766	-.019081	.00376	.076845	-.08058	.23427
8	-.008713	-.020962	.003537	.081114	-.089458	.251685

Table 6D: Impulse Response of lnRM to a Shock in lnintR

.

step	(4) oirf	(4) Lower	(4) Upper	(4) fevd	(4) Lower	(4) Upper
0	0	0	0	0	0	0
1	-.003861	-.008212	.000489	0	0	0
2	-.0043	-.010863	.002262	.019493	-.024656	.063642
3	-.002689	-.010987	.005609	.02749	-.043982	.098963
4	.000121	-.009782	.010024	.024289	-.051246	.099824
5	.002947	-.008299	.014193	.018971	-.039434	.077376
6	.004796	-.007507	.017098	.018634	-.017673	.054942
7	.00552	-.007618	.018657	.022757	-.023461	.068975
8	.005383	-.008479	.019245	.027526	-.045131	.100183

Table 6E: Impulse Response of lnRM to a Shock in lnY

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step	(5) oirf	(5) Lower	(5) Upper	(5) fevd	(5) Lower	(5) Upper
0	0	0	0	0	0	0
1	.003838	-.00039	.008066	0	0	0
2	.008974	.003728	.01422	.019257	-.023134	.061647
3	.012438	.005963	.018913	.078402	-.021746	.17855
4	.015612	.008069	.023154	.14942	-.010362	.309203
5	.017803	.009191	.026415	.230407	.014685	.44613
6	.018866	.009277	.028456	.306202	.046792	.565613
7	.01948	.00901	.02995	.36702	.075727	.658313
8	.020083	.008799	.031366	.413968	.098691	.729245