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**Money supply, GDP and price level causality and long-run relationship in
Kenya: An empirical analysis**

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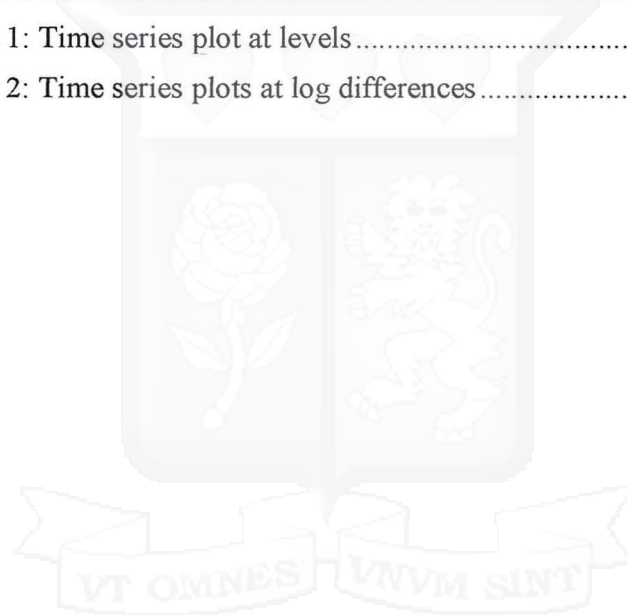
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ABSTRACT

This research study is mainly based on the fundamental relationship between money supply, prices and the gross domestic product in Kenya. The quarterly time series data of real Gross Domestic Product (GDP), money supplies (MS) and consumer price index (CPI) for the period 2000-2016 were used. The stationary properties of the data series were investigated using the Augmented Dickey Fuller method. To investigate on the existence of a long run relationship among these macroeconomic variables, Cointegration analysis has been employed. To explore the short run direction of causality between GDP, CPI and MS, the Granger causality test has been applied. The direction of causation between CPI and broad money variable M3 was found to be unidirectional from CPI to M3 without any feedback. Regarding the causal relationship between GDP and money supply, the analysis suggests that the causation runs from M1 to GDP, but GDP does not cause M1. The Co-integration analysis established a co-integrating relationship thus suggesting that there is a long run relationship existing among the three macro-economic variables.



CHAPTER 1: INTRODUCTION

1.1 Background

As a developing economy, one of the key macroeconomic goals of Kenya relies in ensuring that the supply of money in the economy is consistent with the growth and price level objectives set by the government. This can be done via the adaptation of various monetary policies. However, different theoretical perspectives have differing predictions regarding the short and long term trade-offs between money, output and prices. Hence, a decomposition of the causality relationships over time is extremely important in understanding the underlying macroeconomic processes and consequently, in conducting monetary policy so as to enable economics growth.

The economic debate

Over the past few years, economists have been involved in a long debate regarding the role of money supply in an economy particularly when determining the gross domestic product and price levels.

By definition, money supply (MS) refers to the total amount of money in circulation or in existence in an economy. The circulating money basically involves the currency, printed notes, money in the deposit accounts and in the form of other liquid assets. The real Gross Domestic Product (GDP) is a macroeconomic assessment that measures the value of the goods and services produced by an economic entity in a specific period, adjusted for inflation (a general increase in prices and fall in the purchasing value of money). Price level is the average of current prices across the entire spectrum of goods and services produced in the economy, of which, the most common price level index is the Consumer Price Index (CPI).

The relationship between money supply, income, and prices is a controversial issue among the economists. The highlights of this debate can be seen particularly between the Keynesians and Monetarists. The Keynesians emphasize that a change in income cause changes in money stocks through the demand for money whereas the Monetarists,

on the other hand, claim that money plays a significant role, and also consider money supply to be the main factor leading to changes in income and prices (Shams, 2012).

The existing macroeconomic paradigm implies that the dynamic causal relationship among money, income (GDP) and price level is ambiguous and unresolved. In view of these theoretical arguments, it is essential to empirically examine the issue of causality among money, income and price level as well as the short run and long run relationships among them. This area of examination was activated by Sims (1972) after which various economies followed suite and reported varied and contradictory results.

Which of these positions would best describe the Kenyan context can only be determined by applying the empirical methodology that is capable of distinguishing between causality in the short-run and the long-run.

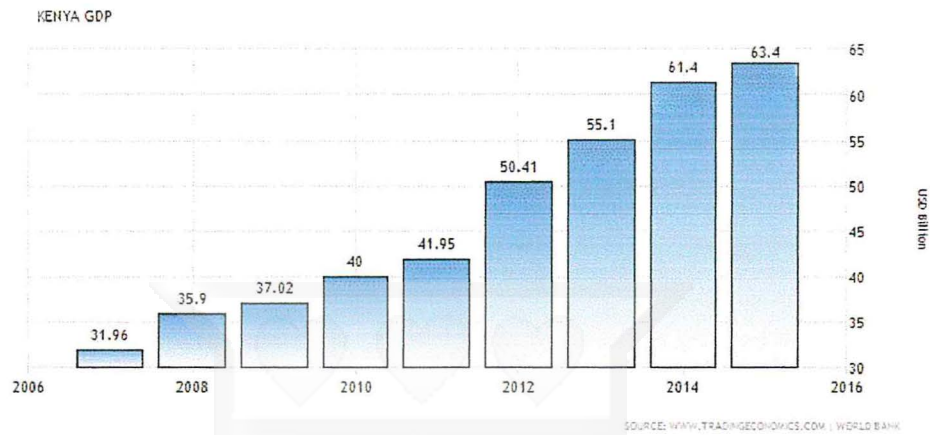
The Kenyan Economy

Kenya is known as the economic and transport hub of East Africa. According to the World Bank, when the Kenyan GDP per capita was \$1350 in 2014, it was reclassified as a lower middle-income country and the largest economy in East Africa after a statistical rebasing, which shifted the base year to 2009, when the economy increased by 25.3%, making it Africa's ninth-biggest economy (The World Bank, 2017).

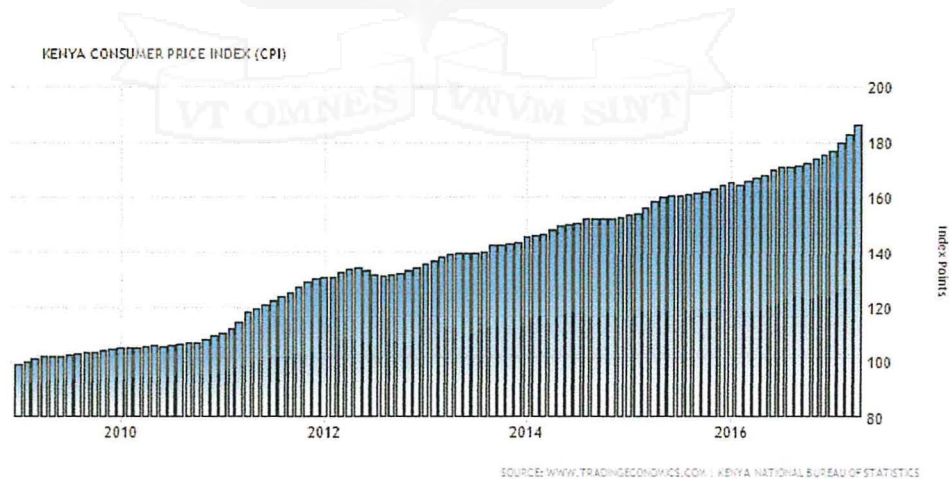
The monetary supply in Kenya is mainly based on the classifications of M1, M2 and M3. Money Supply M1 (The narrow money) in Kenya averaged KES 395.67 Billion from 1995 until 2016, reaching an all-time high of KES 1308.93 Billion in December of 2016 and a record low of KES 71.50 Billion in January of 1996. The money supply M2 in Kenya averaged KES 824.35 Billion from 1995 until 2016, reaching an all-time high of KES 2342.62 Billion in December of 2016 and a record low of KES 231.09 Billion in December of 1995. The money supply M3 in Kenya averaged KES 989,788.06 Million from 1995 until 2016, reaching an all-time high of KES 2,767,141.17 Million in November of 2016 and a record low of KES 244,755 Million in December of 1995

According to the World Bank (2017), the Gross Domestic Product (GDP) in Kenya was worth 63.40 billion US dollars in 2015. The GDP value of Kenya represents 0.10 percent

of the world economy. GDP in Kenya averaged 13.31 USD Billion from 1960 until 2015, reaching an all-time high of 63.40 USD Billion in 2015 and a record low of 0.79 USD Billion in 1961.



According to the Kenya national bureau of statistics (2017), the Consumer Price Index (CPI) in Kenya increased to 186.24 Index Points in April from 182.98 Index Points in March of 2017. Consumer Price Index (CPI) in Kenya averaged 137.01 Index Points from 2009 until 2017, reaching an all-time high of 186.24 Index Points in April of 2017 and a record low of 99 Index Points in January of 2009



Furthermore, as Kenya lays foundation for realization of Vision 2030 goals, macroeconomic stability has been identified as an important enabler of sustainable economic growth (Steve Makambi, May 2013). The key priority for Kenya at the

moment is to focus on stabilizing a low rate of inflation, however, this may cause a negative impact on the growth of the economy if the monetary policy is not targeted towards the most impactful variable.

1.2 Problem Statement

Money, Income and Macroeconomic prices play a very important role in any economy. They represent important variables for which a country's economic health is measured. The direction of the relationship among these variables is still a controversial issue among the various economic schools of thought. Federal Reserve Bank of New York (1962) asserted that 'A country is known by the money it keeps. Healthy money and healthy economy as a rule go hand in hand'. The state of a country's economic health is determined primarily by the country's monetary variable and its influence on the economy as a whole as well as its transmission channel through which monetary policy made translate into concrete effects on the economy.

After the seminal paper by Sims (1972) in the U.S. economy, this area of investigation has been studied extensively in both developing and developed economies over different sample periods and has provided conflicting evidence on this issue, for example, in countries such as Canada (James R Barth, 1974), Singapore (S. Y. Lee, 1983), India (Ramachandra, 1986), Pakistan (Fazal Husain, 2000), Turkey (SAATCIOGLU, 2008), Nigeria (PC Omoke, 2010), Sudan (Ahmed Elsheikh M. Ahmed, 2011), Jordan (Al-Sawai'e, 2012) as well as Bangladesh (Altaf-Ul-Alam, 2017), among many others.

There has not been any empirical analysis as such for the long – run relationship between these three important macroeconomic variables: Gross Domestic Product (GDP), money supply (MS), and the Price level (CPI), in the context of Kenya. The goal of this research is to redress this gap by examining the direction of causality between these three variables using annual data for the 20 year period (1996-2016) for the gross domestic product, money supply and the consumer price indices.

1.3 Objectives

General Objective

To determine the specific strength and direction of the relationship among the three macroeconomic variables under study, namely: real GDP, money supply and price in the Kenyan economy.

Specific Objectives

- I. To examine the existence of a long run relationship among the three variables in the context of the Kenyan economy.
- II. To assess the direction of causality between price movements and money supply.
- III. To assess the direction of causality between Kenyan GDP and money supply.

1.4 Research Questions

- I. Is there a long run relationship between the monetary aggregates and the respective macroeconomic variables?
- II. What is the direction of causality between the price levels and money supply in Kenya?
- III. What is the direction on causality between the GDP and money supply in the Kenyan economy?

1.5 Significance of study

In the formation of monetary policies, central banks either use money supply as an “intermediate target” variable or as an “information” variable (Ashutosh Sharma, 2012). The existence of at least some reliably exploitable relation between money supply and GDP or money supply and prices is therefore important, so that observed fluctuations in money is able to provide a systematic implication for income or prices in the future: From an information-variable perspective or from an intermediate-target perspective- which then makes it important to understand how these causal relationships pan out over different temporal horizons to ensure that effective macro-economic stabilization policies can be designed and implemented effectively.

Thus, in a developing economy like Kenya, one of the important tasks of the central bank in building an effective monetary policy is to understand the causal relationship between money and income and to further understand the dynamics of future movements of some relevant aspects of the real economy, which can be provided by this study.



CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This section attempts to look into studies that have been done in relation to money supply, GDP and prices. The first part of the literature review outlines the theoretical framework of the evolution of this issue and the second part provides a detailed review of the tests that have been carried out over the past regarding the causation among the variables.

2.2 Theoretical Framework

Plausible theoretical arguments began formulating right from what is said to be one of the oldest economic theories - the quantity theory of money. According to this theory, changes in the value of money are mainly determined by changes in the amount of its circulating medium (Mitchell, 1896). In other words, the theory basically argues that money is an exogenous variable. On the contrary, Cagan (1965) brought in the argument that money supply had the traits of both exogenous as well as an endogenous properties. His study proposed a relation in which the money supply is endogenously determined by changes in the real sector, for short run and cyclical fluctuation.

This argument was taken further right after the great depression, when Keynes (1936) advocated for the dominance of fiscal or budgetary policy, stating that monetary policy was not an effective means of stabilizing the economy. Keynes basically accepted the Quantity Theory as accurate over the long-term but not over the short term, due to the existence of the “liquidity trap”- which can only be rectified by the public sector stepping in to assist the economy. Therefore stressing on the point that the direction of causation runs from income to money without any feedback.

However, Milton Friedman’s research reinforced the value of monetary policy from an obsolete instrument to an effective instrument for growth and minimized inflation. Friedman (1968) quoted “True, money is only a machine, but it is an extraordinarily efficient machine. Without it, we could not have begun to attain the astounding growth in output and level of living we have experienced in the past two centuries” (Page

12). Thus, monetarists, on the other hand, see the opposite, i.e. that the direction of causation runs from money to income without any feedback. Monetarists basically tend to discard the existence of long-run Phillips curve trade-off, while allowing for the possibility of short-run trade-off as expectations adjust.

An extreme rational expectation formulation denies even the short-run Phillips curve trade-off and argues that only an unexpected rise in money supply will lead to change in output, whereas the expected change in money supply will lead to a rise in relative nominal prices with no real effects (Lucas, 1972). On the other hand, nominal rigidities models by incorporating rational expectations had shown that monetary shocks do have real effects (Fischer (1977), Phelps and Taylor (1977), Taylor (1979)).

The different theoretical predictions also have varied implications for causality between nominal and real magnitudes over varying time horizons. The monetarist position implies a short-run tradeoff between real and nominal magnitudes, with money supply impacting prices alone in the long-run. The rational expectations school would rule out short-run as well as long-run causality from anticipated money supply to output. The different Keynesian models, emphasizing rigidities, lead to theoretical short-run or short-run as well as long-run causation from money supply to output depending upon whether the structural rigidities are short-term or long-term.

2.3 Empirical Review

In the seminal paper by Sims (1972) based on research of Granger (1969) causality, Sims developed a test of causality and applied it to the Gross National Product (GNP) and money stock's aggregate quarterly data of the United States, to examine the causal relationship between money and income. This study concluded that causality was unidirectional from money to income and therefore, there seemed to be no contradiction to the view claimed by the monetarists.

However, this result was not obtained by subsequent studies. Replicating Sims' test in the Canadian economy, Barth & Bennett (1974) showed bidirectional causality between money and income.

Williams, Goodhart and Gowland (1976) also used the Sims statistical technique to assess the criteria in the United Kingdom. The study found a contrary result to that of Sims. There was some evidence of unidirectional causality running from nominal incomes to money and not vice versa.

With the aim of finding the validity of this theory in the context of Singapore, Lee & Li (1983) used the Sims statistical methods and found bidirectional causality between income and money and unidirectional from money to prices. Lee & Li (1985) also conducted a similar research on Malaysia and found that the relationship between money and GDP was, again, essentially two way. This approach was later followed by Joshi and Joshi (1985) - which found bidirectional causality in the Indian economy that runs from income to money with a feedback from money to income.

Ong Chin Huat (2000) re-examined to case of Singapore for causality between money supply (M1, M2 and M3) and GDP. His results showed that the money supply and GDP were co-integrated. The Granger causality concludes a bidirectional causality for M1 and GDP; unidirectional causality is found from GDP to money supply for both M2 and M3.

Abbas and Husain (2000) examined the causal relationship between money and income and between money and prices in Pakistan, which also found a unidirectional causality from income to money indicating that probably real factors rather than money supply have played a major role in the growth of national income of Pakistan; and a bi-directional causality between money and prices which implied that the increase in money supply raises the general price level which in turn increases the demand for money which results further increase in money supply.

Ahmed and Suliman (2011) also carried out the test based on Sims' methodology to examine the case of Sudan during the period 1960 – 2005. The results first showed that the direction of causation between real GDP and prices is uni-directional; meaning causality ran from real GDP to Consumer Price Index (CPI) without feedback. Second, causation ran likewise from Money supply to price and not from price to money supply. Lastly, there was no causality between real GDP and Money supply variable, however, real GDP, Money supply and Consumer Price Index were co-integrated, meaning that

there exists a long run relationship between these variables in the case of Sudan within the time frame investigated.

Using a similar methodology, in the case of Jordan, Al-Fawwaz and Al-Sawai'e (2012) analyzed the annual data for the period 1976-2009 and found out that there is no existing short-term relationship between money supply (M1) and GDP growth in Jordan. However, the monetary policy has not had any impact on the Jordanian macroeconomic variables, while it found out that there is a causal relationship from money supply to prices, with low degree of (0.21).

Tajudeen Mukhtar Olatunji (2012) provided empirical evidence from Nigeria for the period 1960-2011. The test indicated the existence of a long run relationship among the macroeconomic variables. In the short-run, real GDP and money supply stand out econometrically exogenous, whereas the presence of causal relationships among the variables shows that money supply is not neutral in the short-run. There were uni-directional short-run relationships running from broad money to price. Having considered the definitions of money stocks, broad money (M2) appeared to have a stronger causal effect on real output than narrow money (M1). Money supply showed to contain better information about the source of shocks that is affecting the economy when compared to others variables. This implied that money supply could be very useful for predicting the current and future growth rate in output and prices in the Nigerian economy. In addition, findings were concluded to be consistent with the quantity theory of money as opposed to other economic paradigms.

In the most recent study on the economy of Bangladesh, Mohammad Altaf-Ul-Alam (2017) shows the proof of Keynesian view, i.e. real GDP causes an increase in money supply, for the period 1979-2014. The Analysis also delineates that there is a significant long run relationship between real GDP, broad money and CPI. Furthermore, the monetary sector analysis proved that GDP is weakly exogenous implying that GDP has a smaller role in short-term adjustments.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter describes the procedures and methodologies that will be used in conducting the study to arrive at conclusions regarding the Money supply, GDP and price level causality and long-run relationship in Kenya.

3.2 Research Design

This study sought to investigate the causal relationship between money supply and price level and money supply and GDP in Kenya. Time series research design under non-experimental research design is adopted in the study.

3.3 Data collection

The main type of data that will be used for the study is quarterly time series data, measured in Kenyan shillings, which is limited to the period (2000 to 2016). The key sources of data are the Central Bank of Kenya (CBK) annual reports, the World Bank and Kenya National Bureau of Statistics. All data are natural log-transformed in the study.

Description of the variables used is presented in the table below:

Variable	Description
Money supply M1	Sum of currency in active circulation and demand deposits held by the private sector
Money Supply M2	Sum of M1 and quasi-money. Quasi money is made up of fixed deposits and negotiable certificate of deposits and other bank savings and deposits.
Money Supply M3	Sum of M2 and net deposits with non-bank financial institutions and finance companies
Real Gross domestic product	Value of economic output adjusted for price changes
Consumer-price index	Measures changes in the prices paid by consumers for a basket of goods and services

3.4 Data Analysis

3.4.0 Model Specification

This section reviews the model specification that will be used for the study. According to Sims C. A. (1972) and Ahmed Elsheikh M. Ahmed (2011), the relationship can be measured using the following models:

First, to determine the causality between money supply and price level:

$$MS_t = \sum_{i=1}^n \alpha_i CPI_{t-i} + \sum_{j=1}^n \beta_j MS_{t-j} + \varepsilon_{1t} \quad (1)$$

$$CPI_t = \sum_{i=1}^n \gamma_i CPI_{t-i} + \sum_{j=1}^n \delta_j MS_{t-j} + \varepsilon_{2t} \quad (2)$$

Secondly, to determine the causality between the money supply and GDP:

$$GDP_t = \sum_{i=1}^n a_i MS_{t-i} + \sum_{j=1}^n b_j GDP_{t-j} + \varepsilon_{3t} \quad (2)$$

$$MS_t = \sum_{i=1}^n c_i MS_{t-i} + \sum_{j=1}^n d_j GDP_{t-j} + \varepsilon_{4t} \quad (3)$$

Granger (1969) and Sims (1972) highlight the 8 different hypothesis that can be derived from this scenario, which are represented in the table below:

Direction	MS and CPI	MS and GDP
Unidirectional	MS to CPI	MS to GDP
Unidirectional	CPI to MS	GDP to MS
Bidirectional	CPI to MS, and MS to CPI	GDP to MS, and MS to GDP
Independence	No Granger Causality	No Granger Causality

Therefore, to address these objectives, the procedure would begin firstly by the Unit Root test, which will be examined to detect stationarity in the data used in order to avoid spurious regressions and, fulfil the basic assumption underlying the causality test. The Cointegration analysis is then tested to determine the existence of a long-term relationship. Cointegration also provides the evidence of the existence of causality, however, it does not specify the exact direction of the causality between variables. Hence, the final test would be the Granger Causality test to examine the direction of causation of this relationship between the variables.

3.4.1 Unit Root tests

Using conventional significance tests, a statistical relationship can be shown between two variables despite the fact that none in reality exists. This happens when two variables are non-stationary. A regression between them will lead to spurious results. This study will use a conventional unit root test- Augmented Dickey-Fuller test (1979) for two basic reasons as stated previously; to avoid the problem of spurious regression and accomplish a basic assumption underlying the application of causality test is that the time series in question should be stationary.

For the Augmented Dickey-Fuller (ADF) test, consider a simple AR(1) process:

$$y_t = \rho y_{t-1} + x_t \delta + \varepsilon_t \quad (4)$$

Where y_t is the observed variable, x_t are optional exogenous regressors which may consist of constant or a constant and trend, ρ and δ are parameters to be estimated, and ε_t is assumed to be white noise with zero mean and constant variance. If $\rho \geq 1$, y_t is a non-stationary series and the variance of y_t increases with time and approaches to infinity. Conversely, if $\rho \leq 1$, y_t is a stationary series.

On subtracting y_{t-1} on both sides of the equation, we get:

$$\Delta y_t = \alpha y_{t-1} + x_t + \varepsilon_t \quad (5)$$

Where $\alpha = \rho - 1$

The null and alternative hypothesis can be written as;

$H_0; \alpha = 0$ (y_t is unit root)

$H_a; \alpha < 0$ (y_t is stationary)

The study is evaluated using a conventional t_{ratio} test for α .

$$t_{\alpha} = \frac{\alpha^{\gamma}}{se(\alpha^{\gamma})}$$

Where α^{γ} is an estimate of α and se is the standard error.

Another reason to subjecting the three macroeconomic variables series individually to unit root analysis is that individual economic time series may not be stationary, but there may be cases of linear combination among them. This means that non-stationary economic time series could produce stationary relationships if they are cointegrated. If the residuals of the three variables do not contain unit roots, the econometric relationship among the variables could be co-integrating.

3.4.2 Co-integration analysis

If the residuals of the three variables is stationary, the econometric relationship among the variables might be co-integrating. Cointegration enables the examination of the existence of a long-run relationship between or among variables.

In this study, the Johansen's procedure (1988) will be adapted to test for cointegration. This is because The Johansen test and estimation strategy (maximum likelihood) makes it possible to estimate all cointegrating vectors even when there are more than two variables. The ADF test performed beforehand to access the order of integration of each variable before applying Johansen's procedure. If there are three variables each with unit roots, there are at most two cointegrating vectors.

The Johansen test provides estimates of all cointegrating vectors. Just as for the Dickey-Fuller test, the existence of unit roots implies that standard asymptotic distributions do

not apply. This procedure proposed two likelihood ratio tests- the trace test and the maximum eigenvalue.

a) *The trace test*

The trace test tests the null hypothesis of r co-integrating vectors against the alternative hypothesis of n co-integrating vectors. The test statistic is given by:

$$J_{trace} = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

b) *The Maximum Eigen Value*

The maximum eigenvalue test, on the other hand, tests the null hypothesis of r co-integrating vectors against the alternative hypothesis of (r+1) co-integrating vectors. Its test statistic is given by

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

Where T is the sample size, and $\hat{\lambda}_i$ is the i^{th} largest canonical correlation (Ssekuma, 2011).

Since Johansen method is sensitive for autocorrelation in residuals, it will be determined by the appropriate lag lengths to estimate a model that is not suffering from autocorrelation problem. Schwarz criterion is used to determine the lag length periods (lagged one period), then testing autocorrelation lengths for specific lag, and for choosing acceptable test of co-integration.

Granger (1969) and Sims (1972) stated that, if two variables are co-integrated, causality must exist in at least one direction, either unidirectional or bidirectional. Co-integration only indicates the presence or absence of Granger causality but does not indicate the direction of causality between or among variables.

3.4.3 Granger causality test

Granger (1969) proposed a model for measuring causality between co-integrated variables. The test is carried out on the hypothesis stated in equation (1) - (4) under the model specification, in order to determine if historic values of one random variable can help predict the future values of the other random variable. Causality can basically be elaborated as; the question of whether x causes y, to see how much of the current value of y can be explained by past values of x, and test whether adding any lagged values of y can improve these estimates. It is inferred that y is a Granger caused by x, if y can be predicted from past values of y and x then from past values of y alone, (Granger C. J., 1969).

The random variables in this case are the Money supply, GDP and Prices. The study aims to identify whether the money supply causes prices, or vice versa, as well as whether the Money supply causes changes in output or vice versa.

When carrying out the test, the implied null hypothesis is that Money supply does not Granger cause CPI in the first regression equation and CPI does not Granger cause the Money supply in the second regression equation. The test will be conducted within the framework of the f-test. Hence, if the p-value of the f-test is significant at 5% significant level, then the null hypothesis will be rejected.

CHAPTER 4: DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents the findings of the data analysis and their interpretations. It starts off with the trending of the variables and descriptive statistics. The chapter further provides a time series analysis for the stationarity, Cointegration as well as the Granger causality tests, which were carried out to give reliable estimates. E-views is the software that has been mainly utilized to obtain these results.

4.2 Response rate

The study uses time series data in the period 2000 to 2016. Data on money supply and consumer price index were obtained from the Kenya National bureau of statistics, whereas the gross domestic product (GDP) data was retrieved from the World Bank website. The money supply units are measured in Kes million, the consumer price index is measured in index points and the gross domestic product is measured in USD.

4.3 Descriptive statistics

Table 4.1 below shows the summary statistics of the main variables that have been included in the model. These include the mean, median, maximum, minimum, standard deviation, skewness and kurtosis of the quarterly data observed. Mean is used to locate the center of the relative frequency distribution. Additionally, standard deviation gives the spread or dispersion in a series, whereas skewness is a measure of negative or positive symmetry of a distribution of a series around its mean, and kurtosis is the peakedness of the distribution (Chepkemai, 2014).

Table I: Descriptive statistics results

	GDP	CPI	M1	M2	M3
Mean	944.5412	99.10706	467.0297	954.6639	1122.544
Median	917.8965	92.94508	387.8160	724.7528	851.5410
Maximum	1156.873	173.8855	1288.926	2328.429	2750.364
Minimum	820.5608	46.73018	110.3633	307.2233	343.8780
Std. Dev.	102.4298	39.07747	322.3352	648.8657	771.6424
Skewness	0.481209	0.379186	0.734987	0.796945	0.799055
Kurtosis	1.989432	1.803530	2.407864	2.310850	2.312528
Jarque-Bera	5.517909	5.685557	7.115768	8.543670	8.575287
Probability	0.063358	0.058264	0.028499	0.013956	0.013737
Sum	64228.80	6739.280	31758.02	64917.14	76333.02
Sum Sq. Dev.	702954.5	102312.2	6961300.	28208792	39893946
Observations	68	68	68	68	68

Analysis of the skewness shows that all the regressors are positively skewed meaning that there is frequent occurrence of small negative outcomes, and extremely bad scenarios are not as likely, and more than half the data exceeded its mean value.

Additionally, all the data tended to follow a leptokurtic distribution meaning the data is highly peaked.

The graphs in Appendix I show that none of the series looks stationary in levels; their general trend is upward. However, the log differences of the data displayed in appendix II, show signs of stationarity.

4.4 Correlation analysis of data

Table 4.2 displays the correlation between real GDP, Money and CPI. This correlation matrix measures the two-way relation between the mentioned variables. It indicates a very high correlation between variables. In addition, all the variables display a positive correlation among each other.

Table II: Correlation Matrix between Real GDP, MS and CPI 2000-2016

	GDP	CPI	M1	M2	M3
GDP	1.0000	0.9846	0.9874	0.9831	0.9831
CPI	0.9846	1.0000	0.9862	0.9822	0.9826
M1	0.9874	0.9862	1.0000	0.9953	0.9951
M2	0.9831	0.9822	0.9953	1.0000	0.9999
M3	0.9831	0.9826	0.9951	0.9999	1.0000

4.5 Test for stationarity

The Augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1981) test is used to determine the stationarity of time series. The results of the unit-root tests are reported in Table III which indicate the rejection of null hypotheses in a level of 10 %, 5 % and 1 % respectively, which shows that all the variables are stationary at I(1).

The numbers in parentheses are the lags used for the ADF test, which are augmented up to a maximum of 10 lags. The choice of optimum lag for the ADF test was decided on the basis of minimizing the Schwarz information criterion.

Table III: Augmented Dickey Fuller Test

	Variables	Model	ADF	difference
Gross domestic product	GDP	Intercept	-2.509739 (0)	1 st
Money supply	M1	With trend and intercept	-5.435398 (0)	1 st
	M2	With trend and intercept	-6.141585 (0)	1 st
	M3	With trend and intercept	-5.683744 (0)	1 st
Consumer price index	CPI	No trend/Intercept	-3.158921 (0)	1 st

4.6 Research findings

To obtain the research objective (I) of examining the existence of a long run (co-integrating) relationship among the three macroeconomic variables in the context of the Kenyan economy, the Johansen Procedure was used. Table IV shows the Co-integration test using M1 as the monetary aggregate variable, table V shows the co-integration test result using M2 as the monetary aggregate variable and table VI shows the co-integration test result using M3 as the monetary aggregate variable.

The co-integration tests indicate that a long-run relationship does exist among prices, money supply, and economic growth.

Table IV: Co-integration test (using M1 monetary aggregate)

Sample (adjusted): 2000Q4 2016Q4				
Included observations: 65 after adjustments				
Trend assumption: Linear deterministic trend				
Series: GDP CPI M1				
Lags interval (in first differences): 1 to 2				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.358422	41.36405	29.79707	0.0015
At most 1	0.174339	12.51547	15.49471	0.1338
At most 2	0.000974	0.063350	3.841466	0.8013
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
1 Cointegrating		Log		
Equation(s):		likelihood	-564.4994	
Normalized cointegrating coefficients (standard error in parentheses)				
GDP	CPI	M1		
1.000000	-2.441959	-0.053132		
	(0.60381)	(0.07632)		

The likelihood ratio test indicates one cointegrating equation at 5 percent significance level. As a result, the long-run equilibrium relationship among the tested variables is based on the following cointegrating vector: [1.00, -2.441959, -0.053132]

These values represent the coefficient for real GDP (normalized to one), M1, and CPI.

Hence, the long-run equilibrium relationship can be expressed as:

$$\text{Real GDP} = -0.053132M1 - 2.441959CPI$$

Table V: Co-integration test (using M2 monetary aggregate)

Sample (adjusted): 2000Q4 2016Q4				
Included observations: 65 after adjustments				
Trend assumption: Linear deterministic trend				
Series: GDP CPI M2				
Lags interval (in first differences): 1 to 2				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.352884	36.11279	29.79707	0.0082
At most 1	0.112427	7.822888	15.49471	0.4845
At most 2	0.001087	0.070706	3.841466	0.7903
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
1 Cointegrating Equation(s):		Log likelihood	-558.8367	
Normalized cointegrating coefficients (standard error in parentheses)				
	GDP	CPI	M2	
	1.000000	-3.548640 (0.57801)	0.031570 (0.03055)	

The likelihood ratio test indicates one cointegrating equation at 5 percent significance level. As a result, the long-run equilibrium relationship among the tested variables is based on the following cointegrating vector: [1.00, -3.548640, 0.031570]

These values represent the coefficient for real GDP (normalized to one), M2, and CPI.

Hence, the long-run equilibrium relationship can be expressed as:

$$GDP = 0.031570M2 - 3.548640CPI$$

Table VI: Co-integration test (using M3 monetary aggregate)

Sample (adjusted): 2000Q4 2016Q4				
Included observations: 65 after adjustments				
Trend assumption: Linear deterministic trend				
Series: GDP CPI M3				
Lags interval (in first differences): 1 to 2				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.335140	36.89795	29.79707	0.0064
At most 1	0.147328	10.36636	15.49471	0.2536
At most 2	0.000102	0.006631	3.841466	0.9345
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
1 Cointegrating Equation(s):		Log likelihood	-580.5058	
Normalized cointegrating coefficients (standard error in parentheses)				
GDP	CPI	M3		
1.000000	-3.357547	0.016015		
	(0.58155)	(0.02681)		

The likelihood ratio test indicates one cointegrating equation at 5 percent significance level. As a result, the long-run equilibrium relationship among the tested variables is based on the following cointegrating vector: [1.00, -3.357547, 0.016015]

These values represent the coefficient for real GDP (normalized to one), MS, and CPI. Hence, the long-run equilibrium relationship can be expressed as:

$$\text{Real GDP} = 0.016015\text{M3} - 3.357547\text{CPI}$$

The Cointegration analysis does imply that causality exists between the series but it does not indicate the direction of the causal relationship. With an affirmation of a long run relationship among m, y and p, the final step of estimation would be a test for Granger causality (Mohsen Mehrara, 2012). This will in turn attain the research objectives II and

III outline in the project; to assess the direction of causality between price movements and money supply, as well as GDP and money supply. Therefore, table VII below presents the pair-wise granger causality between GDP, CPI and the monetary aggregates.

Table VII: Granger causality test

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
M1 does not Granger Cause GDP	65	2.92487	0.0413
GDP does not Granger Cause M1		0.99634	0.4011
M1 does not Granger Cause CPI	65	2.31936	0.0848
CPI does not Granger Cause M1		2.37206	0.0796
M2 does not Granger Cause GDP	65	2.60176	0.0606
GDP does not Granger Cause M2		0.88783	0.4529
M2 does not Granger Cause CPI	65	0.68243	0.5664
CPI does not Granger Cause M2		4.74894	0.0050
M3 does not Granger Cause GDP	65	2.31314	0.0854
GDP does not Granger Cause M3		1.41643	0.2472
M3 does not Granger Cause CPI	65	0.49638	0.6862
CPI does not Granger Cause M3		3.47961	0.0215

Comparing the Probability values of the test results to the conventional level of p-value which is 0.05 at 3 lags, results reveal a unidirectional causality running from M1 (narrow money) to GDP. Furthermore, the results also display a unidirectional causality from CPI to M3 (broad money), with no feedback. There is no evidence of causality between narrow monetary aggregates (M1 and M2) and CPI, as well as the broader monetary aggregates (M2 and M3) and GDP.

CHAPTER 5: CONCLUSION

The objective of this study was to examine the long run relationship and causality between Income (Real GDP), money supply (MS) and prices (CPI) in Kenya from 2000-2016. The Augmented Dickey Fuller test, Johansen test and Granger Causality were employed, catering for the stochastic properties for the macroeconomic variables.

The results from correlation analysis indicate that there is a very strong correlation between the three variables pairwise. Furthermore, the co-integration analysis has established the existence of one co-integrating equation, thus implying that a long-run relationship exists among CPI, money supply, and economic growth (Faiz Masnan, 2013).

The Granger causality test reveals a unidirectional causality from narrow money (M1) to GDP. This means that M1 appears to have the strongest causal effect on the real output and not much of an effect on prices, which indicates an inclination towards the monetarist view. Our results, in this case are more or less similar to the view provided by the seminal paper based in US (Sims, 1972), Malaysia (Muhd Zulkhibri, 2007), Canada (Artis, 1992), as well as Denmark and Sweden (Hayo, 1999).

According to Abdunnasser Hatemi-J (2004), the established uni-directional causality from money to output reveals two policy implications. First, active monetary policy has a role in reducing the severity of the business cycles and unobservable shocks. Second, in looking for the sources of output fluctuations, money is a major factor.

The test further indicates a unidirectional causality from CPI to the broad money supply aggregate (M3), and displays no causality of CPI with the narrow monetary aggregates (M1&M2). These results are pretty much in line with those obtained by Bangladesh (Starme, 1988). Thus, in the context of an econometric model for Kenya, the observation that "prices Granger-cause money" does allow us to reject the treatment of money supply as an exogenous variable.

According to (Starme, 1988), these results cast doubt over monetarist claims that structural problems in developing countries are largely the result of inflation which is,

itself, ultimately due to a failure of the monetary authorities to exercise appropriate control over the money supply. The observation of causality running from prices to money with no evidence of significant feedback in the opposite direction seems to favor an interpretation which reverses the chain of events in the monetarist account: structural constraints give rise to price increases, inflation feeds through to increasing budget deficits and consequent expansion of the money stock.

To conclude, some words of caution should be highlighted for the study. Other tests under this may be employed such as the Granger no-causality developed by Toda and Yamamoto (1995) and the Granger causality test in vector error correction model (VECM), the results of which can be compared to this research in order to provide a stronger analysis. A larger data period could also be used and broken down for disaggregated analysis, which may be difficult to do so in the current study (as the co-integration and causality tests are quite sensitive to sample size), future studies should take this recommendation into consideration (Ong Chin Huat, 2000). In addition, inclusion of more variables such as exchange rates, technology shocks, taxation, among many others could also form a better hypothesis of detailed study under this topic as they also play an important role in the determination of output growth, and policy-making.



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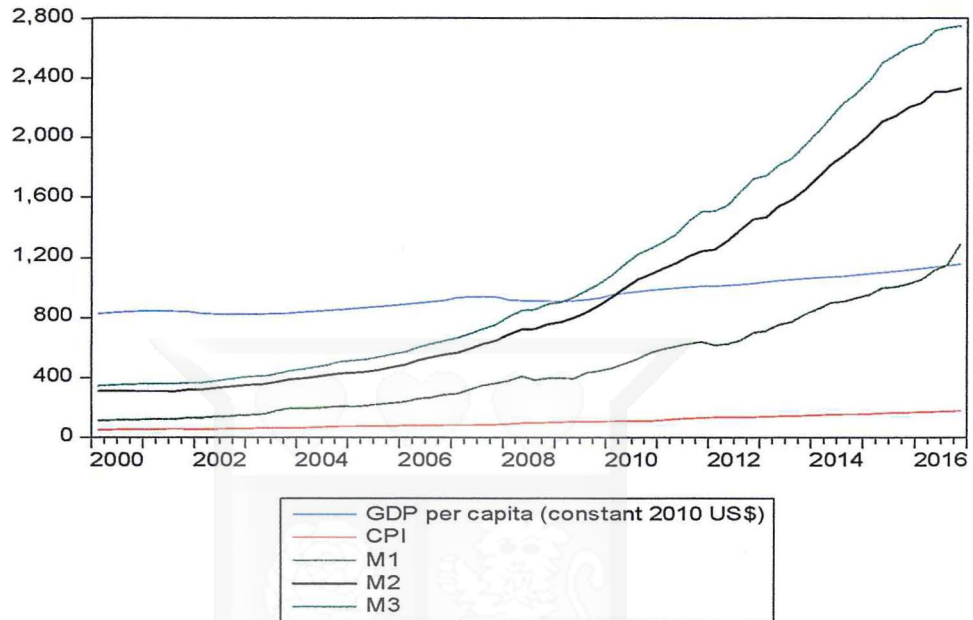
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APPENDICES

Appendix 1: Time series plot at levels



Appendix 2: Time series plots at log differences

