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MONEY GROWTH AND INFLATION IN ZAMBIA: A COINTEGRATION AND CAUSALITY ANALYSIS

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ABSTRACT

The study investigated whether money growth is the major determinant of inflation in Zambia, while controlling for the effects of the nominal exchange rate, interests rates and oil prices, using Cointegration, Error correction, and Granger causality analysis. The study found a positive long run relationship between inflation and money supply, nominal exchange rate, and oil prices, while there was a negative long run relationship between inflation and the 91 day treasury bills rate (interest rate). Changes in interest rates have the major role in controlling any deviation of the equilibrium inflation rate, followed by changes in money supply, then changes in oil prices, and lastly, exchange rates. Therefore, money plays a major role in the conduct of monetary policy in Zambia.

JEL Classification: E31, E51, E52, F31

Keywords: Inflation, Money, Monetary policy, Exchange rates

1. INTRODUCTION

The adverse effects of continuous increases in prices (or inflation) on the economy are widely documented. For this reason, price stability has been a central goal of monetary policy in recent years. In this respect, Barro (2013) noted that “monetary policy, whether expressed in terms of interest rates or growth of monetary aggregates, had been increasingly geared toward the achievement of low and stable inflation".

Blejer (1998) notes that, in most industrial and emerging economies inflation has averaged between 2-3 percent since the beginning of the 1990s and that inflation in this range is considered moderate or mild inflation and is not regarded as a problem. However, the inflation rate in Zambia for the most part has been high and volatile over the past decades. At the time of the country's independence in 1964, the inflation rate as measured by the GDP deflator was 4.08 percent. By the end of the 1970s, the inflation rate had increased to 21.9% and by the end of the 1980s the inflation had reached an astronomical rate of 107.02%. By 1991 when the country embarked on liberalization and structural reforms, the rate of inflation had fallen to 97.7%. After undergoing structural reforms and economic stabilization in the 1990s, the country's inflation rate was brought down to single digits in 2006 when the annual inflation rate was recorded at 5%. The inflation rate during this period hovered around 7 % from that time until much more recently when it short up again to double digits. As at end of May 2016, the inflation rate was recorded at 21.3%. At the end of January 2017, the inflation rate had reduced to the single digit of 8% (See BoZ, 2017). As this brief history indicates, inflation in Zambia has been usually high and highly variable.

According to Monetarists, money growth is the main determinant of inflation in the long run. The quantity theory illustrates how money determines inflation, which was affirmed by Milton Friedman's 1956 famous statement that "inflation is always and everywhere a monetary phenomenon". Over the years, several studies have investigated the relationship between money growth and inflation. Recent studies by Minford, P and Srinivasan, N (2011), Woodford, M (2008), and Zhang, C 2013, all found that money growth was the major determinant of inflation.
However, studies that focused on the relationship between money growth and inflation in Zambia did not explicitly illustrate the size of the impact of money growth on inflation relative to other determinants such as exchange rates. For instance, Chileshe, 2014, found monetary aggregates and exchange rates to have a significant effect on output and prices, but did not rank their size of impact. Therefore, this study tried to fill this gap by investigating whether money growth is the major determinant of inflation in Zambia as outlined in the classical theory of inflation.

The study utilized Johansen cointegration, Error correction model, and granger causality analysis in order to estimate the effects of money on inflation, while controlling for exchange rate, oil price, and interest rates effects. The study found a positive long run relationship between inflation and money supply, nominal exchange rate, and oil prices, while there was a negative long run relationship between inflation and the 91 day treasury bills rate (interest rate). The study

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did not find any short run causality between the inflation rate and money supply, and/or control variables.

In the sections that follow, we give an overview of the theoretical and empirical literature on inflation. This is followed by an overview of the data and methodology used in the study. The paper ends with a discussion of the data analysis and findings of the study.

2. LITERATURE REVIEW

There are many and diverse theories that have been advanced in the economic literature to explain the nature and causes of inflation. Some theories such as the Classical theory of inflation attribute inflation purely to monetary factors, while others such as the Keynesian theory of inflation emphasize aggregate demand as the primary determinant of inflation. In this section, we discuss in detail these two competing theories and other relevant theories of inflation. The section ends with an overview of some of the empirical studies that have been conducted in the developed and developing countries that have investigated the relationship between money supply and inflation.

2.1 Theoretical Literature:

This subsection discusses the main theories of inflation beginning with the Classical and Keynesian theories on the nature and causes of inflation.

The Classical Theory of Inflation

The quantity theory of money is the leading theory of the effects of money on the economy in the long run. The theory can be traced to the work of early monetary theorists such as David Hume and Irving Fisher's equation of exchange. The quantity theory of money states that changes in the general level of prices are determined primarily by changes in the quantity of money. According to this theory, the price level (*P)* is directly proportional to changes in the quantity of money *(M*). This means that a given percentage change in the money stock leads to an identical percentage change in the price level. This relationship between the quantity of money in circulation and the price level is expressed as:

$$MV=PY \quad .....(1)$$

In this equation, P is the price level, Y is output, M is the quantity of money, and V is the income velocity of money. The quantity theory of money assumes that the velocity of money is fixed. With fixed velocity and real GDP fixed by the factors of production, nominal GDP can only change if the price level changes. Therefore, the quantity theory of money implies that the price

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level is proportional to the money supply. Since the inflation rate is the percentage change in the price level, the quantity theory of money is also a theory of the inflation.

Keynesian Theory of Inflation

John Maynard Keynes (1883-1946) believed that changes in the money supply can affect the price level. However, in contrast to the classical economists, Keynes argued that there is no direct and proportionate relationship between the quantity of money and the price level. In Keynes's view, changes in the money supply affect the price level indirectly through its effect on the interest rate. An increase in the money supply given the demand for money, leads to a fall in the interest rate thereby increasing investment and aggregate demand through the multiplier process. This increase in aggregate demand relative to aggregate supply causes the price level to rise.

Thus, in Keynes's view the relation between money and the price level is indirect rather than direct and proportionate. The Keynesian theory emphasises that the price level changes because of changes in aggregate demand relative to aggregate supply rather than the quantity of money.

Monetarism

Monetarism is attributed to the Nobel Prize winning economist Milton Friedman (1912-2006). According to Friedman (1956), "inflation is always and everywhere a monetary phenomenon" and can only be produced by a more rapid expansion in money supply than output. Monetarism stresses that the money supply determines both nominal GDP and the price level. The theoretical foundation of monetarism is the quantity theory of money which was restated by Friedman. Friedman's theory of national income is given by:

$$PY = (1/k)\, M \qquad \text{........(2)}$$

In this equation, P is the price level, Y is real income, k is the proportion on money that people demand to hold in the form of money balances and M is the money supply. Assuming that k and Y are constant, this equation shows that the price level is directly proportional to the money supply. In the modern quantity theory of money, k is stable. According to monetarists, an increase in money supply given a stable money demand increases the amont of cash balances in the hands of the public. This means that people have excess cash balances than they want to hold. Therefore, to get rid of the excess cash balances, people spend the excess money on goods and services thereby increasing aggregate demand and the price level. Thus, in the view of monetarists, an increase in money supply directly affects prices and income by increasing the aggregate demand for goods and services.

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Demand-Pull Inflation

According to this theory, demand-pull inflation occurs when aggregate demand is rising faster than aggregate supply resulting in an increase in prices and wages. According to Keynes, inflation is caused by an inflationary gap that arises when aggregate demand exceeds aggregate supply at the full employment level of output. When the aggregate demand for goods and services exceed the available supply of output, a natural consequence is a rise in the general level of prices in the economy.

Demand-pull inflation can arise due to a government budget deficit, an expansion of bank credit for private investment, a depreciation of the exchange rate that boosts export sales, a monetary stimulus to the economy, faster economic growth in other countries, and improved business confidence that prompts firms to raise prices to achieve better profit margins.

Cost-Push Inflation

Cost-push inflation occurs when costs increase independent of any increase in aggregate demand. Cost-push inflation can occur when powerful trade unions push for higher wages which in turn causes firms to pass the increase in their production costs to consumers in form of hiher prices for goods and services. Cost-push inflation also occurs when firms operating in monopolist or oligopolistic markets increase their profit margins which results in increased prices for consumers. Another cause of cost-push inflation is the increase in the prices of raw materials especially the price of oil which pushes up production costs and consequently prices for goods and services.

Imported Inflation Theory

According to this theory, inflation in one country can be transmitted to another country through trade and financial links that exist between countries. Under a fixed exchange rate regime, inflation can be transmitted from one country to another through internationally traded goods. The goods arbitrage for internationally traded goods equalises domestic goods prices with foreign prices. This implies that the domestic rate of inflation and the inflation rates of different countries will converge. Inflation can also be transmitted through excess demand from one country to another by increasing other countries' exports and initiating an expansionary income multiplier in those countries. Excess demand can also be transmitted through balance of payments deficits and surpluses. Economic agents may generate either a deficit or surplus in the balance of payments to eliminate their excess real balances or build up real balances through a balance of payments surplus. A floating exchange rate can prevent the transmission of excess demand from one country to another by depreciation in the exchange rate. Inflation in the

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depreciating country would worsen than under fixed exchange rates.

Structuralist Inflation Theory

According to the structural theory of inflation, the root cause of inflation is found in the economic structure of a country. This theory presupposes that changes in the structure of the economy causes changes in the prices of certain products relative to others which are propagated to the price level due to downward rigidity of wages and prices. Structural inflation models are based on three main elements; relative prices that change when economic structure changes; downward inflexibility of nominal wages and a passive money supply closing the inflation gap caused by structural factors. In this view money supply adjusts passively to the inflationary pressure originating from the economic structure.

2.2 Empirical Literature:

Roffia and Zaghini (2007) analyzed the short run effects of strong monetary growth on inflation dynamics for fiftten (15) indutrialized economies using quartely time series data for the period 1970 to 2006. Their study utilized broad monetary aggregates equivalent to M2 and M3 as indicators of monetary growth and the consumer price index as a measure for inflation. Other variables in the study included the share price index and the price of housing as indicators of asset prices. The results of the study indicated that over a 3-year horizon, the positive link between monetary aggregates and prices holds in approximately fifty percent of the cases. An econometric investigation suggests that a contemporaneous increase in the gap measures of the real stock price and real housing price and strong dynamics of loans to the private sector significantly increase the probability of turning an episode of excessive money growth into an inflationary outburst (Roffia and Zaghini 2007).

Vladova and Yanchev (2015) examined the relationship between money supply and prices in Bulgaria for the period 1998 to 2012 using dynamic cross-correlations, Granger cauasality in the framework of unrestricted VAR models, and the Johansen cointegration technique to allow for the analysis of the short run and long run dynamics of money supply and inflation. They found a two-way relationship between money supply and price dymamics in Bulgaria. They found that the link from prices through money demand to money supply may be theoretically justified because of the endogeneity of the money supply mechanism under the currency board arrangement. At the same time they found evidence for feedback effects from monetary growth to inflation (Vladova and Yanchev, 2015).

Bhattarrai (2011) studied the effects of the exchange rate and money supply on growth, inflation and interest rates in the United Kingdom (UK) using a simultaneous equation model to analyse

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the interdependence of interest rates and inflation on the growth rate of money supply, the exchange rate and the lagged interest rate. The study found that depreciation of the Sterling has contributed to economic growth in the UK by enhnacing competitiveness. In addition, it was found that interest rates have been persistent and contractionary and that money supply has been non-neutral in the short run.

Emerenini and Eke (2014) also examined the determinants of inflation in Nigeria from 2007 to 2014 using monthly data and employed the method of Ordinary Least Squares (OLS), Cointegration and Granger causality in their study. They found that expected inflation, the exchange rate, and money supply influenced inflation. Futher, their study found that the annual treasury rate and the monetary policy rate did not influence inflation during the period studied.

Mbutor (2013) investigated the contribution of money supply to the dynamncs of inflation in Nigeria using annual time series data for the period 1970 to 2012 using Cointegration analysis, Vector Error Correction (VEC) and Variance decomposition. The study found a postive relationship between money supply and inflation. However, gross domestic product (GDP) was found to be the strongest contributor to inflation in Nigeria. According to them, the result is reflective of the nature of the Nigerian economy as GDP nests all the stuructural factors that that impact inflation (Mbutor, 2013). Bakare (2011) investigated the determinants of money growth and its mplications for inflation in Nigeraia using simulation techniques and an error correction model. The study found that credit extention to the private sector determinded money supply and further found a postive relationship between money supply and inflation in Nigeria.

Uzodigwe , Ajana (2015) also examined the dynamic impact of money supply on inflation in ECOWAS member states for the period 1980 to 2012 using country specific and panel data employing a distributed lag model. In their study, they found that money supply affects inflation in the current and first period. In addtion, they found significant country-specific effects on these variables.

Mbongo, Mutasa, and Msigwa (2014) studied the effects of money supply on inflation in Tanzania using ordinary least squares (OLS), vector autoregression (VAR), and error correction mechanism (ECM). Using OLS and ECM methodology, they found a significant relationship between money supply and inflation in both the short run and long run. In addition, results fron the application of VAR methodology indicated that current inflation is affected by past inflation. Laryea S, Sumaila U (2001) also investigated the detreminants of inflation in Tanzania for the period 1992 to 1998 using quartely data. Using an error correction model (ECM), they estimated an inflation equation for Tanzania. They found that inflation in Tanzania in both the short run and long run is mainly influenced by monetary factors. Other factors such as output volatility and

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excahnge rate movemnents also affected inflation to some extent.

Akinboade, Siebrits, Niedermeir (2004) studied the deterinants of inflation in South Africa for the period 1970 to 2000 using quarterly data. Their study looked at the effects of the money market, labor market and foreign exchange conditions on domestic inflation using Ordianary Least squares (OLS), Cointegration, and Vector Error Correction Mechanism methodolody. They found that in the short run labor costs, broad money supply, and domestic inflation are postively correlated and that in the long run rising labor costs significantly affected inflation. Further, they found that the nominal interest rate reduced inflation in the long run and that inflation in South Africa was largely of a structural nature.

Chileshe (2014) examined the effectiveness of monetary policy in Zambia by investigating the money demand function and the monetary transmission mechanisms using quartely data. The study utilized the Autoregressive Distributed Lag (ARDL) to investigate the money demand function and the Vector Autoregressive methodology to analyse the monetary transmission mechanism. The study found that broad money monetary aggregates and the exchange rate are important channels in the transmission of monetary policy in Zambia. However, interest rates were found to have an insignificant effect on output and prices.

Chaudhry, Farooq and Murtaza (2015) also investigated the impact of money supply growth on the rate of inflation in Pakistan using annual time series data for the period 1973 to 2013. The study examined the short run and long run effects of money supply growth on inflation using the Autoregressive Distributed Lag (ARDL) model.

They found that interest rates and money supply affected inflation in the long run and that the level of output reduces the inflation rate in the short run.

Yousfat (2015) examined the relatioship between money growth and inflation in GCC countries using times series data for the period 1970 to 2013. Using Johansen cointegartion methodology, the study found that money growth has a significant and postive impact on inflation in the long run. The study further found that interest rates and imports positively affect inflation while excahnge rates and GDP have a negaitive effect on inflation in the long run.

Gungor, Berk (2006) studied the relationship between money supply and inflation in Turkey for the period 1996 to 2006 using monthly data. Using a Multilayer perceptron neural network model, the study found that money supply has a significant impact on the inflation rate in Turkey and that the inflationary process in Turkey has significant inertia. Bozkurt (2014) also examined the relationship between money supply, inflation and economic growth in turkey for the period 1992 to 2012 using cointegration analysis. The study found that money supply and money

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velocity are the main determinants of inflation in Turkey in the long run and that income was also positively related to inflation.

Regasa, Denbel, Ayen (2016) investigated the causal relationship betwwen money supply and inflation and between inflation and economic growth for the period 1970 to 2010 using Johansen cointegration. The study found a long run bildirectional causality between inflation and money supply and unidirectional causality from economic growth to inflation.

Ahiabor (2013) investigated the effects of monetary policy on inflation in Ghana for the period 1985-2009 using the method of ordinary least squares. The sudy found a long-run postive relatioship between money supply and inflation while interest rates had negative relationship wth inflation. Further, the echange rate was found to postively affect inflation.

3. DATA AND METHODOLOGY

This section describes the type and sources of data used in the study, the model and econometric procedures followed to arrive at our findings.

3.1 Data Sources:

The study utilized monthly time series data for the period 2001 to 2014. The data was obtained from the Central Statistical Office (CSO) and the Bank of Zambia (BOZ). The variables of interest include the consumer price index (CPI), broad money supply (M2), the nominal exchange rate (NEXRATE), the Spot Brent oil price (OILPRICE) and the 91-Day Treasury bills rate (TBILL).

3.2 Model Specification:

Based on economic theory and the main drivers of the inflation process in Zambia, the model used in the study expresses inflation measured by the headline consumer price index (CPI) as a function of broad money supply (M2), the nominal exchange rate (NEXRATE), the Spot Brent oil price (OILPRICE) and the 91-Day Treasury bills rate (TBILL). These variables are specified in the following general model:

$$CPIt = f\,(NEXRATEt, M2t, OilPRICEt, TBILLt) \qquad (3)$$

Where: CPI is the headline measure of consumer prices in Zambia. It captures the cost of a basket of goods purchased by the typical urban consumer; NEXRATE is the nominal exchange rate between the kwacha and the dollar defined as the price of a dollar ($1) in terms of the kwacha. It is the number of kwacha units per unit of the US dollar. NEXRATE has been used in

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the model to capture imported inflation; M2 is the broad classification of the money supply and is used to capture the monetary drivers of inflation; OILPRICE is the spot price of Brent per barrel and is used as a proxy of supply shocks. It basically represents the cost of production in this model; TBILL is the 90-Day BOZ Treasury bills rate and is used in the model to capture the effects of interest rates on inflation. Therefore, the log transformation of the equation (3) yields a regression model that is specified as follows:

$$logCPIt = \beta 0 + \beta 1\ logNEXRATEt + \beta 2\ logM2t + \beta 3\ \ logOILPRICEt + \beta 4\ logTBILLt + \varepsilon t \quad ....(4)$$

In this model, εt, is the disturbance or error term. The rest of the variables in the model are as defined above, but in natural logarithms format.

3.3 Method of Analysis:

This study utilized modern techniques of time series analysis to estimate and analyse the relationship between money growth and inflation.

These techniques include unit root tests, the Johansen cointegration test, Vector Error Correction and Granger Causality. Unit root tests were employed to determine whether the variables in the model are stationary or nonstationary. This was done so that we avoid the problem of spurious regression. The Johansen cointegration test was employed to determine whether the variables in the model are cointegrated and establish whether there is a long run equilibrium relationship between the variables of interest. The Vector Error Correction approach was then used to model the short-run dynamics of the variables. Finally, we employed Wald Statistics to test for short run and long run causality among the variables.

3.4 Unit Root Tests:

A unit root test is a test of stationarity or nonstationarity in a time series. A time series that has a stochastic trend is said to contain a unit root. Consequently, such a time series will show a systematic pattern that is unpredictable. To test whether the variables of interest are stationary or not, we tested the respective variables for a unit root. A time series is said to be nonstationary if it is found to contain a unit root. If not, the series is said to be stationary. There are many unit root tests including the Dickey Fuller test (DF), Phillips-Perron test (PP), Zivot-Andrews, Augmented Dickey Fuller test (ADF), Elliot-Rothenberg-Stock test (P test and DF-GLS). However, this study utilized the Augmented Dickey Fuller test devised by Dickey and Fuller (1979). This is a widely used test of stationarity in the economics literature. The ADF test is implemented in practice by running the following regression:

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$$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} + \sum_{j=1}^{m} \alpha_j \Delta Y_{t-1} + \varepsilon_t \qquad \text{.................................(5)}$$

εt is a pure white noise error term and $\Delta Yt_{-1} = (Yt_{-1} - Yt_{-2})$, $\Delta Y_{t-2} = (Yt_{-2} - Yt_{-3})$ etc. in order to obtain an unbiased estimate of δ, the number of lagged difference terms included in the test should be enough so that the error tem is serially uncorrelated. We run the ADF tests on the respective time series in the model using Eviews 8.0. This is done automatically in Eviews and by specifying the appropriate options such as whether to test the series in levels, first and second differences. In addition, the test has to specify whether to include an intercept, trend and intercept or none. The lag length should also be specified and by using the Schwartz Information Criterion we get the optimal lag length. We tested for a unit root in both the levels of the series and the differences.

The hypothesis for the unit root is as specified below:

H0: $\theta = 0$ (non stationary, unit root exist)

H1: $\theta < 0$ (stationary)

Confirmatory Stationary Test – Kwaiatkowski, Phillips, Schmidt, and Shin (KPSS) test

To circumvent the limitation that ADF test always has a low power, Kwiatkowski, Phillips, Schmidt, and Shin (1992) proposed an alternative test which *yt* is assumed to be stationary under the null. In this study, the Phillip Peron (PP) test could not be used to confirm or complement the results because mostly PP and ADF usually produce the similar conclusion (Xu and Sun, 2010)[5]. Therefore, in order to address the shortcomings of the ADF test, Kwaiatkowski, *et. al.* (1992) [KPSS] developed an alternative test. The null hypothesis that y_t is I(0) is formulated as $H_0: \sigma_e^2 = 0$. The KPSS test is the Lagrange multiplier given by (Verbeek, 2004).

$$KPSS = \frac{T^{-2} \sum_{t=1}^{T} S_t^2}{\lambda^2} \qquad \text{............(eq. 5)}$$

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$S_t = \sum_{j=1}^{t} u_j,$ u_t is the error term of regressing dependent variable y_t on D_t and λ^2 is a consistent estimate of the long run variance of error term (u_t).

[5]Attempting to distinguish between DS and TS see Kwiatkowski *et. al.* (1992) **KPSS**.

For the results to warrant validity, this study utilises both unit root and the stationary tests jointly. The results for both tests were compared and checked if the conclusions differ. However, in a case where the results for the ADF differs from the KPSS test, then the KPSS results will be preferred because of the pitfall that ADF suffers.

3.5 Johansen Cointegration:

Cointegration was first introduced by Engle and Granger (1987) and further improved upon by Engle and Yoo (1987, 1991), Phillips and Ouliaris (1990), Stock and Watson (1988), Phillips (1991) and Johansen (1988, 1991, 1994). Two or more integrated variables are said to be cointegrated if there exists a linear combination of these variables that is stationary, *I(0)*. This implies that cointegrated variables move closely together in the long run and the linear combination represents the long run or equilibrium relationship among these variables. Cointegration points to the existence of a long run relationship to which cointegrated variables converge over time.

The unit root tests conducted on the logarithmic series of all variables in our model (LCPI, LEXRATE, LM2, LOILPRICE, and LTBILL) indicate that these variables are integrated of order one, *I(1)*. This situation established the basis for conducting a test for cointegration to determine whether there is at least one linear combination of the variables that is stationary, *I(0)*. Since we are dealing with a multivariate case, we applied the Johansen (1988) maximum likelihood procedure. The Johansen test is used to determine the maximum number of cointegrating vectors. In addition, the test is able to obtain the maximum likelihood estimators of the cointegrating matrix and adjustment coefficients. The Johansen procedure provides two test statistics namely the trace and the maximum eigenvalue statistics. The trace statistic tests the null hypothesis that there are at most r cointegrating relations against the alternative of m cointegrating relations (series are stationary), $r = 0, 1, \ldots, m - 1$. The maximum eigenvalue statistic tests the null hypothesis that there are r cointegrating relations against the alternative hypothesis of $r + 1$ cointegrating relations.

The Johansen test utilises a sequential test procedure in determining the number of cointegrating

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relationships. In the first step, the null hypothesis of zero cointegration relationships is tested against the alternative hypothesis of 1 or more cointegrating relationships. In the second step, the null hypothesis of atmost 1 cointegrating relationship is tested against the alternative hypothesis of at most 2 cointegrating relationship and so on until the null hypothesis cannot be rejected any more. In carrying out the Johansen test, we must decide on the optimal number of lags to include in the test and the appropriate specification of the model regarding whether to include trend or intercept in the test equation.

3.5.1 Vector Error Correction Model

A Vector Error Correction Model (VECM) is a Vector Autoregressive Model (VAR) in first differences.

According to Engle and Granger (1987), if two variables are cointegrated, then there exists an error correction mechanism whereby deviations from the long run equilibria are automatically corrected. Therefore, the error correction mechanism (ECM) corrects for disequilibrium. With the ECM, a proportion of the disequilibrium in one period is corrected in the next period. The ECM describes the short-run dynamics or adjustments of the cointegrated variables towards their equilibrium values. A vector error correction (VEC) model is a restricted VAR that is used with nonstationary series that are cointegrated. The VECM model makes it possible to model the short run correction mechanism of a system of variables to their long run equilibrium. The VECM (p) form is written as follows:

$$\Delta y_t = \delta + \gamma Y_{t-1} + \sum_{i=1}^{p-1} \varphi_i^p \Delta y_{t-1} + \varepsilon_t \qquad ....(6)$$

Δ is the differencing operator, such that: $\Delta Y_t = y_t - y_{t-1}$

The VECM is a system of equations for each variable that describes the short run adjusment of that variable towards the long run equilibrium. Since the adjusment process may take a number of periods, each equation in the system or VECM will have lagged variables. The existence of cointegration among the variables in our model established a basis for estimating a VECM to describe the short run adjustment mechanism of the variables towards their long run equilibrium values.

4. ESTIMATION RESULTS

In this part we present the results of the data analysis beginning with tests of statianrity or

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nonstationarity.

4.1 Unit Root Tests:

Stationarity is the assumption that the future will be like the past. This is an important assumption in regression analysis involving time series data because it helps us avoid the problem of misspecification or spurious regressions highlighted in Engle and Granger (1987). It is therefore important to test for stationarity before conducting any analyses based on time series data.

4.1.1 ADF Test – Levels of Data Series

The results of the ADF test on the log of CPI, log of EXRATE, log of M2, log of OILPRICE and the log of TBILL are tabulated in the table below:

Table1: ADF Test for Natural Logarithms of the Data Series

Variable	Computed ADF Statistic	Lag Length	Critical Values		
			1%	5%	10%
LCPI	-2.053454	1	-4.01499	-3.43746	-3.14294
LExrate	-2.506664	1	-4.01499	-3.43746	-3.14294
LM2	-0.364961	0	-4.01464	-3.43729	-3.14284
LOilprice	-2.63802	1	-4.01499	-3.43746	-3.14294
LTbill	-2.375079	4	-4.01606	-3.43798	-3.14324

The results show that the natural logarithms of the CPI, crude oil price, broad money supply and the exchange rate are all nonstationary as the computed ADF statictic for each series does not exceed the critical values at all levels of significance. Therefore, we cannot reject the null hypothesis that the variables contain a unit root.

4.1.2 Determining the Order of Integration

A time series is said to be integrated if it follows a random walk (nonstationary). A time series that is nonstationary can be made stationary by taking the first or second difference etc. A time series is said to be integrated of order 1 that is *I(1)* if taking its first difference makes it stationary. If it is differenced twice to make it stationary, it is said to be integrated of order 2 that is *I(2)*. In general, a time series that is differenced *d* times is said to be integrated of order *d* that is *I(d)*. Therefore, we took the first differences of each variable and applied the ADF test to the respective data series. The table below shows results of the ADF test applied to the first

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differences of the logarithms of the respective data series:

Table 2: ADF Test Results for 1st Differences of Data Series

Variable	Computed ADF Statistic	Lag Length	Critical Values		
			1%	5%	10%
ΔLCPI	-8.343525	1	-4.01499	-3.43746	-3.14294
ΔLExrate	-9.60898	0	-4.01499	-3.43746	-3.14294
ΔLM2	-7.535365	0	-4.01499	-3.43746	-3.14294
ΔLOilprice	-8.275981	0	-4.01499	-3.43746	-3.14294
ΔLTbill	-6.635081	3	-4.01606	-3.43798	-3.14324

The results of the ADF test on first differences of the respective variables in the model show that all the variables become stationary at first difference. The computed ADF statistic for the various data series exceeds the respective critical values. Therefore, we reject the null hypothesis of a unit root for all data series. Hence, we conclude that the first differences of the log of CPI, log of OILPRICE, log of (M2) and log of TBILL are integrated of order 1, that is *I(1)*.

The unit root test results above show that all the variables in our model are integrated of order *I(1)*. This established a basis for us to test whether these variables are cointegrated. For Variables to be tested for cointegration, they must be integrated of order 1, *I(1)* and not stationary, *I(0)*.

The table below shows that KPSS has complimented the ADF. Note that the in the case of KPSS the null and alternative hypothesis is opposite that of ADF.

Table 3: KPSS Unit Root Results

	Levels			First Difference	
Variable	Trend	No Trend	Trend	No Trend	Order of Integration
Log CPI	0.3739	1.569	-8.3435	-8.2474	I(1)
Log NEXRATE	0.1936	0.9178	0.03904	0.0354	I(1)
Log M2	0.1625	1.6015	0.1221	1.4040	I(1)
Log Oil Price	0.0799	1.9623	0.03839	0.0567	I(1)
Log TBILL	0.2596	0.8303	0.0229	0.1314	I(1)

Note: *** indicates the null hypothesis is rejected at 5 per cent levels of significance.

4.2 Cointegration Analysis:

We carried out the Johansen test by first running a Vector Autoregression (VAR) model using

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Eviews 8.0 to determine the optimal number of lags to include in the test. The VAR model included the log of CPI, log of EXRATE, log of M2, log of OILPRICE and the log of TBILL. We then obtained the optimal lag length using information criteria.

The table below shows the optimal lag lengths suggested by the various information criteria:

Table 4: Optimal lag length Test Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	100.5522	NA	2.05e-07	-1.209522	-1.112604	-1.170162
1	1325.572	2356.999	5.19e-14	-16.39964	-15.81814*	-16.16348
2	1382.447	105.8321	3.47e-14*	-16.80313*	-15.73704	-16.37018*
3	1398.063	28.06803	3.92e-14	-16.68434	-15.13366	-16.05459
4	1414.548	28.58844	4.38e-14	-16.57656	-14.54129	-15.75001
5	1439.824	42.23266	4.40e-14	-16.58005	-14.06019	-15.55670
6	1469.656	47.95773*	4.18e-14	-16.64121	-13.63677	-15.42107
7	1493.088	36.18693	4.33e-14	-16.62137	-13.13234	-15.20443
8	1517.040	35.47266	4.48e-14	-16.60810	-12.63448	-14.99436

As can be seen from the table above, the optmal lag length for the VAR chosen by the Schawarz Information Criteria (SC) is 1, Final Prediction Error (FPE), Akaike Information Criteria (AIC) and Hannan-Quinn Information Criteria(HQ) each suggest a lag length of 2 while the Likelihood-Ratio (LR) suggets a lag length of 6. Based on a visual inspection of the corrrelograms for the various lag lengths suggested by the different information criteria, we adopted a lag length of 6 suggested by the LR criterion as this sufficiently dealt with the problem of autocorrelation in the data. In choosing the lag length, we also considered that we are using monthly data where the maximum required number of lags is 12. The results of the Johansen test depend on the number of lags included in the test and also on the assumptions made regarding the deterministic trends in the data.

Since the asymptotic distribution of the LR test on which the Johansen test is based does not follow the chi-square distribution, we need to specify an assumption about the trend underlying the data. Eviews offers five specifications depending on whether the intercept or trend or both is included in the VAR and/or in the cointegrating equation. The sixth option in Eviews gives a summary of the five assumptions. We therefore chose option 6 to judge the sensitivity of result to the various assumptions. The table below tabulates the results by choosing the sixth option in Eviews:

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Table 5: Summary of Trend Assumptions

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	2	5	1	0
Max-Eig	2	2	2	1	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

We ruled out models 1 and 5 since these are not realistic. With this in mind, we compared the results of the trace and max-eigen statistics for models 2, 3, and 4 on the number of cointegrating relationships and decided to adopt model 4 and carried out the Johansen cointegration test using this model. The table below shows the results of the Johansen cointegration test using six lags and option 4:

Table 6: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.261999	112.0815	88.80380	0.0004
At most 1	0.178074	63.77574	63.87610	0.0510
At most 2	0.089568	32.59505	42.91525	0.3570
At most 3	0.071364	17.67508	25.87211	0.3662
At most 4	0.036445	5.903026	12.51798	0.4727

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

Table 7: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.261999	48.30573	38.33101	0.0027
At most 1	0.178074	31.18069	32.11832	0.0648
At most 2	0.089568	14.91997	25.82321	0.6416
At most 3	0.071364	11.77205	19.38704	0.4367
At most 4	0.036445	5.903026	12.51798	0.4727

Max-eigenvalue 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

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Based on results of the trace and maximum Eigen value statistics, we find evidence of cointegration between the consumer price index, nominal exchange rate, broad money supply, Brent spot oil price and the treasury bills rate at the 5% level of signifiacance for the period of the study. The results also show that there is one cointegrating vector which links these variables in a stable and long run relationship. The table below shows the normalized estimated long run equilibrium relationship between the log of CPI, log of the EXRATE, log of M2, log of OILPRICE and the log of TBILL:

Table 8: Normalized Long run Cointegrating Coefficients

1 Cointegrating Equation(s): Log likelihood 1470.694					
LCPI	LM2	LNEXRATE	LOILPRICE	LTBILL	M02)
1.000000	-0.443543	-0.142274	-0.294624	0.039138	0.005716
	(0.43569)	(0.28556)	(0.17120)	(0.05702)	(0.00682)

Normalized cointegrating coefficients (standard error in parentheses) @TREND(01

The table above shows that there is a long run relationship between inflation, money supply, nominal exchange rate, oil price, and the treasury bills rate (interest rates). Thus, the estimated long run equilibrium relationship can be restated as:

$$LCPI = 0.443543LM2 + 0.142274LNEXRATE + 0.294624LOILPRICE - 0.039138LTBILL + 0.005716T$$

As we can see from the estimated model, there is a positive long run relationship between inflation and money supply.

In addition, we find a positive long run relationship between the nominal exchange rate, oil prices while there is a negative relationship between inflation and the 90 day treasury bills rate (interest rate). This result is consistent with most literature.

4.2.1 Vector Error Correction Estimates

We therefore estimated the VECM for the log of CPI, log of EXRATE, log of M2, log of OILPRICE and log of TBILL based on Model 4 and 6 lags using Eviews 8.0. The table below shows the estimated VECM (the whole table is shown in the appendix):

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Table 9: Vector Error Correction Estimates

Cointegrating Eq:	CointEq1
LCPI(-1)	1.000000
LM2(-1)	-0.443543
	(0.43569)
	[-1.01804]
LNEXRATE(-1)	-0.142274
	(0.28556)
	[-0.49823]
LOILPRICE(-1)	-0.294624
	(0.17120)
	[-1.72095]
LTBILL(-1)	0.039138
	(0.05702)
	[0.68640]
@TREND(01M01)	0.005716
	(0.00682)
	[0.83811]
C	4.573528

Error Correction:	D(LCPI)	D(LM2)	D(LNEXRATE)	D(LOILPRICE)	D(LTBILL)
CointEq1	-0.021269	-0.064034	0.040492	-0.059575	-0.139047
	(0.00414)	(0.05486)	(0.02279)	(0.05605)	(0.10398)
	[-5.13762]	[-1.16713]	[1.77687]	[-1.06284]	[-1.33719]

Standard errors in ( ) & t-statistics in [ ]

The first part of the table displays estimates of the cointegrating equation (long run relationship) while the second part presents estimates coefficients of the speed of adjustment to equilibrium with their respective standard errors and t-values. From the table, we see that about 2.1% of the disequilibrium is corrected in the following month by changes in inflation, 6.4% of disequilibrium is corrected by changes in money supply, 4% of disequilibrium is corrected by changes in the nominal exchange rate, 6% of disequilibrium is corrected by changes in oil prices and about 14% of disequilibrium is corrected by changes in the 90-day treasury bills rate.

4.3 Granger Causality Tests:

In this section, we present results of the VECM system estimation. The system estimation of the VECM model enables us to carry out Granger causality tests using the Wald coefficient tests. In this case we can test a multivariate hypothesis of the cointegrating equation effect on all endogenous variables in the model and accept or reject the null hypothesis by looking at the *p*-

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value of the computed chi-square statistic. In the tables that follow, we show results of the tests for long run and short run causality among the variables in our model.

4.3.1 Long Run Causality

In the table below we show only ten (10) coefficients of the estimated system of equations based on the Least Squares estimation method. The entire system estimation of the VECM model is shown in the appendix:

Table 10: VECM Estimation results

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.021269	0.004140	-5.137616	0.0000
C(2)	0.477658	0.090143	5.298899	0.0000
C(3)	-0.110317	0.098662	-1.118132	0.2639
C(4)	-0.039224	0.097614	-0.401829	0.6879
C(5)	0.024894	0.097506	0.255306	0.7986
C(6)	-0.213777	0.096897	-2.206228	0.0277
C(7)	-0.115421	0.086161	-1.339585	0.1809
C(8)	0.017670	0.014753	1.197720	0.2315
C(9)	0.008344	0.015103	0.552480	0.5808
C(10)	-0.023495	0.015408	-1.524789	0.1278

In this system estimation of the VECM, the coefficient of the cointegrating equation or error correction term or the speed of adjustment towards long run equilibrium is negative and significant (*P-value* is less than 5%), we conclude that there is long run causality running from money supply (LM2), nominal exchange rate (LEXRATE), oil prices (LOILPRICE) and the treasury bills rate (LTBILL) to the inflation rate.

4.3.2 Short Run Causality

We conducted Granger causality tests to see the short run causality running from the independent variables (lagged values of coefficients in the VECM model) to the dependent variable (inflation). Hence, we checked if each independent variable caused the dependent variable.

Money supply to Inflation: The table below shows results of the Wald test for the lagged values of the money supply:

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Wald Test: Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1.347780	(6, 127)	0.2409
Chi-square	8.086682	6	0.2318

Null Hypothesis: C(8)=C(9)=C(10)=C(11)=C(12)=C(13)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(8)	0.017670	0.014753
C(9)	0.008344	0.015103
C(10)	-0.023495	0.015408
C(11)	-0.021654	0.015476
C(12)	0.013048	0.015105
C(13)	0.016610	0.013781

Since the P-value exceeds 5%, we cannot reject

H0: C(8)=C(9)=C(10)=C(11)=C(12)=C(13)=0.

Therefore, there is no short run causality running from money supply to inflation.

Exchange Rate to inflation: The table below shows the Wald test for the lagged values of the exchange rate:

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Wald Test: Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1.845367	(6, 127)	0.0954
Chi-square	11.07220	6	0.0862

Null Hypothesis: C(14)=C(15)=C(16)=C(17)=C(18)=C(19)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(14)	0.010884	0.017167
C(15)	-0.016148	0.017394
C(16)	0.014029	0.016527
C(17)	0.034359	0.016371
C(18)	0.018240	0.016760
C(19)	0.015582	0.017008

Restrictions are linear in coefficients.

Since the *P-value* exceeds 5%, we cannot reject the null hypothesis that:

H0: C(14)=C(15)=C(16)=C(17)=C(18)=C(19)=0. Therefore, there is no short run causality running from the exchange rate to inflation.

Oilprice to Inflation: The table below shows the Wald test for the lagged values of the oilprice:

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Wald Test: Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1.329975	(6, 127)	0.2486
Chi-square	7.979850	6	0.2396

Null Hypothesis: C(20)=C(21)=C(22)=C(23)=C(24)=C(25)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(20)	-0.002492	0.006768
C(21)	-0.005108	0.006748
C(22)	0.008152	0.006804
C(23)	-0.013131	0.006782
C(24)	0.007648	0.006866
C(25)	0.007446	0.006601

Restrictions are linear in coefficients.

Since the *P-value* exceeds 5%, we cannot reject

H0: C(20)=C(21)=C(22)=C(23)=C(24)=C(25)=0.

Therefore, there is no short run causality running from the exchange rate to inflation.

Treasury bill to inflation: The table below shows the Wald test for the lagged values of the treasury bills rate:

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Wald Test: Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	0.645689	(6, 127)	0.6935
Chi-square	3.874132	6	0.6937

Null Hypothesis: C(26)=C(27)=C(28)=C(29)=C(30)=C(31)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(26)	-0.003795	0.003445
C(27)	0.004277	0.003494
C(28)	-0.004083	0.003517
C(29)	0.005431	0.003523
C(30)	-0.004833	0.003560
C(31)	0.002197	0.003438

Restrictions are linear in coefficients.

Since the P-value exceeds 5%, we cannot reject

H0: C(26)=C(27)=C(28)=C(29)=C(30)=C(31)=0.

Therefore, there is no short run causality running from the exchange rate to inflation.

Based on the Granger causality tests conducted using the Wald coefficient test, we can conclude that there is no short run causality running from the lagged values of the nominal exchange rate, money supply, oil prices, and the treasury bills rate to the inflation rate. However, we find evidence of long run causality running from the money supply, nominal exchange rate, oil price, and the treasury bills rate.

4.4 Diagnostic Testing:

Having estimated the VECM model, we performed a number of diagnostic tests to check the appropriateness of the estimated VAR model used in the study.

Serial correlation

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we tested the estimated model for serial correlation by checking the correlogram Q-statistics and by using the Breusch-Godfrey Serial correlation LM test. Both tests indicated absence of serial correlation. Both results are shown in the Appendix. Based on the Breusch-Godfrey Serial correlation LM test, the *P-value* is more than 5%. Therefore, we fail to reject the null hypothesis of no serial correlation in the residuals and conclude that there is no serial correlation in the estimated model.

Heteroscedasticity

We tested for heteroscedasticity by using the Breusch-Pagan-Godfrey test. The results also show the absence of heteroscedasticity and are also presented in the Appendix. Since the *p-value* is more than 5%, we fail to reject the null hypothesis of no heteroscedasticity in the residuals and conclude that there is no heteroscedasticity in the estimated model.

Normality:

We also tested for normality of the residuals using the Jarque-Bera test. The results show that the residuals are normally distributed. The results of the test are shown in the Appendix.

The computed *p-value* of the Jarque-Bera statistic exceeds 5%. Therefore, we fail to reject the null hypothesis and conclude that the residuals are multivariate normal.

The diagnostic tests conducted above show that there is no serial correlation and heteroscedasticity in the estimated model and that the residuals are normally distributed. Hence, we can conclude that our model has passed all the specification and efficiency tests and can be accepted.

5.0 Concluding Remarks

This study set out to investigate whether money supply growth is the main determinant of inflation in Zambia. The study applied econometric techniques of cointegration, vector error correction and causality analysis. The Johansen cointegration test shows that there is a significant and positive stable long run relationship between money growth and inflation in Zambia. The analysis also indicates that depreciation of the kwacha/dollar exchange rate and increases in world oil prices also affect inflation postively in the long run. However, a rise in short term interest rates on treasury securities negatively affects inflation in the long run. Granger causality tests indicate that there is long run causality running from the money supply, exchange rate, oil prices and the short term interest rates to the inflation rate. However, the study does not find evidence of short run causality running from these variables to the inflation rate. In terms of

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policy implications, the study finds that money growth is still an important variable in the inflationary process in Zambia. Hence, successful control of inflation requires controlling money growth is through a tight monetary policy.

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Appendix

Date: 06/20/17 Time: 07:33
Sample: 2001M01 2014M12
Included observations: 159
Q-statistic probabilities adjusted for 31 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.|. |	.|. |	1	-0.027	-0.027	0.1158	0.734
.|. |	.|. |	2	-0.062	-0.063	0.7419	0.690
.|. |	.|. |	3	0.032	0.028	0.9050	0.824
.|. |	.|. |	4	0.033	0.031	1.0807	0.897
.|* |	.|* |	5	0.081	0.086	2.1591	0.827
.|* |	.|* |	6	0.121	0.130	4.5967	0.596
.|. |	.|. |	7	-0.023	-0.006	4.6843	0.698
*|. |	*|. |	8	-0.124	-0.119	7.2816	0.507
.|. |	.|. |	9	-0.007	-0.035	7.2907	0.607
.|. |	.|. |	10	0.068	0.038	8.0851	0.621
.|* |	.|. |	11	0.074	0.069	9.0347	0.619
.|* |	.|* |	12	0.174	0.195	14.314	0.281
.|. |	.|. |	13	-0.021	0.030	14.391	0.347
.|. |	.|. |	14	0.018	0.062	14.446	0.417
*|. |	*|. |	15	-0.094	-0.136	16.001	0.382
.|. |	.|. |	16	0.049	-0.024	16.432	0.423
.|* |	.|. |	17	0.089	0.025	17.869	0.397
*|. |	*|. |	18	-0.083	-0.095	19.114	0.385
.|. |	.|. |	19	-0.048	-0.012	19.532	0.423
*|. |	.|. |	20	-0.079	-0.047	20.667	0.417
.|. |	.|. |	21	-0.055	-0.046	21.234	0.445
.|. |	*|. |	22	-0.055	-0.107	21.806	0.472
.|. |	*|. |	23	-0.036	-0.107	22.043	0.518
.|. |	.|. |	24	0.033	0.019	22.244	0.565
*|. |	*|. |	25	-0.163	-0.136	27.301	0.341
*|. |	*|. |	26	-0.081	-0.091	28.549	0.332
*|. |	*|. |	27	-0.068	-0.066	29.440	0.340
.|. |	.|. |	28	-0.028	-0.050	29.592	0.383
.|. |	.|. |	29	-0.019	-0.028	29.663	0.431
*|. |	*|. |	30	-0.103	-0.096	31.761	0.379
*|. |	*|. |	31	-0.121	-0.093	34.710	0.295
.|. |	.|. |	32	-0.054	-0.004	35.300	0.315
.|. |	.|. |	33	0.027	0.014	35.452	0.353
*|. |	*|. |	34	-0.112	-0.096	38.011	0.292
.|. |	.|. |	35	-0.014	0.023	38.050	0.332
*|. |	.|. |	36	-0.067	-0.058	38.992	0.337

*Probabilities may not be valid for this equation specification.

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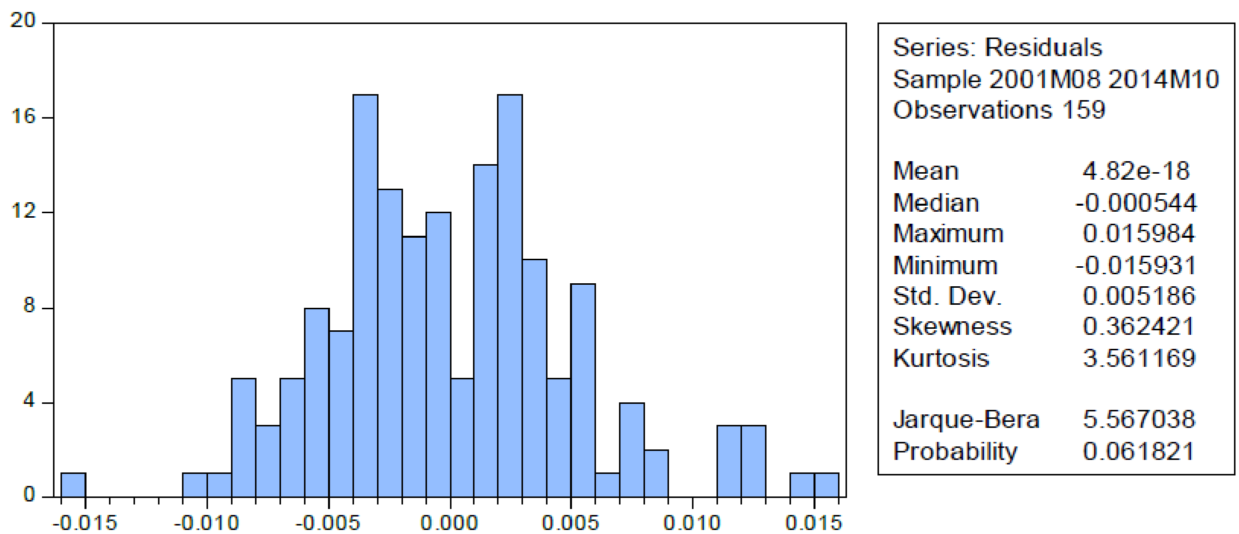
Table 1 Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.866114	Prob. F(2,125)	0.1590
Obs*R-squared	4.609756	Prob. Chi-Square(2)	0.0998

Table 2 Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.983695	Prob. F(35,123)	0.5040
Obs*R-squared	34.77283	Prob. Chi-Square(35)	0.4790
Scaled explained SS	28.40936	Prob. Chi-Square(35)	0.7771

Normality Test



H_0: Residuals are multivariate normal vs H_1: Residuals not multivariate normal

