

**IMPACT OF TECHNOLOGY GROWTH ON DEMAND FOR
CURRENCY IN CIRCULATION IN KENYA**

BY

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DECLARATION

DECLARATION

This research project is my original work and has not been submitted for examination in any other university.

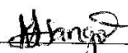
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God Bless you all.

ABSTRACT

Kenya has undergone major technological developments in banking sector which has increased efficiency, effectiveness and more so introduction of new forms of payments and new products in the banking sector. Technology is expected to reduce demand for currency in circulation by increasing the speed of money circulation, increasing supply, greater diversity of goods whose money values are transferred by electronic payment instruments, as well as allocation of electronic balance by some publishers. However, the impact of technological growth on money demand has received much attention from researchers but there is no still solid evidence on whether technology growth has reduced demand for currency in circulation. Inspired by the refutable empirical finding on technology growth and demand for money relationships and limitations of country specific studies; this study analyzed the impact of technology growth on demand for currency in circulation in Kenya. The study applied VECM estimation technique and time series quarterly data for the period 2007 – 2014 to investigate the impact of technology on demand for currency in circulation. Keynes transaction theory of money demand was used to establish a link between theory and empirics.

The empirical findings suggest a long-run causality running from the explanatory variables to demand for currency in circulation and 34% speed of adjustment to equilibrium; implying that 34% of discrepancy in demand of currency in circulation of the previous year is adjusted for the current year. The results also indicate a short run causality running from commercial lending interest rates, ATMs and Credit cards to demand for currency in circulation.

Technology growth was found to have a long-run and short run effects on demand for currency in circulation. In short- run, ATMs and credit cards were found to increase demand for currency in circulation while mobile money transfer was found to have no impact. GDP and Commercial lending interest rate were also found to have a long-run impact on the demand for currency in circulation. Commercial lending interest rates was found to affect demand for currency in circulation, in that, the higher the commercial lending rates the lesser the demand for currency in

circulation. Previous years' GDP was found to have no impact on current years' demand for currency in circulation.

It could be concluded that technology convert money to electronic forms and this tend to blur the distinction between monetary and non-monetary assets. It is therefore, prudent for the stability of the demand for money to be constantly re-examined by the monetary authorities to ensure an effective control of the monetary base since technological advancement is an ever-changing continuous process.

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ABBREVIATIONS AND ACRONYMS

GDP- Gross Domestic Product

POS- Point of Sale System

CBK-Central Bank of Kenya

CPI-Consumer Price Index

ATMs - Automated Teller Machines

ADF-Augmented Dickey-Fuller

ARCH -Autoregressive Conditional Heteroscedasticity

ECM - Error Correction Model

LM - Lagrange Multiplier

VECM - Vector Error Correction Model

1.0: CHAPTER ONE. INTRODUCTION

Individuals accept money and that's why it is used as a medium of transaction. It determines the volume of transactions and purchases in an economy. Money being an asset like any other asset earns interest. The functions of money as an asset and as a medium of transaction are very crucial to policy makers since they create the speculative and transaction demand for money respectively. Currency in circulation refers to total value of currency (coins and paper currency) that has ever been issued minus the amount that has been removed by the central bank. Money demand is the proportion of total assets that people are willing to hold in the form of money (instead of illiquid assets). For one to use money must desire to hold it, hence that the demand for money.

A lot of literature has been done on determinants of money demand whereby financial innovation is one of them. Modern technology changes in the financial sector from barter trade to card to electronic money transfer which includes and not limited to mobile money transfer (MMT), Automated Teller Machines (ATMs), Electronic Funds Transfer (EFT), Point of Sale systems (POS), cards, Real Time Gross Settlement (RTGS) and the agency-banking model have revolutionized the payments landscape. Kenya has undergone major technological developments in banking sector which has increased efficiency, effectiveness and more so introduction of new forms of payments and new products in the banking sector. Changing technologies like mobile money transfer is expected to reduce the demand for currency in circulation. This study is aimed at analyzing whether technological change in payment systems actually reduces demand for currency in circulation.

1.1 Background of the study

Recent changes in technology in the financial sector have added a lot literature in the modern world. Payments patterns have changed due to technological change in the whole world, from use of cards, web, and mobile phone based payments becoming more and more diffused in our everyday purchases. Technological changes have occurred in the banking sector making the key players develop new products and forms of payments. The cash payments are being substituted with mobile payments as the world economies move towards achieving more efficient, secure,

high speed, convenient and less expensive payment systems. Changes of technology have led to wide expansion of the e-commerce. According to Amir et, al, (2012) transfer of funds by paper-based method is considered as a major obstacle to the trade and thus electronic transfer of funds has been developed along with the development of e-commerce in various forms. The form of technological money transfer methods used which includes mobile money transfer (MMT), Automated Teller Machines (ATMs), Electronic Funds Transfer (EFT), Point of Sale systems (POS), cards, Real Time Gross Settlement (RTGS) and the agency-banking model have revolutionized the payments landscape. The effect of technology has considerable business, economic, political and social impacts. Economically, expanding the use of electronic money will be evident on the money supply, money demand, monetary policy and central bank.

Substitution of electronic money, whether in terms of the influence on money supply and of the influence on the demand for money, is especially important because firstly, fluctuations in money market will cause fluctuations in other macro markets; and secondly, influence of monetary policy will be questioned, considering the money demand reduction under circumstances similar to Keynes liquidity trap. Unlike money published by the central bank, electronic money is internal money. Electronic payment is one of the payment methods which does not affect maintenance, transaction, precautionary and speculation incentives of money. However, it may reduce demand for currency in circulation. In fact, the demand for currency in circulation is decreased by increasing the speed of money circulation, increasing supply, greater diversity of goods whose money values are transferred by electronic payment instruments, as well as allocation of electronic balance by some publishers. Experience of using electronic payment instruments in Kenya, dates back to the late 1989 by introduction of the first ATM. By the year 2007, mobile money transfers services were first introduced by launch of Safaricom's Mpesa which has long been the lone success story in the Mobile Money universe. This is a notable change in technology in terms of money transactions. In Kenya only 23% of the population has access to a bank account. By contrast, 14 million of our 20 million adult population use M-PESA, transacting over Sh2 billion a day Mobile money transfer and mobile banking will accelerate the development agenda - as tele - density picks pace; the potential for economic growth becomes significant. Mobile money payments in Kenya are rated as a world-leading mobile-money system

in the world. As result of this many researchers have found that technological changes payment systems have a positive impact on money demand, others have found no impact on the money demand but no researcher found a negative impact on the money demand. The refutable findings therefore indicates that it is uncertain that technological growth makes significance contribution to demand for currency in circulation leaving the subject matter wide open to debate and hence the reason for this study.

1.1.1 E-banking Revolution in the Kenyan banking industry

The Kenya banking sector has undergone tremendous changes against the background of general trend in globalization, development of the internet and the resulting explosion of e-commerce. Registrations have been enacted to provide a framework and guidelines to enhance adoption of new technology in Kenya. The National Payments System Act of 2011 was passed with the aim of bringing all payment service providers within a single regulatory framework under the CBK including mobile phone money transfer service providers. In 2010, the agency banking guidelines were issued and in the same year, CBK started licensing deposit taking micro-finance institutions.

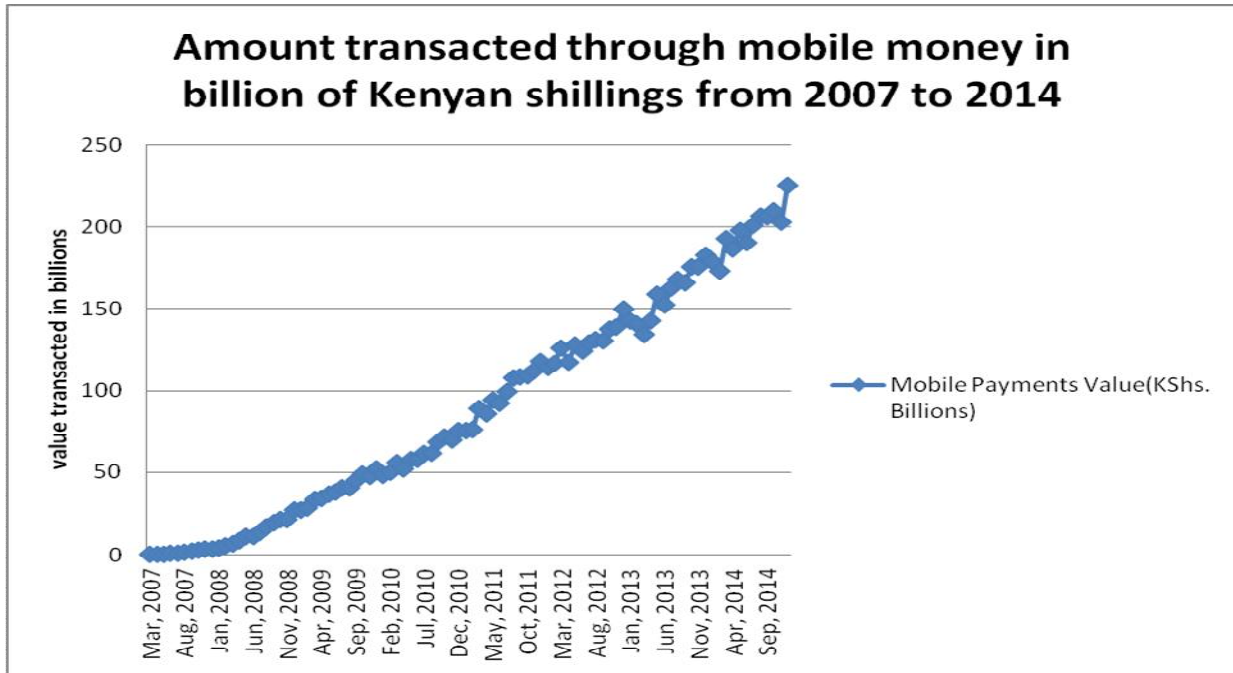
The first feature of technology in the banking sector was the Automated Teller Machines (ATMS). The number of ATMs has been steadily increasing since Standard Chartered Bank introduced the first ATM in Kenya 1989. By the year 2000, there were about 100 ATMs and by December, 2014 there were 2,613 ATMs spread all over the country. In mid 2005, Kenya's banking Industry moved a milestone by introducing Real Time Gross and Settlement system (RTGS) which was renamed Kenya Electronic Payment and Settlement system (KEPSS).

Mobile money transfers services were first introduced by launch of Safaricom's Mpesa in Kenya in 2007, which has long been the lone success story in the M-Money universe. This is a notable change in technology in terms of money transactions. In Kenya only 23% of the population has access to a bank account. By contrast, 14 million of our 20 million adult population use M-PESA, transacting over Sh2 billion a day Mobile money transfer and mobile banking will accelerate the

development agenda - as tele - density picks pace; the potential for economic growth becomes significant.

Mobile money systems consist of electronic money accounts that can be accessed via mobile phone. There are currently five mobile money companies in Kenya, four run by mobile phone operators. Safaricom's M-PESA was introduced in March 2007; Zain's-Zap was initiated in January, 2010 (now Airtel money); YuCash, was started in December, 2009 by Essar; and Orange Money (Iko Pesa) was launched in November, 2010 by Telkom Kenya. Tangaza mobile money launched in January, 2011 is a mobile money transfer not run by a mobile phone company. One can have an account linked to SIM cards for any mobile phone service provider to allow access to the Tangaza money account via the mobile phone. In view of their depth and outreach, mobile payment platforms have become an integral part of the national financial payments system as their scope in terms of the number of transactions is wider than that of traditional channels such as banks. The success in outreach of the mobile money transfer model is attributed to a large network of agents who have increased the access points for financial service. By the end of 2014, Kenya had over 25.9 million mobile money subscribers and well over 4,574,119 agents across the country. M-PESA is by far the largest system accounting for more than 90% of mobile money subscriptions.

Figure 1: Amount transacted through mobile money in billion of Kenyan shillings



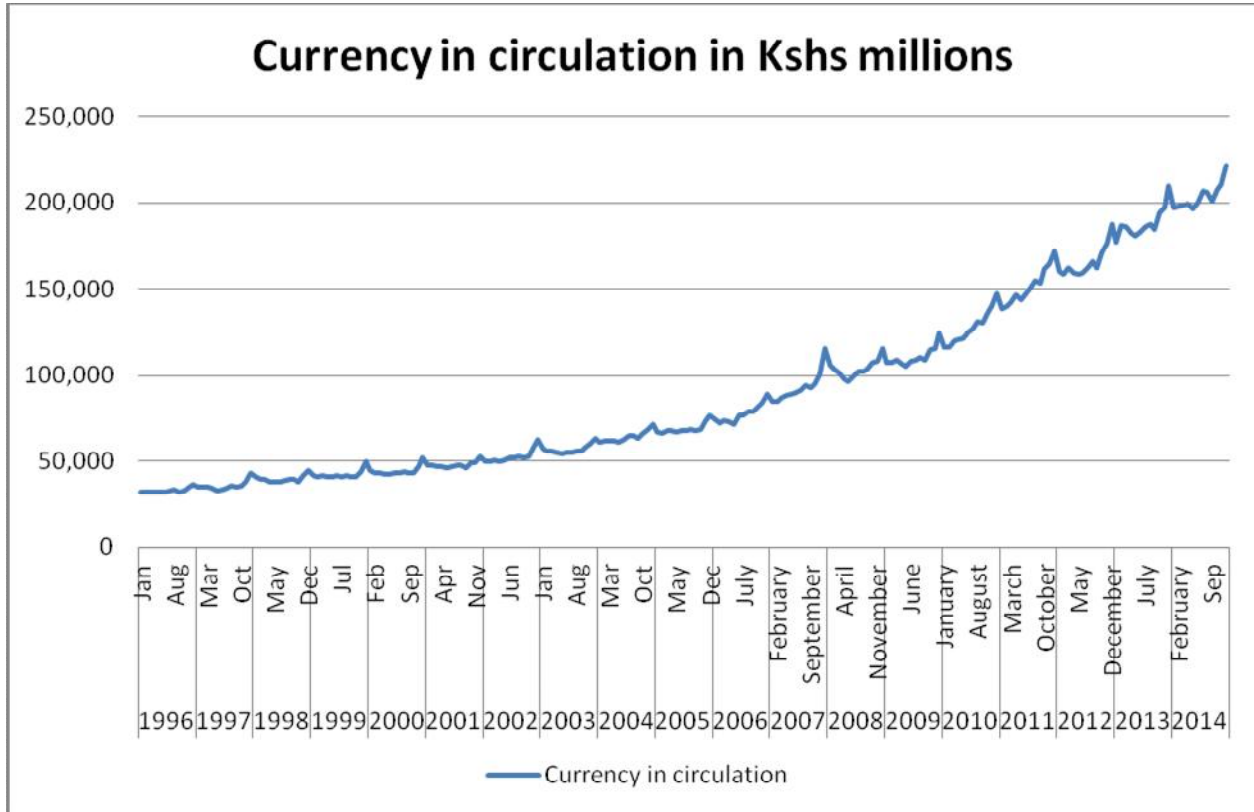
Data Source: Central Bank of Kenya

Figure 1. shows that mobile money transfers has rapidly increased to date.

1.1.2 Currency demand in Kenya

If the supply of a country's currency depreciates in relation to other currencies and more money is required to buy goods and services. Currency in circulation is the total amount of paper currency, coins and demand deposits that is held by consumers and business rather than by financial institutions and central banks.

Figure 2: Currency in circulation



Data Source: Central Bank of Kenya

Figure 2. shows that currency in circulation has rapidly increased to date.

1.1.3 Role of technology in the banking sector

Embracing technology in the banking sector plays an important role in the economy. Technology in the financial sector has led to well developed payment system which promote efficiency and effectiveness settlements of accounts from one party to another. As the efficiency in payment technologies increases the demand for money decreases. The role of technology is to reduce demand for currency in circulation.

With the technology like mobile money transfer, credit cards, point of sale, electronic money transfer, the user will have the following advantages; Firstly, reduce carrying lots of cash which is prone to theft. Secondly, the person will have mitigated the risk of being give a fake currency, since no physical handling of the cash. Thirdly, the client will be able to reduce money

laundering, since every person transacting their money electronically is legally registered and the central bank of Kenya and other security agents can track the money and be able to query in case of any doubts. Fourthly, there is a lot of cost involved in handling cash, taking example of a supermarket after a daylong sell, they have to call money transfer agencies like G4S to transfer their money to the nearest bank as opposed to loading the money to ones mobile money and sending it to the bank.

1.2 Problem Statement

Kenya has undergone major technological developments in banking sector which has increased efficiency, effectiveness and more so introduction of new forms of payments and new products in the banking sector. The role of technology is to reduce demand for currency in circulation by increasing the speed of money circulation, increasing supply, greater diversity of goods whose money values are transferred by electronic payment instruments, as well as allocation of electronic balance by some publishers but the empirical literature found contradicting results.

Researchers such as Tehranchian et,al (2012) found that technology growth increases demand for money while Kipsang (2013) indicated that technology growth has no impact on money demand. The contradicting findings coupled by limitations of the surveyed literature leave the subject matter wide open to debate.

The reviewed empirical literature has one or more of the following limitations: use few variables that represent technology growth leaving key variables like mobile money transfer and use of wrong proxies to represent technology growth. This study accounts for these limitations by giving demand for currency in circulation the right definition and including all relevant variables that define technology changes.

1.3 Objectives

1.3.1 General Objective

- i. Analyze the impact of technology growth on demand for currency in circulation.

1.3.2 Specific Objectives

- i. To establish the relationship between technology growth and demand for currency in circulation.
- ii. Identify other factors which affect demand for currency in circulation.
- iii. Draw policy recommendations from the findings.

1.4 Research Questions

The study ought to answer the following questions;

- i. What is relationship between technology growth and demand for currency in circulation?
- ii. What are other factors which affect demand for currency in circulation?
- iii. What are the policy implications of the findings from the study?

1.5 Significance of the study

The role of technology is to reduce demand for currency in circulation. The statistical evidence on the relationship between technology growth and demand for currency in circulation found contradicting results and therefore, the impact of technology growth on demand for currency in circulation remains inconclusive leaving the subject matter wide open to debate. The study also accounts for the limitations of the surveyed studies in the literature.

The results from the study will give insight to policy makers on whether technology growth affects the stability of demand for currency in circulation thus affecting the predictability of monetary policy. The study forms the basis for further research on technology growth and demand for currency in circulation.

1.6 Overview of the study

This study has been divided into five chapters. The first chapter deals with the general introduction of the study which gives an overview of the ideology to be dealt with. The second chapter develops objectives and raises research questions from revisiting the already existing contributions which has been made available by many scholars. The third chapter was dedicated to the methods and the design selected to conduct the research. Chapter four presents the empirical results and interpretations. Chapter five will give summary, conclusion, policy implications and recommendation for further study.

2.0: CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to explore and review the existing theories and empirical studies that have been done on electronic payment systems and their impact on demand for currency in circulation. It will also assist in choosing the appropriate methodology for econometric analysis.

2.2 Theoretical Literature

Money demand theories indicate that the main factors that influence the quantity of money people hold are real GDP (income), returns on money and other assets, price levels (inflation), exchange rates, tastes and technology. Fisher (1911) in his book “the purchasing power of money” developed the fisher’s identity ($M.V=P.T$) to represent the quantity theory of money which states that a percentage change in money supply (high powered money which is currency in circulation- M_0) equals same percentage change in price level (inflation and deflation). Piguco (1917) developed the Cambridge cash balance equation ($M= k.P.T$) which accounted for the amount of high powered money people wish to hold in form of currency in circulation and the ratio of the currency in circulation to the total money value of all transactions in the economy. Quantity theory of money assumes that money demand is chiefly a transactions demand and those with excess money will spend it on goods and services but Keynes (1936) extended it by introducing the speculative demand for money.

The speculative demand for money states that people demand money because money is a better asset than other assets (higher rate of returns than other assets). The theory assumes that agents can hold either money or bonds but never both and this does not accord with reality and therefore, the theory was extended by Tobin (1958) and Markowitz (1959) to portfolio choice theory so that people can hold both money and bonds. The argument is that there exist a tradeoff between returns and risks in which risk averse individuals will diversify their portfolio. Some assets dominate money (have positive returns at no risk like saving accounts and treasury bills) and

therefore, there is no reason for having speculative demand for money implying that money can be hold for transaction and precautionary purposes.

The quantity theory of money was rested by Friedman (1956). He took money like any other asset which can be consumer durable goods or producer (capital) good and therefore, demand for money can be analyzed using consumer demand theory or capital (investment) theory. From consumer demand theory point of view, demand for money is a function of wealth (GDP as a measure of permanent income), returns on money and other assets, and taste factors. Friedman argued that the velocity of money is highly predictable and that the demand for money function is highly stable and insensitive to interest rates. This implies that the quantity of money demanded can be predicted accurately by the money demand function.

2.3 Empirical Literature

There have been major developments in payment system in the last two decades in terms of technological changes which has led to lots of empirical research on technological changes over the demand for currency in circulation. However, the statistical evidence on the relationship between technology growth and demand for currency in circulation remains inconclusive. Some researchers found a positive relationship while others found no impact. The surveyed recent empirical literature is organized according to the two views.

2.3.1 Studies that shows technology growth increase demand for currency in circulation

Nyamongo & Lydia (2013) analyzed the effects of financial innovations in the banking sector on the conduct of monetary policy in Kenya during 1998 – 2012. Using Error Correction Model, results showed that the financial innovation has had positive outcomes and seems to improve the interest rate channel of monetary policy transmission. Financial innovation was represented by mobile money and ATMs and other variables which also are important in explaining financial innovation were excluded from the study.

By examining the impact of modern technology on money demand, Tehranchian et, al, (2012) showed that the long-run impact of modern technology on demand for money is strongly greater than short-run in Iran. They used cross-sectional data and autoregressive distributive lag model in their analysis in which they found that by increasing the number of ATMs and credit cards, the demand for currency increased in both short and long runs. In this study the researcher did not take into account the effects of mobile money transfer as a measure of technology on money demand which is regarded as limitation to this study.

Mwangi (2011) analyzed the effects of financial innovation on money demand in Kenya for the period 2000 - 2012. The Augmented Dickey Fuller and Phillip-Perron was applied to establish the order of integration of the variables, Johansen Maximum Likelihood test to establish the existence of cointegration and the number of cointegrating equations among the variables in the models. Error Correction model was used to examine the relationship among the variables. The results revealed that financial innovation has had a positive impact on the demand for money in Kenya both in the long-run and in the short-run. This study was limited on the variables that explain the financial innovation like use of RTGs, EFTs, POS and other cards. Hence there is need to include this variables in the definition of financial innovation and see what the impact financial innovation has on demand for currency in circulation.

Using panel data estimation covering the period 2009-2005 related to European Union for demand deposits, Brito & SOL MURTA (2003) examined the effects of the ATM and the POS in the demand for money in Europe. Using Generalized Least Square Method (GLSM), they conclude that the use of ATM and POS has a significantly positive effect on demand deposits. In this study the researcher only considered a few variables that explained the effects of technology on money demand leaving the key variables like EFT, mobile money transfer, RTGS and other cards like debit cards.

Holly (1999) analyzed the significance of the effects current payment technologies have had on money supply and demand and their determinants (interest rate and income). He used amount transacted through EFT and ATMs as a proxy for current payment technology in cointegration

model. It was found that the results of cointegration tests provided little evidence that technology advancements in payment systems has had a positive effects on the co-movement of money supply, demand, interest and income. Technological advancements is changing the business and banking landscape almost daily, and it is impossible not to believe that it is having significant effects on the movement of its key factors- money supply and demand. The researcher only tested on the properties of time series data and failed to apply data analysis methods to the data to be able to deduce the effect of technology on money demand and supply and their determinants.

2.3.2 Studies that shows technology growth has no impact on demand for currency in circulation

Kipsang (2013) examined the relationship between demand for money and levels of prices, interest rates, real national output, exchange rate and the pace of financial innovation in Kenya using data from 1970 to 2012 using cointegration and error-correction model. It was found that financial innovation process which was measured as the ratio of M2 to M1 had no impact on money demand balances. This raise questions on why financial innovation was calculated as a ratio of M2 to M1 instead of using the amount transacted through mobile money, ATMs, EFTs and other technological payment systems.

Kenyoru (2013) analysed the effects of financial innovation on financial deepening in Kenya using time series date covering the period 2007 to 2012. The financial innovation was defined as Mobile money and engency banking, the results showed that financial innovation had insignificant impact on financial depening. This means that the rise in mobile money transactions as well as in m-banking in Kenya do not significantly influence financial deepening.

Sichei and Kamau (2012) using data covering 1997:4-2011:2, analyzed demand for different monetary aggregates (M0, M1, M2 and M3) in Kenya. They used the number of ATMs as a proxy for financial innovation. Their results did not indicate any significant effect of innovations on the demand for money. However, this study used only one measure of financial innovation, which is also not widespread across the country. While acknowledging that the data for other more inclusive measures such as M-Pesa may not have been available and adequate in terms of

observations to allow plausible empirical investigation, the authors did not explore other financial innovation measures used in previous studies. Weil *et al.* (2012) also showed this instability.

Kovanen (2004) using time series monthly data covering the period of 1980 to 2003, examined the determinants of currency demand and inflation dynamics in Zimbabwe. The author measured financial innovation as the ratio of broad money to currency. However, the results from the VAR estimation for financial innovation are not significant.

2.4 Overview of Literature Review

Theoretically, technology that provides liquidity decreases demand for currency in circulation since these payments substitutes provides a means of payment without the need to hold the money itself and also by reduce the cost or time of converting assets in to a means of payment. The empirical review seems to contradict theory and also indicate a lack of universal agreement among researchers on the impact of technology growth on demand for currency in circulation. Some researchers found that technological changes had a positive impact on demand currency in circulation while others found that there was no relationship between technology change and demand for currency in circulation leaving the subject widely opens for debate. The literature also indicates that the quantity of money people holding is influenced by interest rate, real GDP (income), price levels and technology.

The reviewed empirical literature has one or more of the following limitations: use few variables that represent technology growth leaving key variables like mobile money transfer and use of wrong proxies to represent technology growth and demand for currency respectively. This study accounts for these limitations by giving demand for currency in circulation the right definition and including all relevant variables that define technology changes.

3.0: CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides the systematic procedures adopted in conducting the study towards achieving of the research objectives. The chapter starts with description of the study design, followed by theoretical framework, model specification, definition and measurement of variables, data type and source, data analysis technique, time series property test and diagnostic test.

3.2 Description Study Design

To analyze the impact of technological growth on demand for currency the study used non-experimental research design since the data used already existed. The theoretical formulation of the demand for currency function suggests the need to employ time series data for the empirical estimation of the demand for currency in circulation function.

3.3 Theoretical Framework

The literature review surveyed indicates that demand for money is a blend of many theories. Liquidity preference theory and inventory theory of money demand were adopted for this study where currency in circulation is a function of a scale variable, opportunity cost of holding money and technological framework. The hypothetical money demand can be formulated as;

$$\frac{M^d}{P} = f(SC, O, X) \quad (3.1)$$

Where;

M^d is the demand for currency in circulation (M0), P is the price level, such that currency in circulation is a function of a SC is the scale variable (income, wealth or expenditure, in real terms), O is the opportunity cost of holding money and X is technological framework

It is assumed that in the long run, the money market is in equilibrium such that money demand will equal money supply. Therefore, the money supply M^d deflated by the price level p is equal to the real demand for money $\left(\frac{M^d}{P}\right)$

$SC = f(Y_t)$, where Y_t is real GDP at time t. $O = f(i_t)$, where i_t is the opportunity of holding money at time t. $X = f(MM_t, ATMs_t, CCards)$, where MM_t , $ATMs_t$ and $CCards_t$ is value transacted through the mobile phone, ATMS and credit cards in the Kenyan economy at time t respectively.

Hence equation (3.1) becomes which the economic model;

$$\frac{M^d}{P} = f(\text{GDP}, \text{IR}, \text{MM}, \text{ATMs}, \text{CCards}) \quad (3.2)$$

The econometric model from (3.2) becomes;

$$\frac{M_t^d}{P_t} = \beta_0 + \beta_1 \text{GDP}_t + \beta_2 \text{IR}_t + \beta_3 \text{MM}_t + \beta_4 \text{ATMs}_t + \beta_5 \text{CCards}_t + \varepsilon_t \quad (3.3)$$

The general VECM representation

A VECM is a dynamic system with characteristics that the deviation of the current state from its long-run relationship will be fed into its short-run dynamics. A Vector Error Correction Model is not a model that corrects the error in another model but it is a category of multiple time series models that directly estimates the speed at which a dependent variable (Y) returns to equilibrium after a change in and independent variable (X). It is used to estimate both short-run and long-run effects on one time series on another. VECMs are very useful models when dealing with cointegrated data.

$$\Delta X_t = \Phi + \pi X_{t-1} + \sum_{i=1}^{p-1} \Psi_i \Delta X_{t-i} + \varepsilon_t \quad (3.4)$$

Where X_t denote vector of variables in the model, Φ is vector of constants, πX_{t-1} represent the error correction term whereby π denote two factors-the maximum rank (vector of cointegrating

parameters) and VEC coefficients that measure the speed of adjustment to the long run steady state, ψ denote vector of parameters containing short run information, ε_t is vector of white noise errors, and p represent maximum lag. It should be noted that;

- i. If $\text{rank}(\pi) = 0$; the variables are not cointegrated and non-stationarity of $\mathbf{I}(\mathbf{1})$ type vanishes by taking first difference.
- ii. If $\text{rank}(\pi) = k$ where $k = \text{full rank}$; the variables are stationary and therefore; no need to refer to the VEC representation. We don't deference the variables, but we model their relationship in level.
- iii. If $\text{rank}(\pi) = m$ where $0 < m < k$; the variables are cointegrated, and there are m linear combinations (m cointegrating relations) which are stationary.

The data used was non-stationary and cointegrated, the best model applied was VECM; hence equation (3.3) becomes;

$$\begin{aligned} \Delta MdP_t = & \alpha + \eta MdP_{t-1} + \sum_{j=1}^{p-1} \lambda_j \Delta MdP_{t-j} + \sum_{j=1}^{p-1} \gamma_j \Delta GDP_{t-j} + \sum_{j=1}^{p-1} \beta_j \Delta dIR_{t-j} + \\ & \sum_{j=1}^{p-1} \delta_j \Delta MM_{t-j} + \sum_{j=1}^{p-1} \phi_j \Delta ATMs_{t-j} + \sum_{j=1}^{p-1} \Psi_j \Delta CCards_{t-j} + \varepsilon_t \end{aligned} \quad (3.5)$$

Where $\lambda, \gamma, \beta, \delta, \phi, \psi$ are the short run dynamic coefficients, p denote maximum lag length for each variable, ε is the error term, t denote time, and $\eta \mathbf{MdP}_{t-1}$ is the error correction term whereby η represent speed of adjustment to equilibrium.

3.4 Model specification

The variables are integrated and cointegrated and therefore; the adequate model was a vector error correction model (VECM- also called cointegrated Vector Autoregressive model).

In this analysis we have six variables, $GDP_t, dIR_t, MM_t, ATMs_t$ and $CCards_t$ which are all endogenous, using the matrix form we have;

$$MdP_t = [GDP_t, dIR_t, MM_t, ATMs_t, CCards_t] \quad (3.6)$$

$$MdP_t = A_1 MdP_{t-1} + A_2 MdP_{t-2} + \dots + A_p MdP_{t-p} + \varepsilon_t \quad (3.7)$$

A VAR (p=2) can be reformulated in a vector error correction model as follows:

$$\begin{pmatrix} \Delta GDP_t \\ \Delta dIR_t \\ \Delta MM_t \\ \Delta ATMs_t \\ \Delta CCards_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta GDP_{t-1} \\ \Delta dIR_{t-1} \\ \Delta MM_{t-1} \\ \Delta ATMs_{t-1} \\ \Delta CCards_{t-1} \end{pmatrix} + \begin{pmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \\ \pi_{31} & \pi_{32} \\ \pi_{41} & \pi_{42} \\ \pi_{51} & \pi_{52} \end{pmatrix} * \begin{pmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} & \beta_{51} \\ \beta_{12} & \beta_{22} & \beta_{32} & \beta_{42} & \beta_{52} \end{pmatrix} * \begin{pmatrix} GDP_{t-1} \\ dIR_{t-1} \\ MM_{t-1} \\ ATMs_{t-1} \\ CCards_{t-1} \end{pmatrix} + \varepsilon_t \quad (3.8)$$

The analysis for the error correction part for the first equation ΔGDP_t which gives;

$$\eta_1 MdP_{t-1} = \begin{pmatrix} [\pi_{11}\beta_{11} + \pi_{12}\beta_{12}] * [\pi_{11}\beta_{21} + \pi_{12}\beta_{22}] * [\pi_{11}\beta_{31} + \pi_{12}\beta_{32}] \\ * [\pi_{11}\beta_{41} + \pi_{12}\beta_{42}] * [\pi_{11}\beta_{51} + \pi_{12}\beta_{52}] \end{pmatrix} * \begin{pmatrix} GDP_{t-1} \\ dIR_{t-1} \\ MM_{t-1} \\ ATMs_{t-1} \\ CCards_{t-1} \end{pmatrix} \quad (3.9)$$

Which can be rewritten as:-

$$\eta_1 MdP_{t-1} = \pi_{11} \begin{pmatrix} \beta_{11} GDP_{t-1} + \beta_{21} dIR_{t-1} + \beta_{31} MM_{t-1} \\ + \beta_{41} ATMs_{t-1} + \beta_{51} CCards_{t-1} \end{pmatrix} + \pi_{12} \begin{pmatrix} \beta_{12} GDP_{t-1} + \beta_{22} dIR_{t-1} + \beta_{32} MM_{t-1} \\ + \beta_{42} ATMs_{t-1} + \beta_{52} CCards_{t-1} \end{pmatrix} \quad (3.10)$$

Which shows clearly the two co-integrating vectors with their respective speed of adjustment terms π_{11} and π_{12} .

Table 1: Rank of matrix η and its implications

Rank of η	Implications
$r = 0$	There is no cointegration. No stable long-run relations between variables. VECM is not possible (only VAR in first differences).
$0 < r < k$	There are r cointegrating vectors. These vectors describe the long-run relationships between variables. VECM is o.k.
$r = k$	All variables are already stationary. No need to estimate the model as VECM. VAR on untransformed data is o.k.

Whereby r is cointegration rank and k is the number of variables in the VECM.

3.5 Definition and Measurement of Variables

A summary of the definition of variables used and how they are measured is stated below. The observable attributes of the variables are used to make inferences about the determinants of demand for currency in circulation. Defining and measuring the study variables helps in making the study concepts operational.

Table 2: Definition and description of the above variables

Abbreviat ion	Variable	Units	Description	Expected sign
MdP	M0 divided by Consumer Price Index	KES in millions	Currency in circulation (coins and paper notes) divided by consumer price index	Positive (expected sign of the lagged variable)
GDP	Seasonally adjusted Gross Domestic Product	KES in millions	Seasonally adjusted GDP as measured by Central Bank of Kenya used as scale variable of demand for real money balances.	Positive
IR	Interest Rate	%	Commercial lending interest rates	Negative
MM	Mobile Money	KES in millions	Value transacted through mobile phone.	Negative
ATMs	Automated Teller Machines	KES in millions	Value transacted through ATMs.	Negative
CCards	Credit Cards	KES in millions	Value transacted through credit cards.	Negative

3.6 Data type and sources

The study used quarterly secondary data that covered the period 2007 to 2014. The time period choice was based on availability of data. The data was sourced from Central Bank of Kenya and Kenya National Bureau of Statistics websites which are reliable sources of data.

3.7 Data analysis technique

The study used vector error correction model (VCEM) in the analysis after undergoing time series property tests (stationarity and cointegration). According to granger representation theorem, the relationship between two cointegrated variables can be expressed as error correction model (Gujarati, 2004). The error correction model is a means of reconciling the short run behavior of economic variable with its long run behavior (Gujarati, 2004). The error correction model does not suffer distortion due to estimation of mini lags when the data set are non-stationary, overcomes loss of information that occurs from simple attempt to address non-stationarity through differencing, and it's also unlikely to exhibit some degree of multicollinearity between regressors in the model. Eviews econometric software was used to carry out the regression.

3.7.1 Time Series Property Tests

Many estimation challenges are expected in time series data. These include non-stationarity of data which leads to invalid asymptotic analysis since they face spurious and inconsistency regression problems. The study used the unit root test Augmented Dickey-Fuller test (Hill, et, al, 2011). Time series variables are said to be cointegrated if they have a long term or equilibrium relationship between them (Gujarati & Porter, 2009). The general rule of cointegration is that if two or more series are individually integrated but their linear combination of them has a lower order of integration; the series are cointegrated. There is one exception of the general rule called the special case of cointegration and that's why cointegration tests such as Engle-granger tests, Philips-perron test and Johansen test depend on series that are strictly integrated of order one [$I(1)$], assuming that there exist special cases where a linear combination is [$I(0)$] stationary

variables and hence cointegrated. Johansen test for cointegration was used to test existence of long run relation between the variables.

3.7.1.1 Augmented Dickey-Fuller Test for Unit Roots

This test is used to test for presence of unit root on variables and it includes extra lagged terms of the dependent variable in order to eliminate autocorrelation in the test equation. A random walk model with drift was used to test for unit root and establish the order of integration.

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \sum_{i=1}^p \beta_i \Delta Y_{t-1} + \varepsilon_t \quad (3.11)$$

Where Y_t represents MdP, GDP, IR, MM, ATMs and CCards variables at time t .

Assumptions;

The error terms are uncorrelated and they really have a constant variance.

Hypothesis;

H0: Unit root (non-stationary) Vs H1: Stationary

The model is analyzed and if the null hypothesis of unit root is rejected a conclusion is drawn that the series is stationary otherwise the series is non-stationary.

3.7.1.2 Lag length selection

Pesaran and Shin (1999) found Schwarz Bayesian Criterion (SBC) a consistent model selection criterion, unlike Akaike information criteria and in this study two lags were used since many lag length selection criterion choose optimum of two lags as opposed to SBC which choose one lag for both the cointegration test and the ECM.

$$AIC = \ln\left(\frac{SSE}{T}\right) + \frac{2k}{T} \quad (3.12)$$

where, $k = p + q + 2$ the number of coefficients estimated P is lag length on dependent variable, q is lag length on independent variables.

$$SBC = \ln\left(\frac{SSE}{T}\right) + \frac{k \ln(T)}{T} \quad (3.13)$$

SBC was used over AIC because $\frac{k \ln(T)}{T}$ is greater than $\frac{2k}{T}$ for $T > 8$, the SBC restricts additional use of lags more than AIC.

3.7.1.3 Johansen's Test for Cointegration

According to Asteriou (2007), if you have more than two variables in the model, then there is a possibility of having more than one co-integrating vector. By this, the variables in the model might form several equilibrium relationships. In general, for k number of variables, we can have only up to $k-1$ co-integrating vectors. To find out how many cointegrating relationships exist among k variables, Johansen's methodology was used.

Assumptions:

The variables are non-stationary and their residues are stationary. If the residue is stationary even though the dependent and independent variables are non-stationary, the regression is not spurious.

Methods;

Two methods were used in determining the number of co-integrating relations, and both involve estimation of matrix η .

The hypothesis of interest involves the rank of η . If the rank of η is q and $q \leq n-1$, then one can decompose η into two $n \times p$ matrices α and β such that $\eta = \alpha\beta'$. The matrix β contains q linear cointegration parameters vectors whereas α is a matrix consisting of n error-correction parameter vectors. The maximum likelihood estimate of α and β whose residues are ε_{it} and ε_{jt} respectively, the residue product matrices will be:-

$$s_{ij} = T^{-1} \sum_{t=1}^T \hat{\varepsilon}_{it} \hat{\varepsilon}_{jt} \quad \text{for } i, j = 0, 1 \quad (3.14)$$

The eigenvalues system is solved as;

$$\left| \lambda S_{11} - S_{10} S_{01} \right| = 0 \quad (3.15)$$

Two Johansen's maximum likelihood tests, the maximal eigenvalue test and the trace tests are used to determine the number of the cointegration vectors. The statistics from maximal eigenvalues test for the null hypothesis of r ($H_0: R = r$) cointegration vectors against the alternative of $r+1$ ($H_1: R = r + 1$) cointegration vector is

$$\hat{\lambda}_{\max} = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (3.16)$$

The trace test statistics for null hypothesis of at most r cointegration vectors $H_0: R = r$ versus $H_1: R > r$ is

$$\hat{\lambda}_{\text{trace}} = -T \sum_{j=r+1}^n \ln(1 - \hat{\lambda}_j) \quad (3.17)$$

If the results are consistent with the hypothesis of at least one or two cointegration vector(s), the researcher then uses the maximum likelihood method to test the hypothesis regarding the restrictions of β' . The existence of cointegration implies long-run causality in at least one direction between the variables in the system i.e. at least one adjustment parameter (an element of α) must be non-zero. Then the researcher can move on to estimate the ECM or VECM.

3.8 Diagnostic Tests

Diagnostic tests such as serial correlation, normality test, conditional heteroscedasticity, and stability of parameters were conducted to ensure that the coefficients of the estimates are efficient, consistent and reliable in making inference.

The study used Breuch-Goldfrey langrange multiplier (LM), ARCH test, Jargue-berra statistic, and both cumulative sum and cumulative sum squares test in testing for serial correlation, heteroscedasticity, normal distribution, and stability respectively.

3.8.1 Breuch-Goldfrey langrange multiplier (LM)

This is a diagnostic test used to test for serial correction in the error term. When the error terms from different time periods (or cross-section observations) are correlated, we say that the error term is serially correlated. Serial correlation (also called autocorrelation) in the residuals means that they contain information, which should itself be modeled.

The assumption of no serial correlation can be expressed as:

$$E(\varepsilon_t \varepsilon_s) = 0, \text{ for } t \neq s \text{ or } V(y_t / x_t) \equiv E(\varepsilon \varepsilon') = \sigma^2 I$$

On the other hand, the presence of serial correlation can be expressed as:

$$E(\varepsilon_t \varepsilon_s) \neq 0, \text{ for } t \neq s \text{ or } V(y_t / x_t) \equiv E(\varepsilon \varepsilon') = \sigma^2 \Omega$$

Where the off-diagonal elements of Ω are not all equal to zero (the diagonal elements are all equal to one).

Langrange multiplier is used in this study to test for serial correction on the error term. The operational version of the test is carried out by obtaining the product of the number of observations (T) and the coefficient of determination (R^2) of the auxiliary regression:

$$\hat{\varepsilon}_t = M d P_t + \dots + \sum_{i=1}^N \rho_i \hat{\varepsilon}_{t-i} + \mu_t$$

$$LM - test = T * R^2 \sim \chi^2(N) \quad (3.18)$$

The null hypothesis;

$$H_0 : \rho_i = 0, \text{ for } i = 1, \dots, N \quad \text{No serial correlation}$$

Alternative hypothesis;

$$H_1 : \rho_i \neq 0, \text{ for } i = 1, \dots, N \quad \text{There is serial correlation}$$

Decision rule: if the test statistic is smaller than its critical value we cannot reject the null.

The serial correlations is caused by omission of the relevant variables as regressors, this can be corrected by including the lagged variable of the said variables. Also serial correction may be

caused by serial correlation in the error term; this can be corrected by transforming the variables and re-estimating the transformed model.

3.8.2 ARCH test

For many time series there is a tendency to volatility clustering, that is periods of high and low uncertainty. The variance is expected to be constant or homoscedasticity, ARCH model has been used to model these uncertainties by specifying equations for the (conditional) mean and the (conditional) variance.

The assumption of homoscedasticity can be expressed as:

$$E(\varepsilon_t^2) = \sigma^2, \text{ for all } t \text{ or } V(y_t / x_t) \equiv E(\varepsilon\varepsilon') = \sigma^2 I$$

On the other hand, the presence of serial correlation can be expressed as:

$$V(y_t / x_t) \equiv E(\varepsilon\varepsilon') = \sigma^2 \Omega$$

Where the off-diagonal elements of Ω are not all equal to zero (the diagonal elements are all equal to one). The (autoregressive conditional heteroscedasticity test) ARCH-test involves the estimation of the following (auxiliary) regression: $\hat{\varepsilon}_t = \gamma_0 + \sum_{i=1}^N \gamma_i \hat{\varepsilon}_{t-i} + \mu_t$

$$H0: \gamma_i = 0, i = 1, 2, \dots, N \text{ Homoscedasticity}$$

$$H1: \gamma_i \neq 0 \text{ Heteroscedasticity}$$

If the researcher fails to reject the null hypothesis it means that the variance is constant and there no ARCH present. When the residuals are heteroscedastic, OLS produces biased estimates of the standard errors of the coefficients; this renders hypothesis testing unreliable. Since the produced estimates are required to be unbiased and consistent.

3.8.3 Jargue-berra statistic

This is a goodness-of-fit test of whether sample data have the skewness and kurtosis matching a normal distribution.

$$JB = n \left[\frac{skewness^2}{6} + \frac{(kurtosis - 3)^2}{24} \right] \quad (3.19)$$

Where

$$skewness = \frac{\frac{1}{n} \sum_{i=1}^n (x_i - \pi)^3}{\left[\frac{1}{n} \sum_{i=1}^n (x_i - \pi)^2 \right]^{3/2}}$$

$$kurtosis = \frac{\frac{1}{n} \sum_{i=1}^n (x_i - \pi)^4}{\left(\frac{1}{n} \sum_{i=1}^n (x_i - \pi)^2 \right)^2} \text{ and } \mathbf{x} \text{ is each observation, } \mathbf{n} \text{ is the sample size}$$

If $JB > \chi^2_{(\alpha, 2)}$ then the null hypothesis is rejected which means that the data do not follow a normal distribution otherwise if the null hypothesis is accepted then there is no difference between the distribution in question and the normal distribution.

3.8.4 Cumulative sum and cumulative sum squares test

CUSUM CUSUMQ Tests are essentially used for monitoring change detection in regression coefficients. CUSUM test is based on the cumulative sum of the equation errors in regression. EViews represents graphically the cumulative sum of errors together with critical lines of 5%.

The equation parameters are not considered stable if the whole sum of recursive errors gets outside the two critical (dotted) lines.

CUSUM of Squares test is similarly calculated and interpreted as CUSUM test, with the difference that instead recursive errors we use recursive doubled errors.

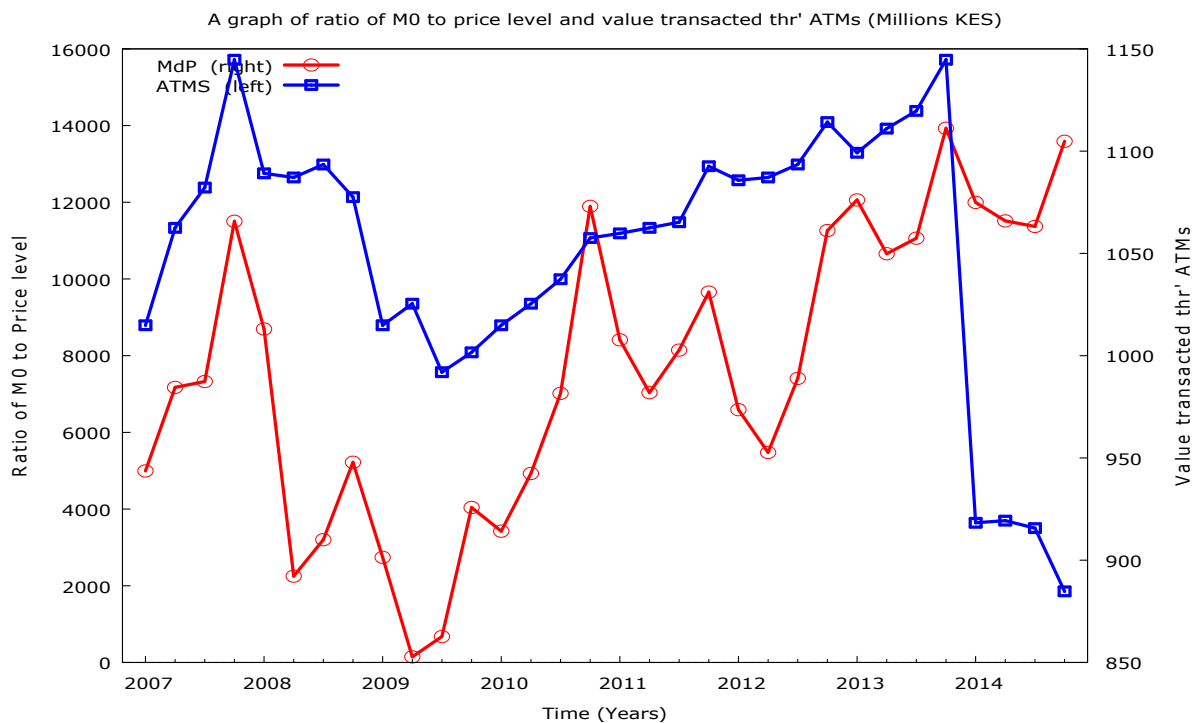
4.0: CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.0 Introduction

This chapter presents and explains the empirical findings of the study. Figure 3 gives the time series plots for the variables. Table 2 and 3 presents the time series property tests (unit root test and cointegration result respectively). The VECM estimates are in Table 4 while table 5 presents the diagnostic test results. The chapter ends with the interpretation and discussion of results.

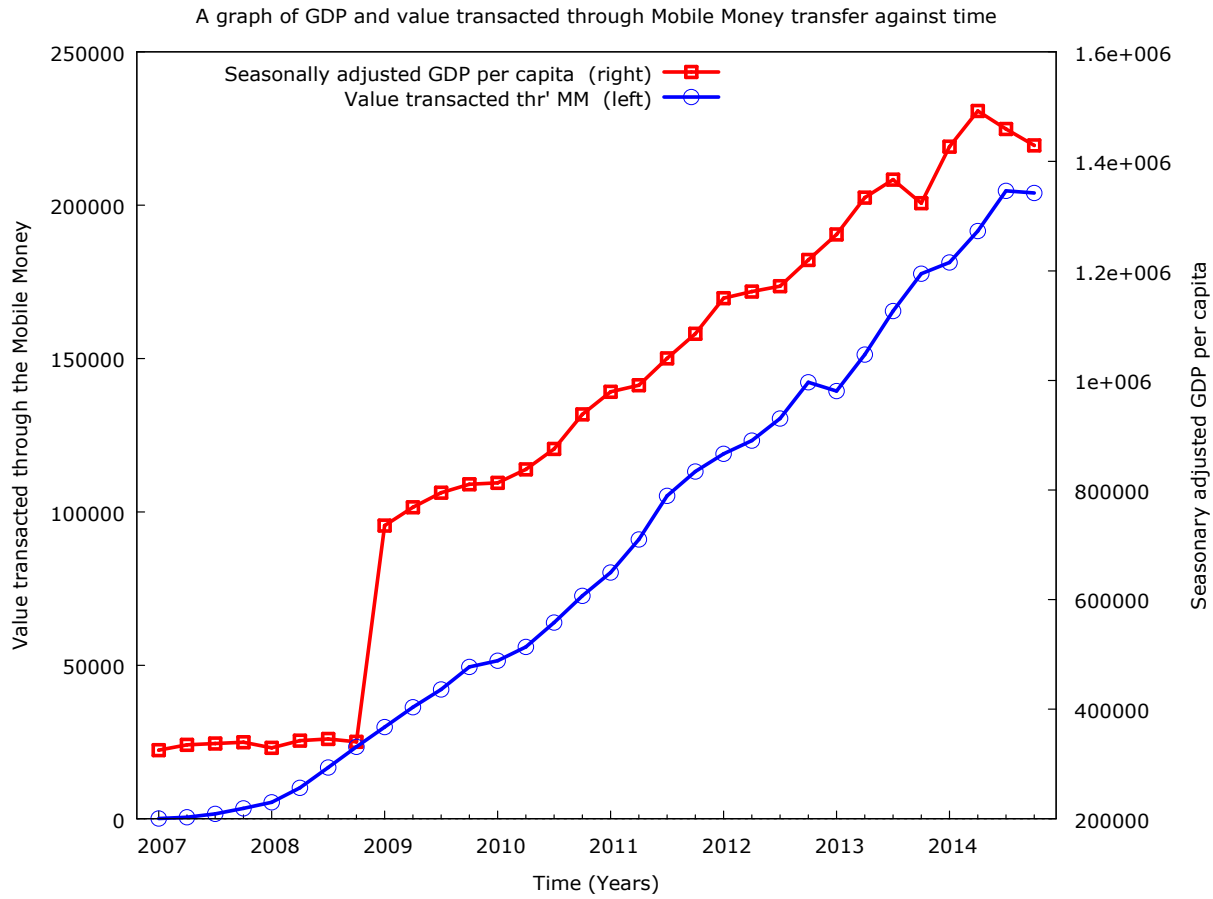
4.1 Empirical results

Figure 3: Time series plots for all the variables to help choose the right random walk test to use



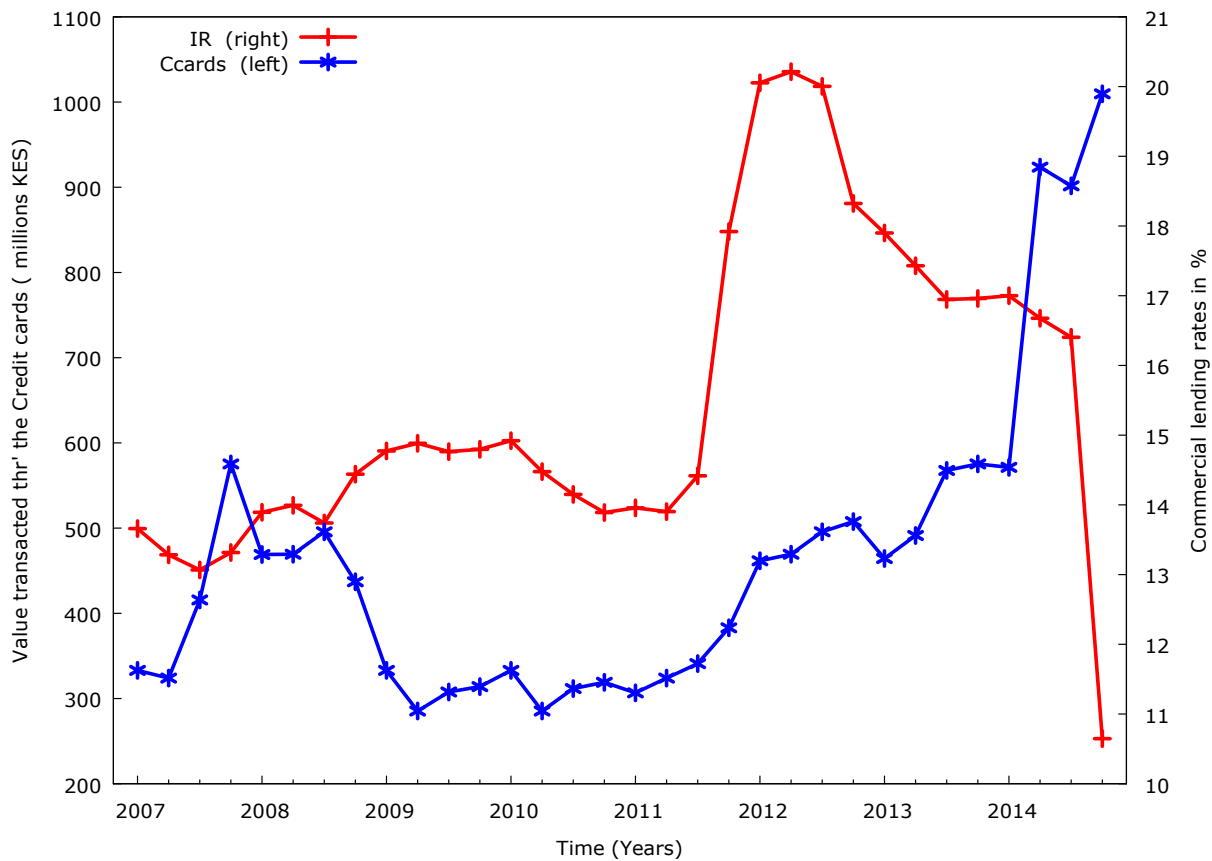
This figure shows that ratio of M0 to Consumer Price Index (MdP) have obvious upward trend and value transacted through the ATMs have upward trend till 2014 where it faces a steady drop,

suggesting that MdP and ATMs time series are non-stationary and hence a random walk with drift was specified.



This figure shows that GDP and Mobile Money transfer have steady upward trend as well as variability over the years, suggesting that GDP and MM time series are non-stationary and hence a random walk with drift was specified.

A graph of Commercial lending rates and value transacted through the Credit cards against time



This figure shows that value transacted through credit cards have obvious upward trend and the commercial lending interest rates (IR) have upward trend till 2014 third quarter where it faces a steady drop, suggesting that Credit cards and IR time series are non-stationary and hence a random walk with drift was specified.

Table 3: Summary Statistics

Summary Statistics, using the observations 2007:1 - 2014:4 for the variables MdP, GDP, IR, MM, ATMs and CCards (32 valid observations)

	Mean	Median	Minimum	Maximum	Std. Dev.	C.V.	Skewness	Ex. kurtosis
MdP	993.795	988.12	852.758	1111.18	71.4841	0.072	-0.21	-0.96
GDP	911457.	958767.	325082.	1.49201e+ 006	398686.	0.437	-0.27	-1.20
IR	15.462	14.7683	10.6467	20.2133	2.27635	0.147	0.53	-0.25
MM	86967.1	76449.8	64.3905	204684.	67227.7	0.773	0.28	-1.23
ATMs	10656.	11406.	1854.7	15717.	3548.7	0.333	-0.966	0.26
CCards	462.56	449.33	285.33	1009.7	183.83	0.397	1.63	2.22

Table 3: shows summarized statistics for all the variables used in the analysis in terms of mean, median, minimum, maximum, standard deviation, coefficient of variation, skewness and expected kurtosis.

Table 4: Augmented Dickey-Fuller test for unit root (Radom Walk with intercept)

VARIABLE	ADF STATISTIC			5% CRITICAL VALUE	DECISION
	Level	1 st difference	2 nd difference		
MdP	-2.222801	-5.811974		-2.963972	I (1)
GDP	-0.267998	-5.629125			I (1)
IR	-1.651915	-1.447412	-3.577329		I(2)
MM	-2.303978	-4.645385			I (1)
ATMs	-1.373120	-5.986870			I(1)
CCards	0.594461	-5.611538			I(1)

Table 4. Show results for Augmented Dickey-Fuller tests for unit root. The result shows that the variables are integrated of order one except the commercial lending interest rates which is integrated of order two and its first difference was used in the analysis.

Table 5: Johansen tests for cointegration

Trend: constant

Number of obs = 28

Sample: 2008Q1 – 2014Q4

Lags interval: 1 to 2

Unrestricted Cointegration Rank Test (Trace) and Max-Eigen statistics							
		Trace Statistics			Max-Eigen Statistics		
Hypothesized	Eigenvalue	Trace	0.05	Prob.**	Max-	0.05	Prob.**
No. of CE(s)		Statistic	Critical		Eigen	Critical	
			Value		Statistic	Value	
None *	0.956666	229.9973	95.75366	0.0000	87.88665	40.07757	0.0000
At most 1 *	0.920827	142.1106	69.81889	0.0000	71.01147	33.87687	0.0000
At most 2 *	0.713464	71.09917	47.85613	0.0001	34.99698	27.58434	0.0047
At most 3 *	0.637512	36.10219	29.79707	0.0082	28.41340	21.13162	0.0040
At most 4	0.235777	7.688784	15.49471	0.4993	7.529091	14.26460	0.4286
At most 5	0.005687	0.159694	3.841466	0.6894	0.159694	3.841466	0.6894
Trace and Max-Eigen test statistic indicates 4 cointegrating eqn(s) at the 0.05 level							
* denotes rejection of the hypothesis at the 0.05 level							

Table 5. Show results for trace and maximum eigenvalues tests. The result shows there is existence of at least four cointegrating equations at 5% level of significance. To accept the null hypothesis, the Trace and Maximum Eigen value statistic must be smaller than the 5 percent critical values reported for each. The results indicate that both the Trace and Maximum Eigen value tests reject zero in favor of at least four cointegration equations. This result proves that the variables are tied together in four ways in the long run, that is, there are four unique long run equilibrium relationships.

Table 6: Vector Error-Correction Estimates

Sample: 2008:1-2014:4 No. of obs = 28 AIC = 84.31582

Log likelihood = -1054.421 SBIC = 90.31074

	Coefficient	Std. Error	t-Statistic	Prob.
MdP				
cointEq1	-0.337498**	0.128179	-2.633019	0.0233
cointEq2	-0.000120	0.000161	-0.748586	0.4698
cointEq3	-3.013814	9.650516	-0.312296	0.7607
cointEq4	0.001293	0.001159	1.115490	0.2884
D(MdP(-1))	-0.179280	0.104252	-1.719682	0.1135
D(MdP(-2))	-0.175585	0.116338	-1.509263	0.1594
D(GDP(-1))	4.34E-05	0.000119	0.363643	0.7230
D(GDP(-2))	-3.85E-05	7.87E-05	-0.489568	0.6341
D(dIR(-1))	-6.405361	7.491899	-0.854972	0.4108
D(dIR(-2))	-23.99044***	6.108056	-3.927673	0.0024
D(MM(-1))	0.001768	0.001564	1.130490	0.2823
D(MM(-2))	-0.002200	0.001403	-1.568691	0.1450
D(ATMs(-1))	0.013905***	0.002827	4.917770	0.0005
D(ATMs(-2))	0.024357***	0.003605	6.756621	0.0000
D(CCards(-1))	0.226864	0.157745	1.438162	0.1782
D(CCards(-2))	-0.489358**	0.158935	-3.078985	0.0105
Constant	22.07106	13.65741	1.616050	0.1344
R-squared	0.946272	Mean dependent var	1.397500	
Adjusted R-squared	0.868123	S.D. dependent var	47.89915	
S.E. of regression	17.39452	Akaike info criterion	8.830164	
Sum squared resid	3328.264	Schwarz criterion	9.639003	
Log likelihood	-106.6223	Hannan-Quinn criter.	9.077434	
F-statistic	12.10850	Durbin-Watson stat	2.076888	
Prob(F-statistic)	0.000088			

***, ** indicate significant at 1% and 5% levels respectively.

Table 6. Shows results of the Vector Error Correction Model. The results indicate that there a cointegrating equation one (cointEq1) which is the stable equilibrium point. Cointegrating

equation one coefficient is negative and significant and therefore; there is a long-run causality running from the explanatory variables to demand for currency in circulation.

Table 7: Wald Test for short run

Variable	Test	Chi-square	Prob>chi-square
MdP	MdP(-1)= MdP(-2)=0	4.73	0.094
GDP	GDP(-1)= GDP(-2)=0	0.97	0.6171
IR	dIR(-1)= dIR(-2)=0	14.25	0.0008
MM	MM(-1)= MM(-2)=0	4.73	0.1161
ATMs	ATMs(-1)= ATMs(-2)=0	45.41	0.0000
CCards	CCards(-1)= CCards(-2)=0	36.74	0.0000
The null hypothesis (H0) is rejected if the probability value χ^2 is less than 5%.			

Table 7. Shows results of Wald test for short run of H0: all the coefficients of the variables are equivalent to zero versus H1: the coefficients are not equal to zero. The results show that there a short run causality running from commercial lending interest rates, ATMs and Credit cards to demand for currency in circulation.

Table 8: Diagnostic test statistics

	Test	H0	Obs * R-squared	Prob > chi2
Serial correlation	Lm test	No autocorrelation	2.439864	0.2953
Normality	Jarque-bera test	Residuals normally distributed	1.821053	0.402312
Heteroscedasticity	ARCH test	Homoscedastic	3.052185	0.2174
Stability	CUSUM	Stable		
	CUSUMQ	Stable		

The null hypothesis (H0) is rejected if the probability value χ^2 is less than 5%.

Table 8: gives results of the diagnostics test and the results show that the residuals are homoscedastic, normally distributed and are not auto-correlated. Both cumulative sum and cumulative sum square test indicates that the parameters are stable (the curve is within the two red lines-see the figure below).

4.2 Interpretations of the results

Stationarity

The guideline for the ADF test is that once the absolute value of ADF statistic is greater than the 5% critical value, we reject the null hypothesis of unit root and conclude that the series is stationary. The ADF results indicate that the variables are integrated of order one except commercial lending interest rates which was integrated of two [I (2)].

Cointegration

The guideline is that if the trace and the max statistic are greater than the 5% critical value, we reject the H_0 . Both the trace and max statistic arrived at the same conclusion, if this is not the case is up to researcher to decide which test to use. The set of variables was found to have at most four cointegrating vectors (equations) and therefore, VECM was the suitable estimation technique for the money demand model.

The VECM model

a) The long run causality

The cointegrating equation one (cointEq1) is the stable equilibrium point. The coefficient is negative and significant and therefore; there is a long-run causality running from the explanatory variables to demand for currency in circulation. $\text{cointEq1} = \eta = -0.3375$ implies that the deviation from the long-term in demand for currency in circulation for the previous year is corrected by 34% in the following year.

b) The short run causality

The chi-square for all lagged variables of currency in circulation is 4.73 and its probability is 0.0940 implying that all the lagged variables do not jointly cause currency in circulation in short

run. Current year's currency in circulation demand is not influenced by previous year's demand for currency in circulation.

The chi-square for all lagged variables of GDP is 0.97 and its probability is 0.6171 implying that all the lagged variables of GDP do not jointly cause currency in circulation in short run. Current year's currency in circulation demand is not influenced by previous year's GDP.

The chi-square for all lagged variables of lending interest rates is 14.25 and its probability is 0.0008 implying that all the lagged variables of lending interest rates jointly influence currency in circulation in short run. The higher the interest rate, the less currency will be held. This results are in line with Tehranchian et,al (2012) and Mwangi (2014) who found that the higher the interest rates the less the demand for currency in circulation.

The chi-square for all lagged variables of mobile money transfer is 4.31 and its probability is 0.1161 implying that all the lagged variables mobile money transfer do not jointly influence currency in circulation in short run.

The chi-square for all lagged variables of ATMs is 45.41 and its probability is 0.0000 implying that all the lagged ATM variables jointly affect currency in circulation in short run. Increase of ATMs implies increase in demand for currency in circulation. This results authedcates results of Brito & SOL MURTA, (2003) and Mwangi (2014) who found that ATMs have positive impact on currency in circulation, this is due to improved ease of acquiring cash, which reduced the need to hold large amounts of currency.

The chi-square for all lagged variables of credit cards is 36.74 and its probability is 0.0000 implying that all the lagged variables credit cards jointly cause currency in circulation in short run. Increase of credit cards implies increase in demand for currency in circulation. This is in line with Tehranchian et,al (2012), who found that credits cards increases demand for currency in circulation.

The R²

$R^2 = 0.946$ gives a good fit. It means that the explanatory variables in the model explain 94.6% of the variation in demand for currency in circulation over the study period and 5.4% is explained by other variables not included in the model. Since more than 60% of the variation in the depended variable is explained we conclude that the model fits the data observations well.

Adjusted R²

Adjusted $R^2 = 0.868123$. The Adjusted R^2 takes care of the increased variables that might lower the degrees of freedom. Adjusted R^2 is also a goodness of fit. Since $t_{\text{calculated}}$ for adjusted R^2 ($0.868123/17.39452$) = $0.04990784 < t_{\text{critical}}(0.025, 15) = 2.131$ then the explanatory power of the model will not be reduced significantly.

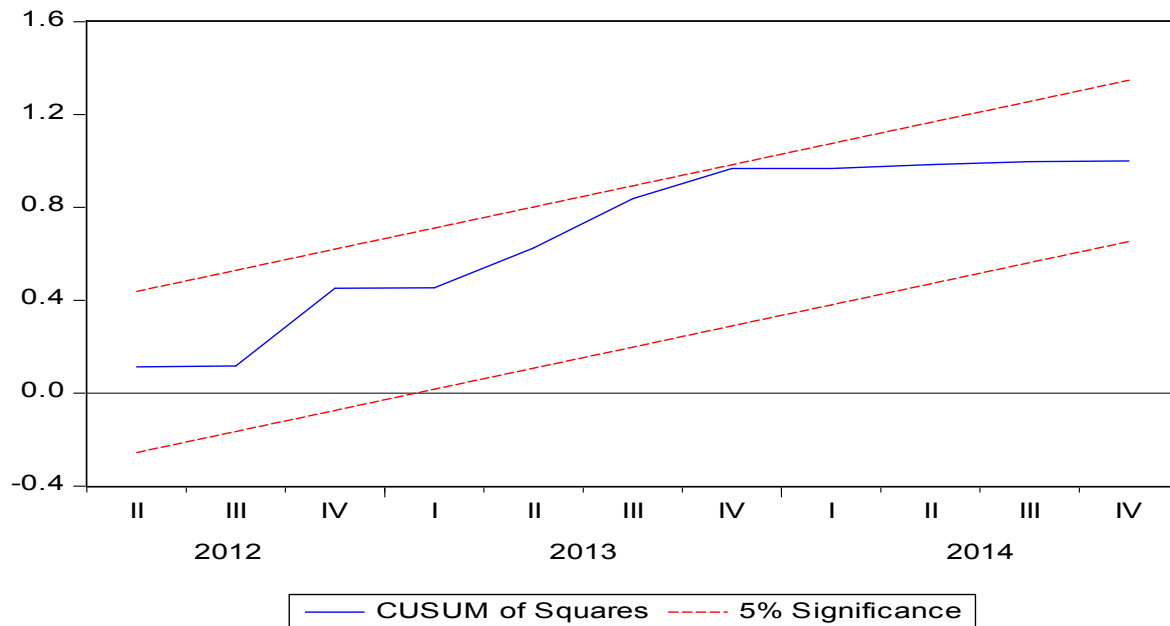
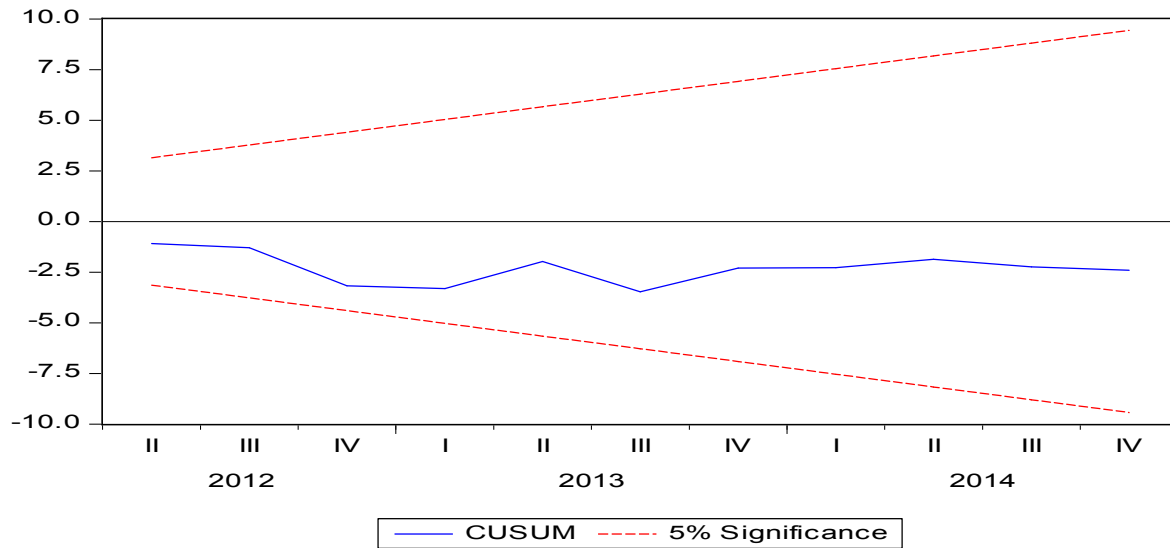
The F statistic

$F = 12.10850$ and its probability value is 0.000088 which is less than 5% and therefore; all the parameters are statistically significance at 5% level of significance. This means that all the explanatory variables jointly explain demand for currency in circulation well.

Diagnostic tests

The results from diagnostic tests indicate that the coefficients of the estimates are efficient, consistent and reliable in making inference since the residuals are homoscedastic, normally distributed and are not auto-correlated. Both cumulative sum and cumulative sum square test indicates that the parameters are stable (the curve is within the two red (dotted) lines-see the figure below).

Figure 4: Stability Condition



The recursive estimations reported in the figure 4. Shows a stable demand for currency in circulation in Kenya for the period under review. Demand for currency in circulation equation lies on the 5% critical bounds (dotted lines) for CUSUM and CUSUM of squares tests. This indicates stability in the parameters of the used equation.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides conclusion, policy implications and ends with a recommendation for further study.

5.2 Conclusion

This study was set to analyze the impact of technology growth on demand for currency in circulation in Kenya. During the study period, it was found that the financial sector has impressively developed and a number of financial innovations have taken place in the country: Mobile money transfer was introduced during this period and the value of transactions conducted through ATMs and credit cards have been increasing till 2014 when ATMs faced some steady drop. Development of such products has increased access to financial products and services, reduced transaction costs and improved the way resources are allocated. These developments affect the way in which the economy reacts to monetary policy; this poses challenges to central banks in their goals of attaining efficiency and stability in the financial system. The study applied VECM estimation technique and time series quarterly data for the period 2007 – 2014 to investigate the impact of technology on demand for currency in circulation. Keynes transaction model of money demand was used to establish a link between theory and empirics.

The empirical findings suggest a long-run causality running from the explanatory variables to demand for currency in circulation and 34% speed of adjustment to equilibrium; implying that 34% of discrepancy in demand of currency in circulation of the previous year is adjusted for the current year. The results also indicate a short run causality running from commercial lending interest rates, ATMs and Credit cards to demand for currency in circulation.

Technology growth was found to have a long-run and short run effects on demand for currency in circulation. In short- run, ATMs and credit cards were found to increase demand currency in circulation while mobile money transfer was found to have no impact. GDP and Commercial

lending interest rate were also found to have a long-run impact on the demand for currency in circulation. Commercial lending interest rates were found to affect on demand for currency in circulation, in that, the higher the commercial lending rates the lesser the demand for currency in circulation. Previous years' GDP was found to have no impact on current years' demand for currency in circulation.

This results are in line with the findings of Tehranchian et,al (2012), Mwangi (2014) and Brito & SOL MURTA, (2003) who found technology having a long run effects on demand for currency in circulation and in short ATMs and credit cards were found to increase the demand for currency in circulation.

It could be concluded that technology convert money to electronic forms and this tend to blur the distinction between monetary and non-monetary assets. It is therefore, prudent for the stability of the demand for money to be constantly re-examined by the monetary authorities to ensure an effective control of the monetary base since technological advancement is an ever-changing continuous process.

5.3 Policy Implications

New products convert money to electronic forms, this tend to blur the distinction between monetary and non-monetary assets. It is prudent for the stability of the demand for money to be constantly re-examined by the monetary authorities to ensure an effective control of the monetary base since technological advancement is an ever-changing continuous process.

The government needs to provide regulatory framework that regulates, harmonizes and protects consumers of financial innovations through enactment of laws. This will safeguard consumers from possible financial loss. This may be as a result of volatility in monetary aggregates like interest rates, inflation, income or foreign exchange rates, losses may also arise from electronic money fraud. Such regulatory framework should also consider international financial partners

5.4 Areas of further research

Further research on how innovations in the financial innovations affect economic growth should be given more attention. It is evident there is a close relation between the two; however it is not empirically clear how the two relate.

An empirical assessment should also be carried out to establish whether financial crisis in the economy are caused by innovations in the financial sector. Further studies should establish how monetary aggregates react in case of a monetary shock resulting from new innovative products

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APPENDICES

Table 9: Data

ID	Year	Quarters	MdP	GDP	IR	MM	ATMS	Ccards
1	2007	1	943.65	325082.00	13.66	64.39	8793.00	333.00
2		2	984.50	334841.00	13.28333	474.90	11333.00	324.00
3		3	987.36	337289.00	13.06667	1571.66	12382.67	415.67
4		4	1065.70	339608.00	13.31667	3371.59	15716.67	575.33
5	2008	1	1013.05	329389.00	13.89333	5342.09	12755.00	469.00
6		2	892.19	342518.00	13.99333	10070.35	12647.33	469.33
7		3	910.03	345551.00	13.74	16681.10	12985.33	495.67
8		4	947.89	340325.00	14.44	23430.23	12134.00	437.00
9	2009	1	901.40	735130.00	14.77333	29860.47	8793.00	333.00
10		2	852.76	768496.00	14.88333	36333.97	9355.33	285.33
11		3	862.69	795090.00	14.76333	42128.13	7569.00	307.67
12		4	925.78	810528.00	14.79667	49481.27	8086.67	314.00
13	2010	1	914.21	813122.00	14.92	51494.90	8793.00	333.00
14		2	942.42	837670.00	14.47667	55997.47	9355.33	285.33
15		3	981.57	875046.00	14.15	63936.67	9993.33	311.67
16		4	1073.01	938145.00	13.89	72644.27	11067.33	319.00
17	2011	1	1007.75	979389.00	13.95667	80255.33	11189.00	306.67
18		2	981.91	991317.00	13.90333	91034.60	11333.00	324.00
19		3	1002.72	1040335.00	14.41667	105249.80	11479.67	341.00
20		4	1031.08	1085239.00	17.92	113177.00	12940.00	383.00
21	2012	1	973.62	1150238.00	20.05333	118948.00	12573.33	461.67
22		2	952.69	1162308.00	20.21333	123261.00	12647.33	469.33
23		3	988.90	1172095.00	20.00333	130450.00	12985.33	495.67
24		4	1061.17	1220007.00	18.32333	142276.67	14091.33	507.67

25	2013	1	1076.14	1266566.00	17.9	139408.33	13290.33	464.33
26		2	1049.83	1333803.00	17.43	151293.00	13921.00	491.33
27		3	1057.42	1366684.00	16.94667	165483.33	14382.00	567.67
28		4	1111.18	1323711.00	16.96	177668.33	15716.67	575.33
29	2014	1	1074.92	1426839.00	17	181323.33	3642.33	571.33
30		2	1065.90	1492005.00	16.67667	191568.67	3698.33	923.67
31		3	1063.17	1459127.00	16.40333	204684.33	3502.67	901.67
32		4	1104.83	1429127.00	10.64667	203982.00	1854.67	1009.67