LONG AND SHORT RUN EFFECTS OF INFLATION ON OUTPUT IN ZAMBIA: 1964-2015

by

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A dissertation submitted in partial fulfillment of the requirements for the award of the degree of Master of Arts in Economics in the School of Humanities and Social Sciences.

University of Zambia.

Lusaka

2017

DECLARATION

This dissertation is my original work and has not been presented for a degree in any other university.

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CERTIFICATE OF APPROVAL

This dissertation of Laston Chiliba has been approved as partial fulfillment of the requirement for the award of the Master of Arts degree in Economics by the University of Zambia

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ABSTRACT

The inflation-output nexus is one of the most important macroeconomic relationships that has attracted considerable research interest for many years. For most developing countries, monetary authorities strive to achieve price stability. This is done in order to avoid the costs and uncertainties associated with inflation. In addition, achieving a sustainable path of output growth is a key objective of most developing countries. This study adopts a bivariate vector error correction (VEC) model composed of output and inflation in order to test the effect of the latter on the former in Zambia over the period 1964-2015. The study also conducts Granger causality test to evaluate the direction of the causal relationship between inflation and output in Zambia. Empirical results show that there is a cointegrating relationship between inflation and output in Zambia. Elasticity estimate show that for a 1% increase in inflation, the average value of output growth decreases by 5.4%.The results further indicate a unidirectional causality running from inflation to output. Therefore, authorities should aim at controlling inflation in order to safeguard output and growth. This calls for fiscal and monetary policy coordination in order to safeguard output whilst ensuring price stability in the economy.

Keywords: Inflation, Output Growth, VAR/VEC, Cointegration, Granger Causality
JEL Classification: E31, O11, O42, O55

ACKNOWLEDGEMENTS

I give glory to God for the gift of life without which this study could not have come to fruition. I am highly and will remain forever indebted to the love of my life, Chitalu, for the encouragement, support and belief that this was possible. A million thanks and sincere gratitude to my supervisor, Dr. Jonathan Chipili, for his guidance, thought provoking questions and patience. I thank Dr. Frank Chansa for his availability during the time that I needed him most. I would like to extend my appreciation and acknowledgement to the faculty members of Economics Department for guidance and the exciting and interactive learning. Finally, I owe Mr. Fortune Zulu of Standard Chartered Bank a great deal of gratitude for giving me the flexibility to pursue this study without which this would not have materalised.

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List of Acronyms

AEG	Augmented Engle-Granger (AEG) Test
AR	Autoregressive
ARDL	Autoregressive Distributed Lag
BRICS	Brazil, Russia, India, China and South Africa
CRDW	Cointegrating Regression Durbin-Watson
CIS	Commonwealth of Independent States
CSO	Central Statistical Office
FEVD	Forecast Error Variance Decomposition
GDP	Gross Domestic Product
GMM	Generalised Method of Moments
INF	Inflation
IMF	International Monetary Fund
LM	Lagrange Multiplier Test
OLS	Ordinary Least Squares
PSTR	Panel Smooth Threshold Regression
SADC	Southern African Development Community
SAPs	Structural Adjustment Programs
VAR	Vector Autoregressive
WDI	World Development Indicators

Chapter One: Introduction

1.1 Overview

The inflation-output nexus is one of the most important macroeconomic relationships that has attracted considerable research interest for many years. For most developing countries, the monetary authorities strive to achieve a stable domestic price level. This is done in order to avoid the costs and uncertainties associated with inflation during episodes of high price volatility. In addition, achieving a sustainable path of economic development is a key objective of most developing countries. In view of this, it can be stated that a low inflationary environment coupled with a sustainably high economic growth is a required combination to ensure a nation's economic development, and should be the central focus for both the central government and monetary authorities. In spite of this, previous studies on the inflation-output nexus have revealed mixed results without a clear consensus on this relationship. Whilst a number of studies show no relationship between inflation and output, many others have shown negative and positive relationships between these two variables. The lack of consensus has motivated this study to examine the Zambian scenario and contribute to the debate on the relationship between inflation and output.

Economic theories vary in explanation of the inflation-output nexus. Most studies show a tradeoff between inflation and output especially when inflation is high and little consensus exists when inflation is low. The same can be said about theoretical models. On one hand, the Keynesian posit that to achieve macroeconomic stability, an economy needs to achieve full employment and stable output growth in a low inflation environment. On the other hand, the new classical economists posit that the economy is always operating at full employment level and any form of expansionary policies will only generate inflation. Prior to the 1930s, policymakers and academics focused on unemployment and how to achieve full employment to drive economic growth (Shiferaw, 2012). However, post 1930s, inflation became a problem and started to attract interest from both academics and policymakers. Recently, monetary policy has been geared towards a low and stable inflation objective due to the fact that monetary authorities and economic agents view inflation to be costly. The general belief is that when inflation is high and unpredictable, the economy performs poorly (Barrow, 2013). Literature is rife with theoretical work on the costs of inflation (Brail, 1995). Inflation imposes distortionary effects on macroeconomic stability as it makes it difficult to plan ahead. It is therefore important to carry out empirical work to estimate the effects of inflation on output. This paper attempts to estimate the effects of inflation on output in Zambia from 1964 to 2015.

1.2 Historical background on inflation and economic growth in Zambia

The Zambian economy was initially a liberalized one but from the time of independence in 1964, the economy largely followed a socialist economic plan with the government being the dominant player in the economic activities of the nation. Almost all the companies in the country were nationalized and firmly put under the control of the government. The country experienced a stable rate of growth fuelled by profits from rising copper prices. Inflation was largely controlled.

Following the oil crisis of the early 1970's, commodity prices plunged and demand for copper was damped leading to a reduction in the export earnings for the country. At the same time, the country had to increase its import bill due to the increase in oil prices. This led to a decline in the terms of trade and current account imbalance resulting in a severe deficit. Monetary authorities resorted to printing money, which exacerbated the inflationary environment. The government then turned to the International Monetary Fund (IMF) for financial assistance. In the early

1980's, the Structural Adjustment Programs (SAPs) as advocated for by the IMF and other external donors led to a rise in the rate of average inflation from 9.1% in 1982 to 55.91% in 1986. The increase in inflation had a negative effect on the country's GDP growth rate. The SAPs did not work as expected as this had a huge implications on the economy and the social cost led to civil unrest manifesting in general strikes and other forms of dissent which caused the government to scrap these and culminated in the suspension of the agreements with the World Bank/IMF. Government embarked on price control measures and promoted the consumption of domestically produced goods as an import substitution measure. This resulted into a decline in the inflation rate albeit for a short-while.

The introduction of the multi-party democracy in 1991 led to the formation of a new government under the movement for multiparty democracy (MMD). The new government embarked on economic reforms, which included the decontrol of prices, removal of subsidies and devaluation of the currency. However, all these measures led to inflationary pressures with an increase in the Consumer Price Index (CPI) from 99.34% in 1991 to 185.89% in 1993. Further policy changes such as tightening of fiscal policy improved the inflationary environment and led to a decline in the CPI from 185.89% recorded in 1993 to 24.78% in 1997 to 21.69% in 2001. From 2001, the CPI trend followed a downward trajectory as the economy stabilized (see Table 1.1). A common observation is that high inflation periods tend to correlate with low or negative output growth. This study aims at assessing this relationship over both the short-run and long-run horizons.

Table 1.1: CPI* and Real GDP**

Date	INF	GDP	Date	INF	GDP	Date	INF	GDP	Date	INF	GDP
1964	0.002	9,820.65	1977	16.70	16,214.00	1990	113.19	18,242.10	2003	21.51	24,810.00
1965	0.002	11,035.70	1978	14.30	16,069.50	1991	99.34	17,885.30	2004	17.96	26,554.70
1966	0.002	12,580.00	1979	12.50	15,434.50	1992	162.25	17,575.70	2005	18.35	28,476.10
1967	0.002	14,698.80	1980	11.10	16,039.20	1993	185.89	18,770.40	2006	9.06	30,726.80
1968	0.002	15,279.60	1981	10.00	15,907.20	1994	61.92	17,151.30	2007	10.69	33,293.20
1969	0.002	13,872.30	1982	9.10	16,301.40	1995	34.81	17,648.40	2008	12.40	35,881.40
1970	0.002	14,350.00	1983	25.00	16,781.20	1996	43.49	18,745.80	2009	13.46	39,189.80
1971	33.30	14,658.60	1984	20.00	16,683.10	1997	24.78	19,460.80	2010	8.20	43,225.60
1972	0.002	16,105.20	1985	50.00	16,679.50	1998	24.35	19,385.70	2011	6.44	45,965.40
1973	0.002	15,851.90	1986	55.91	17,121.90	1999	26.95	20,287.20	2012	6.56	49,059.20
1974	0.002	16,392.30	1987	47.24	17,592.80	2000	25.93	21,077.90	2013	6.98	52,352.70
1975	25.00	16,288.90	1988	51.08	17,935.30	2001	21.69	22,198.50	2014	7.78	55,283.70
1976	20.00	16,738.40	1989	119.13	18,106.50	2002	22.17	23,198.80	2015	10.10	57,273.90

Source: *Central Statistical Office (CSO) and *World Development Indicators. **Federal Reserve Bank of St. Louis (Real GDP in US$ millions)

1.3 Problem statement

Similar to other developing countries, Zambia has experienced high inflation rates for many decades. At independence, substantial agricultural and mineral wealth gave the country good prospects for growth and development.

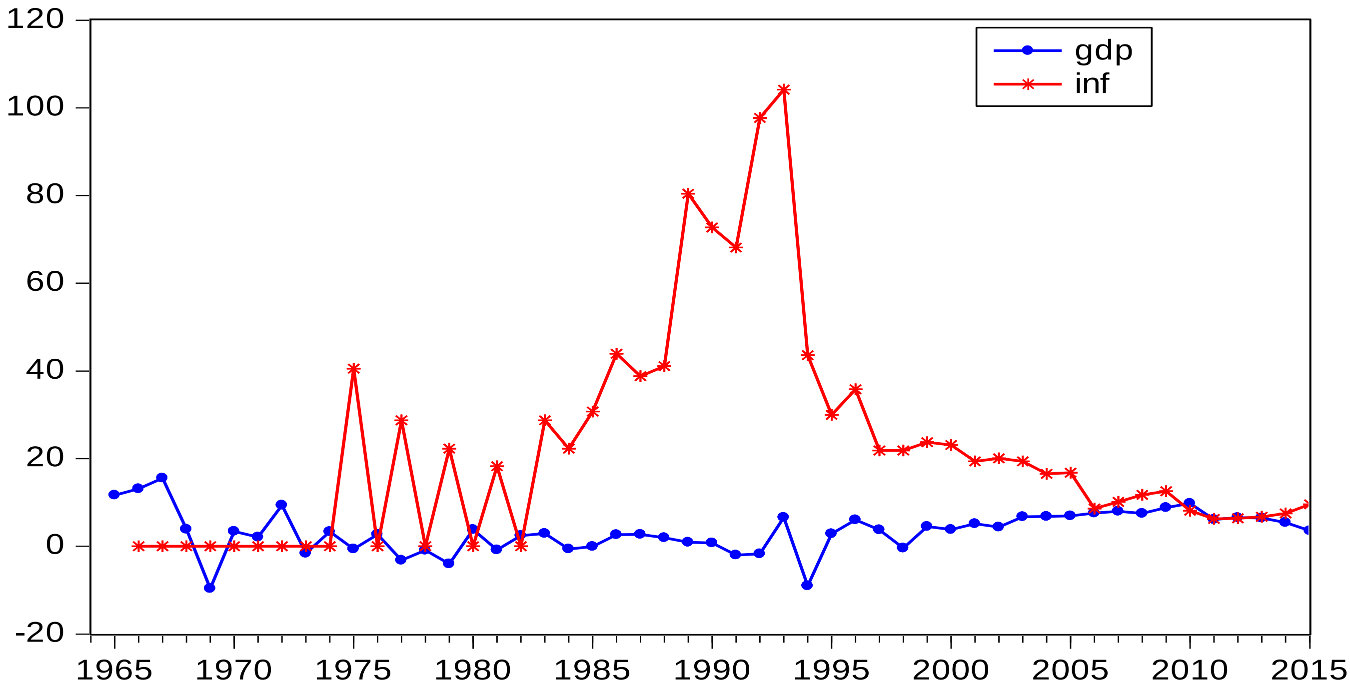

Figure 1: Inflation and Output in Zambia 1964-2015
Source: Author calculation

Figure 1 shows the trend of inflation and output in Zambia over the period 1964 to 2015. Visual inspection of the graph shows that indicates a negative relationship. However, to make a meaningful conclusion, a proper econometric assessment needs to be carried out.

It is clear that inflation in Zambia peaked around the period between 1990 and 1995.This is mainly attributed to the drop in copper prices and the negative effects of the oil shock, leading to a retarded growth (McCulloch, Baulch & Cherel-Robson, 2000). The IMF's refusal to grant Zambia financial rescue lead to a sharp increase in inflation as the government printed money to fund public service wage increases and the election campaign of 1991 and a severe drought of

1992 further lead to a reduction in agricultural activities, thus adding pressure to food inflation. This period is further characterized by a slowdown in economic growth following the period of high inflation volatility.

Owing to its perceived detrimental effects on economic growth and welfare, inflation has received much interest from both academics and policymakers. To aid economic planning and anchor inflationary expectations, central banks undertake inflation forecasting to project the future trends in inflation. This is done in order to manage inflationary pressures and the costs associated with inflation with a view to help spur economic growth. In spite of this effort, empirical evidence on the effects of inflation on the economy in general remains largely unexplored. This paper builds on previous studies on the effects of inflation on economic growth by examining both short and long run horizons. Secondly, unlike previous studies on inflation in Zambia (Mwansa, 1998; Pamu and Simuchile, 2004; Mutoti, 2006) which have largely investigated the determinants of inflation over several sample periods, this paper focuses on inflation effects on output without necessarily restricting to the sources or determinants of inflation in Zambia. Whilst previous studies such as Phiri (2013) examines the threshold effects of inflation on economic growth, this study assesses the causality interactions between inflation and economic growth in the long and short run. The paper also attempts to assess if the super-neutrality of money hypothesis (Sidrauski, 1989), which posits that growth rate in money has no effect on macroeconomic variables, is applicable to Zambia. According to Geweke (1986), super-neutrality of money is the proposition that the growth rate in money is structurally neutral with respect to real macroeconomic variables. Lastly, this paper employs most recent data and a larger data set from 1965 to 2015 at annual intervals to assess the effects of inflation on output in Zambia and utilises a bivariate vector error correction (VEC) approach.

1.4 Research Questions

This paper attempts to investigate the following questions:

i. What is the direction of causality between output and inflation in Zambia?
ii. What is the nature of the relationship between inflation and output in Zambia?
iii. What is the degree of responsiveness of change in output to changes in inflation?

1.5 Research Objectives

The main objective of this study is to assess the effects of inflation on output in Zambia. Specifically, the study seeks to:

i. Establish the direction of causality, if any, between output and inflation.
ii. Establish whether there is a short-run or long-run relationship between output and inflation.
iii. Establish the nature of the response of output and inflation to changes within the system.

Results are expected to provide evidence that inflation has a negative effect on economic growth in Zambia.

1.6 Significance of the study

Understanding the relationship between inflation and economic growth is crucial to the conduct of monetary policy as this helps in anchoring inflationary expectations in the economy. For economic agents, an understanding of inflationary trends and expectations is very important in forming expectations, which plays a crucial role in driving economic activity. This study will contribute to knowledge on how inflation affects output in Zambia. This knowledge is important for monetary authorities and economic agents as it will inform decision making thus helping to reduce inflation uncertainty.

Although several studies in this area have been done in developing countries, there is still no consensus on the effects of inflation on output. Studies from developing countries have employed different estimation methods, sample periods and economic structures and these are done in different country contexts. It is hoped that this study will inform decision makers on the long and short run effect of inflation on output in Zambia. Secondly, it is hoped that this paper will help decision makers in understanding the nature of the relationship between inflation and economic as it is important to maintain an optimal balance in the pursuit of macroeconomic stability. By building on previous studies on inflation in Zambia, this paper adds to the existing body of literature in examining the long and short run effect of inflation on output in Zambia.

Chapter Two: Literature review

2.1 Introduction

This section contains a review of both theoretical and empirical literature on the link between inflation and output. This section starts with a background on the link between inflation and output growth and why this relationship has attracted a lot of interest. This is followed by a review of the theoretical literature. Under theoretical literature, various theories on output growth and inflation including classical, Keynesian, monetarism, new-classical and neo Keynesian are all examined to show how they link the output growth and inflation under the various schools of thought in order to give a theoretical grounding to our study. A review of empirical literature on the relationship between inflation and output global, regional and country level follows before presenting a summary which concludes the chapter.

2.2 Theoretical Literature

It is critical to base the interpretation of econometric correlation results on theoretical underpinnings in order to derive sensible conclusions in a study of this nature. Here, we focus on theoretical models to establish a link and a foundation of how inflation is related to output growth. We examine common theories such as classical, Keynesian, monetarism, new-classical and neo Keynesian to understand how these link inflation to output. Understanding the theory behind these models helps in developing a comparative analysis of the effect of inflation on output growth. For instance, the linkage between inflation and output in the Keynesian and neo-Keynesian theory is captured through the aggregate demand and aggregate supply (AD-AS) framework whilst endogenous growth and neoclassical models link inflation to output through the inflationary effect on capital accumulation and investment. This gives credence to the interpretation of the econometric model used in this study. To understand the relationship between inflation and output and how money affects this interaction, the paper goes further and includes the money in the utility function, liquidity and the transaction costs approaches to aid the theoretical foundation analysis. As alluded to already, there are a number of theories that link Inflation to output. Here we a consider a number to establish the theoretical framework of the discussion in this paper.

2.2.1 Classical Theory

Classical theory foundation has its roots to Adam Smith's supply side model of growth in which the output (Y) is defined as being a function of labour (L), capital (K) and land inputs (T), that is, Y = f (L, K, T). Under the classical theory, output growth is determined by population growth (gL), investment (gK), land growth (gT) and increases in overall productivity (gF) in the economy, that is gY = (gF, gK, gL, gT). According to Smith, output growth was self-reinforcing due to its increasing returns nature. However, the relationship between inflation and growth output in the classical model is not explicit but implied to be negative because it is stated that an increase in wage costs (inflation) leads to a decline in the profit levels of firms, which leads to a decline in output.

2.2.2 Keynesian Theory

The Keynesian theory is firmly rooted in the writings of John Maynard Keynes' *The general of employment, interest and money*. According to Keynesians, government's interventions in the economy through expansionary policies increases investment and promotes aggregate demand and state that potential output is the level of GDP where the economy is at its optimal level. This optimal level of output is equal to the Non-Accelerating Inflation Rate of Unemployment (NAIRU). Keynesians believe that if GDP exceeds its potential, then inflation will accelerate as input prices increase. However if GDP falls below its potential, then inflation will decelerate as input prices decline due to the excess capacity in the economy. If GDP is equal to its potential though, unemployment rate equals the NAIRU level and inflation remains unchanged provided there are no supply shocks in the economy.

In the Keynesian theory, the inflation-output growth relationship is captured through Aggregate Demand (AS) and Aggregate Supply (AS) curves. In the AD/AS model, the AS curve is upward sloping in the short-run meaning that any demand side changes will affect the price level in the economy and thus an increase in output is usually accompanied by an increase in prices. According to Dornbusch, Fischer and Kearney (1996), changes in aggregate demand will affect prices and output only if the AD is upward sloping. In the long-run, the economy is at steady state and any shocks to the economy are assumed to even out and hence changes in labour force, prices of factors of production, expectations and fiscal and monetary policy will not have significant effect on the economy. The implication is that changes in the short-run AD/AS curves results into an adjustment mechanism, which yields an initial positive relationship between inflation and output but turns negative in the eventual adjustment mechanism. Hence, the result is that there is a short-run tradeoff between output and inflation.

2.2.3 Monetarist Theory

The falling output, employment and prices that characterized the 1970s led to the failure of the Keynesian theories, which posited that increases in the price levels followed increases in output at least in the short-run. Monetarist theory was born out of the works of Friedman (1956) who posited that *"inflation is always and everywhere a monetary phenomenon"* that arises from a rapid expansion in the quantity of money in the economy than in the total output. According to monetarists, in the short-run, money supply is the dominant but not the only determinant of prices and output. In the long-run money has no effect on the level of output. This is the concept famously known as the neutrality of money and attributed to Sidrauski (1989). Neutrality of money holds if the steady-state values of macroeconomic fundamentals are not influenced by the level of money supply in an economy at least in the long-run. Therefore, according to the monetarists, excess supply of real money balances is the main cause of increase in aggregate demand for goods and services. In the absence of a proportionate increase in the output level, money supply will lead to excess demand for goods and services, which will cause inflation.

2.2.4 Neo-classical Growth Theory

The neo-classical growth theory is associated with the period starting in the era during which macroeconomists developed long-run models to formulate economic growth and its determinants. This theory is firmly grounded in the growth models attributed to Solow (1956) and Swan (1956). The Solow model is the initial reference of growth analysis in which technological progress is cited as the main determinant of the long-run growth of output per worker. According to this theory, technological advances or capital accumulation can result in output growth in the short-run. In the basic Solow model, output (Y) is said to be determined by capital (K), labour (L) and knowledge or the effectiveness of labour (A). These factors of production are combined to produce output thus,

$$Y(t) = F(K(t), A(t)L(t)) \qquad (2.1)$$

where t denotes time. Solow (1956) adopted growth accounting to provide a direct expression of the composition of output growth. This direct expression is based on equation (2.1) and expressed as,

$$\frac{\dot{Y}(t)}{Y} - \frac{\dot{L}(t)}{L(t)} = \alpha_K \left[\frac{\dot{K}(t)}{K(t)} - \frac{\dot{L}(t)}{L(t)}\right] + SR(t) \qquad (2.2)$$

where,

$\frac{\dot{Y}(t)}{Y}$ is the growth rate of output

$\frac{\dot{L}(t)}{L(t)}$ is the growth rate of labour

$\frac{\dot{K}(t)}{K(t)}$ is the growth rate of capital

α_K is the output elasticity with respect to capital at time t

$SR(t)$ is the Solow residual.

Equation (2.2) shows the channel through which capital, labour and technological advancement will affect the level of output growth in an economy. Although equation (2.2) shows the mechanism through which capital, labour and technological progress influence output growth, it doesn't provide a direct linkage between inflation and output growth. The link between inflation and output growth is however captured by Mundell (1963). The link is derived based on the neo-classical growth theory. The relationship is captured through a model that shows that increases in inflation or inflation expectations reduces people's stock of wealth owing to a reduction in the real rate of return. This model assumes that economic agents switch to assets other than money and hence save more. The increased saving causes reduction in the real interest rate. This further leads to greater savings which imply a higher capital accumulation and hence faster output growth in the economy. This is how growth theory links inflation to output growth.

Swan (1956) examines the connection between capital accumulation and the growth of the productive labour force and makes the assumption that annual output depends on capital and labour and that these are the only factors of production. Despite laying a good foundation of the analysis of output growth, there is little mention of the link between inflation and output growth in these important studies. In the neo-classical model, Mundell (1963) captured the link between inflation and output growth, where he posits that people's wealth is negatively affected by an increase in inflation or inflation expectations. According to Mundell (1966), greater savings translates into higher capital accumulation and thus fosters output growth.

2.2.5 Neo-Keynesian Theory

The neo-Keynesian theory is an extension of Keynes' thesis. One major contribution of neo-Keynesians is the 'natural rate of output' or 'potential or full-employment output'. The potential rate of output is output that would prevail if prices were fully flexible. In this theory, inflation depends on the level of actual output and the natural rate of unemployment. In this set-up, the unemployment rate is given and assumed to be equal to the natural rate of unemployment, that is, a vertical Philips curve (Solow, 1986) whilst there are different possible inflation rates that can actually occur at that unemployment rate. In the neo-Keynesian theory, inflation depends on actual output hence the link between the two variables.

There are many other theoretical models, which relate inflation to output and hence help to explain and extend the theory on how output is linked to inflation. These are models nested in the theoretical formulations stated above but which are relevant to include here as they explicitly relate inflation to output growth through the functions of money. Because inflation is viewed as '*always and everywhere a monetary phenomenon'*, it would be prudent to highlight how changes in demand for money link inflation to output growth in an economy. These models are an extension of the monetarist school due to its focus on the demand for money and how this influences the inflation-output nexus. These models include the money in the utility model, cash in advance model and the transaction cost approach. We consider these in turn.

2.2.6 Money in-Utility Model

The money in the utility function assumes that money yields direct utility through incorporating money balances into an economic agents' utility function. The optimization problem as stated by Yilmaz (2010) is therefore given as,

$$\max \int_0^{\infty} U(c(t), l(t), m(t)) e^{-\rho t} dt \quad (2.3)$$

$$s.t. c(t) + \dot{k}(t) + \dot{m}(t) = f(k(t), l(t)) - nk(t) - (\pi(t) + n)m(t) + \tau(t) \quad (2.4)$$

where c, m, k *and* l are consumption, real money balances, physical capital stock and labour effort per capita respectively. ρ is rate of time preference, n is population growth, π is the rate of inflation and τ is the real money transfer payments. The inflation link to output growth is derived from Fischer (1979) who argues that given that the consumption and real money variables are separable, consumption is affected negatively by money growth rate (inflation).

2.2.7 Cash in Advance Model

The cash in advance model is also known as the liquidity approach and this takes effect through the medium of exchange function of money. By assuming that in addition to the budget constraint, the economic agent faces a liquidity constraint as formally defined by Yilmaz (2010),

$$c(t) + \theta \dot{k}(t) \leq m(t) \quad (2.5)$$

where all consumption goods $c(t)$ and only a fraction $\theta \in [0,1]$ of $\dot{k}(t)$ goods are purchased by real money balances, $m(t)$. In this setup, inflation is linked to output through the effect of higher money growth on steady state capital, which reduces capital labour ratio and hence output in the overall economy. This is attributed to Stockman (1981) who developed a model with an inverse relationship between inflation rate and output growth, in which an increase in inflation leads to a decline in people's welfare. In Stockman's model, money is viewed as a complement to capital and accounts for a negative relationship between the equilibrium level of output growth and inflation rate.

2.2.8 Transaction Cost Approach

The transaction cost approach assumes that every purchase requires the input of transactions services produced by money and time. In other ways, it simply implies that higher money growth rate reduces labour, capital, consumption and real money balances. This is how the transaction cost approach links inflation to output. What this also implies is that the steady-state capital-labor ratio is independent of the rate of money growth under constant returns (Yilmaz, 2010) hence pointing to the fact that the relationship between inflation and output growth is difficult to explain but firmly rooted in the economic theory used to link the two variables.

2.3 Empirical literature.

In the absence of theoretical models, the relationship between inflation and output growth is not very straight-forward. There is no consensus even from empirical studies concerning this relationship. Empirical evidence is very diverse as this section will show. The search for understanding of this relationship has led to inflation-growth output nexus being one of the most widely researched areas in economics (Nell, 2000). A number of empirical research on the effects of inflation on economic growth have shown diverse views without any meaningful consensus being reached (Nell, 2000; Gylfason and Herbertsson, 2001; Klump, 2003; Hodge, 2006). This is largely consistent with Gillman and Kejak (2005) who argue that a wide range of studies adopting different endogenous growth models are all capable of simulating adverse effects arising from inflation on economic growth. In this section, we review literature based on empirical studies done in Zambia, at regional and finally at the global level.

2.3.1 Previous studies of inflation in Zambia

Literature on effects of inflation on growth output in Zambia is limited. Previous studies on inflation in Zambia (Mwansa, 1998; Pamu and Simuchile, 2004; Mutoti, 2006) have investigated the determinants of inflation over several sample periods. These studies examine the sources and determinants of inflation in Zambia and provide a foundation of the initial works previously done in Zambia. Though these studies do not directly study the effect of inflation on output, they contribute to the understanding of the historical behaviour of inflation in Zambia.

In a study of determinants of inflation in Zambia, Mwansa (1998) estimated a VAR and an error correction model of inflation using quarterly data for the period 1985 to 1996. He found that the second lag of M1 is marginally significant for inflation. In the VAR model, he found that shocks to M1 explain 15% of the variations in inflation after 1 year, while shocks to the exchange rate explained as much as 22% of inflation variations after 6 months. Whilst this study did not examine the effect of inflation on output growth, we can infer that money is significant in explaining inflation in Zambia and based on this finding, we can cautiously state that money has an influence on output growth through its effect on inflation. This study examines the effect of inflation on output and departs from the earlier studies by focusing on the long and short run effects of inflation on output in Zambia without necessarily restricting to the sources or determinants of inflation.

Simatele (2004) used error correction models to examine whether monetary aggregates have useful information for predicting inflation in Zambia over the period 1994-2001. The study finds evidence that money supply (M2) contained most information and that the growth rate of money supply (M2) was significant in explaining inflation.

Baldini (2006) used VAR analysis for the period 1980-2004 to examine inflation and fiscal dominance in Zambia. Evidence from this study shows that seigniorage and high inflation recorded in the economy were evidence of fiscal dominance rather than monetary in the control of money supply. This evidence shows the importance of monetary authorities being in control of the money supply in an economy as they are better placed to make decisions better suited to controlling the economy rather than for political reasons.

Phiri (2013) examines effects of inflation on economic growth for the Zambian economy using a threshold autoregressive (TAR) model and the conditional least squares (CLS) estimation technique on quarterly data for the period 1998 to 2011. Results indicate that output growth in Zambia can be stimulated even in a moderately high inflation environment. This study provides evidence in favour of a positive relationship between inflation and growth in Zambia. This is largely consistent with Gillman and Kejak (2005) who conclude that a wide range of studies adopting different endogenous growth models are all capable of simulating adverse effects arising from inflation on economic growth. This entails that it is prudent to examine and make conclusions from studies that use similar methodologies when evaluating the effects of inflation on growth output.

Chibwe (2014) examines the nature of the relationship between inflation and economic growth in Zambia using VAR methodology for the period 1980-2011 and finds no evidence of an equilibrium long-run relationship between these variables. This is contrary to results in Phiri (2013) who finds a positive relationship. This discrepancy could be attributed to the difference in the data span and methodologies used. This study extends work by Chibwe (2014) by examining a larger data set from 1964 to 2015. Furthermore, the study contributes to literature by estimating the output elasticity to inflation changes.

2.3.2 Related literature

There are a number of related studies that have been done for other developing countries. The empirical evidence does not provide a clear consensus despite different methodologies and data spans used. Here we review literature that shows positive, negative and even zero correlation and relationship between inflation and output.

Nell (2000) examines if any given level of inflation is harmful to the South African economy. Results from a VAR model indicate that single digit inflation is beneficial to economic growth though growth costs of deflation far exceeds the growth benefits. However, this evidence is contrary to Hodge (2006) who finds that for the South Africa economy, inflation hampers economic growth over both the short and longer terms. The results from these two studies is further evidence attesting to the fact that the relationship between inflation and output growth is not straight forward and hence consensus is hardly ever met empirically. The lack of consensus is also evident in Chimobi (2010) who evaluated the relationship between inflation and economic growth in Nigeria and finds no evidence of a long-run equilibrium relationship. The discrepancy in the results of the effects of inflation on economic growth is also widespread even at country level. Umaru and Zubairu (2012) examines the effects of inflation on economic productivity in Nigeria and find a positive correlation between inflation and economic growth and these results are consistent with Osuala, Osuala and Onyeike (2013) who find a statistically significant positive relationship between inflation and economic growth.

Eggor and Khan (2014) used a large panel data of both developed and developing economies and based on the PSTR and dynamic GMM techniques to study the relationship between inflation and output growth. Results provides evidence that the inflation-growth non-linearity is sensitive to financial development, investment ratio, trade openness and government expenditures. Whilst this study includes a number of variables which improves the model, our study opts for two variables only due to the fact that data is not readily available for other studies. By focusing on inflation and output growth as the only variables, this makes it possible for us to compare results to prior studies done on the Zambian economy.

Kremer, Bick and Nautz, D. (2009) introduce a dynamic panel threshold model to shed new light on the impact of inflation on long-term economic growth for a large panel sample of 124 countries over the period 1950-2004. Evidence shows that for industrialised and non-industrialised countries, an inflation level above 2% and 17% respectively hinders output growth. They argue that evidence does not support growth-enhancing effects of inflation in developing countries. This is a departure from empirical studies like Phiri (2013) who provide evidence showing that high inflation can support growth.

Bittencourt, van Eyden and Seleteng (2015) investigate the role of inflation rates in determining economic growth in 15 Southern African Development Community (SADC) between 1980 and 2009 based on panel time-series data and analysis. Evidence shows that inflation has hampered growth and slowed economic activity and recommend a stable macroeconomic environment to drive output growth and prosperity in the community. By utilising fixed effects models complimented with instrumental variables, the authors account for heterogeneity and endogeneity in the panels hence producing statistically sound results which show a negative relationship between inflation and output growth.

Samimi and Kenari (2015) examines the impact that inflation has growth rate in 90 developing countries during the period 1995–2003. Using a simultaneous equations model which treats both inflation and growth rate as endogenous variables, the authors find evidence showing that inflation has a significant negative impact on growth rate. The implication here is that inflation is harmful for growth.

Khan and Senhadji (2000), sampled a number of developing and developed countries to examine the inflation threshold effect on output growth. Results show that threshold levels differ between developed and developing countries. They found break-point evidence of 1% - 3% for developing countries and 7-11% for developing countries and that inflation negatively affected growth output above the break-point thresholds levels.

Faria and Carneiro (2001) investigates the relationship between inflation and output in a high inflation set-up for Brazil and find evidence that inflation has no impact on real output in the long run but that in the short-run there is a negative effect from inflation on output. This evidence is in support of Sidrauski's (1967) superneutrality of money in the long run. Gregorio (1992) examined a panel of 12 Latin American countries with persistent higher episodes of inflation. He found evidence in support of a negative relationship between inflation and economic growth in the long run.

Ghosh and Philip (1998) examined the relationship between per capital GDP and consumer price index for a multi country sample using panel regressions and found evidence in favour of a negative relationship between inflation and output growth. Further implication of this study is that of non-linearity in that at lower levels of inflation (2-3 percent a year or lower) inflation and output growth are positively correlated but above this level, inflation and output growth are inversely related.

In an attempt to understand the determinants of inflation in a number of countries which had experienced higher episodes of inflation over a period of time, Bruno and Easterly (1998) used annual CPI of 26 countries over the period 1961-1992. They find inconclusive evidence of a relationship between inflation and growth output.

Another relevant multi-country study is that by Mallik and Chowdhury (2001) who examined dynamics of inflation and output growth using cointegration and error correction models for four South Asian countries (Bangladesh, India, Pakistan and Sri Lanka) using annual and found evidence in favour of a positive relationship between inflation and output growth.

Paul, Kearney and Chowdhury (1997) examined the relationship between inflation and economic growth for 70 countries for the period of 1960-1989 using Granger methodology to test direction and pattern of causality between inflation and economic growth. Results provide evidence that the relationship between inflation and growth was non-uniform across countries with some countries showing no causality whilst others showed unidirectional causality.

Grimes (1991) examined the relationship between inflation and economic growth using a sample of 21 countries for the period 1961-1987 and found a positive relationship between inflation and the economic growth for a short term, and a negative relationship in the long-run.

Dipietro and Sawhney (1999) examined the relationship between inflation and economic growth for a panel of 98 countries for the period 1970-1993. The evidence shows that 81 out of the 98 countries there was no significant relationship between inflation and growth.

Behera and Mishra (2016) investigated the inflation-growth nexus in the BRICS countries for the period 1980-2012. Evidence indicates that a long run positive relationship between inflation and economic growth exists only for China and South Africa and that there is a unidirectional causality between growth and inflation for India and a bidirectional causality for China. This evidence contradicts Samimi and Kenari (2015) who find a negative relationship between inflation and growth in the SADC region.

Majumder (2016) uses Granger causality and error correction model to examine the relationship between economic growth and inflation in Bangladesh during the period of 1975-2013. Results provide evidence in support of a statistically significant long-run positive relationship between inflation rate and growth.

Ozpence (2016) examined the causal relationship between inflation and economic growth in Turkey during the period 2003-2015 using a VAR model and Granger causality. Results finds evidence that there is unidirectional causal link from growth to inflation. This evidence supports Behere and Mishra (2016) though the later examines a panel data set even though results still point to a relationship between inflation and output growth.

Other studies that have examined the effect of inflation on economic growth have studied several countries. This approach is preferred when making conclusions as multi country studies give a richer sample and the panel nature of the data helps to isolate the individual heterogeneity and makes results much more robust. In spite of the multi country study and richer data sets utilised, the lack of consensus is again clear. Thanh (2015) examines the effect of inflation on economic growth in five ASEAN countries and finds evidence in favour of a negative relationship. This result is consistent with Chua Yeh (2009) who examines 140 countries over the period 1970-2005 and finds evidence of a negative relationship between inflation and economic growth. Barro (1995) also finds evidence of a negative but significant effect of inflation on economic growth. Sarel (1996) finds mixed evidence of the effect of inflation on economic growth. At inflation rate below eight percent, inflation has a positive effect on economic growth but beyond this level, the effect turns negative. Behera (2014) finds a positive correlation between inflation and economic growth in a study of six South Asian countries. These studies have all confirmed that there is no consensus on the effect of inflation on economic growth.

Empirical evidence on the effect of inflation on output remain largely inconclusive even for multi country studies as shown in the review of earlier studies. It is clear that there is an effect of inflation on growth and vice versa. What is not clear is the magnitude and the direction of this effect. Several studies recognise that there is s relationship between inflation and output hence have focussed on examining the threshold levels of inflation. The literature review has shown that indeed there is s relationship between inflation and output in both the short-term and in the long-run. Few studies have examined the Zambian case. This study hopes to contribute to literature by examining the Zambian scenario.

Chapter 3: Methodology

3.1 Introduction

This chapter describes the data and the methods used in this study. The chapter starts by defining the data and explaining the sources followed by unit root tests to determine the order of integration of the variables. Cointegration tests are explained in detail and a justification for use of the specified method is provided. The chapter concludes with an explanation of the granger causality test and impulse response functions.

3.2 Data and key variables used

The data for this study spans over the period 1964 to 2015. The period is selected to carry out a comprehensive study from the time of independence.

3.2.1 Inflation

Inflation (INF) is calculated by taking the first difference of the natural logarithm of Consumer Price Index (CPI) and multiplying it by 100. The data is sourced from the Central Statistical Office (1964-2015) and is annual data series.

3.2.2 Output.

The real gross domestic product (GDP) has been used as a proxy for output. This is defined as real GDP at constant national prices for Zambia, millions of 2011 U.S. dollars, annual and not seasonally adjusted. Here we capture the output by computing the first difference of natural logarithm of annual real GDP volume multiplied by 100 and this has been used to reflect annual output for Zambia. This data is obtained from the Federal Reserve economic database of the Federal Reserve Bank at St. Louis (1964-2015).

3.3 Specification of the model

Studies on the effect of inflation on output have often used a bivariate estimation specification. Although popular, the method often suffers from omitted variable bias (Odhiambo, 2013). However, this criticism is not insurmountable as evidenced by a plethora of studies that adopt this methodology (Aucremanne and Wouters, 1999; Gokal and Hanif, 2004; Hasanov and Omay, 2011; Girma, 2012 and Chibwe, 2014). A VAR composed of output growth and annual average inflation in order to test the effect of inflation on output in Zambia. However, a VAR in first difference is only applicable in the absence of cointegration. If the variables are cointegrated though, a vector error correction model (VECM) is used instead. A vector error correction (VEC) model is a restricted VAR model designed for non-stationary series used for series that are known to be co-integrated. The vector error correction (VEC) model restricts the long-run behaviour of the endogenous variables so that their long run relationship converges to equilibrium by allowing the short run adjustment dynamics.

In addition, the study uses Granger causality test to evaluate the magnitude and direction of causal relationships between inflation and growth in Zambia. The Granger causality methodology tests if past values of one variable are statistically relevant in explaining the current value of another variable in addition to the explanation provided by its own previous (lagged) values. All variables used in the Granger causality analysis should be stationary.

The relationship between inflation and output growth can be expressed through a general multivariate vector error correction model (VECM) specified as,

$$\Delta Y_t = a + by_{t-1} + \sum_{i=1}^{p-1} c_i \Delta Y_{t-i} + \varepsilon_t \qquad (3.1)$$

where Y_t is a K x K vector of endogenous variables, $b = \sum_{j=1}^{j=p} A_j - I_k$, $c = \sum_{j=1}^{j=p} A_j$ and $A_j's$ are K x K matrices of parameters and ε_t are K x 1 vector of disturbances. In the absence of cointegration, that is, when *b=0,* the specification shown in (3.1) reduces to a VAR model. However, in the presence of cointegration, the *c* represent short-run response matrix. It is therefore imperative that we test for cointegration to ascertain the existence or not of a long-run equilibrium relationship between inflation and output.

3.3.1 Parameter stability test

For time series data, it is logical to expect instability in the econometric relationship between given variables (Elliot and Muller, 2006). For this study, the period under review is relatively short but long enough to undergo different economic regimes. From 1964 to 2015, the Zambian economy has gone through several regime changes both politically and economically. This represents a challenge in terms of our econometric estimation due to structural changes, unless measures are taken to account for these changes. In the presence of structural breaks, forecasting errors abound and this leads to the general unreliability of the model. Therefore, being able to detect time series data structural changes gives us an idea into the problem we are studying. There are different ways of testing for structural breaks in a time series data. In this study, we adopt Elliot and Muller (2006)'s Quasi-Local Level (qLL) test to test whether there is structural break in the data series. The idea behind the Quasi-Local Level (qLL) is that the tests for parameter constancy and unknown structural break process can both be combined to produce a single efficient test for stability of a given regression function. The qLL tests the null hypothesis,

$$y_t = X_t^{/} \bar{\beta} + Z_t^{/} \delta + \varepsilon_t \qquad t = 1,\ldots..T \qquad (3.2)$$

against the alternative hypothesis

$$y_t = X_t^{/} \beta_t + Z_t^{/'} \delta + \varepsilon_t \qquad t = 1,\ldots..T \qquad (3.3)$$

With non-constant $\{\beta_t\}$ where y_t is a scalar, X_t, β_t are k x 1 vectors, $Z_t^{'}, \delta$ are d x 1 vectors, $\{y_t, X_t, Z_t\}$ are observed where as $\bar{\beta}, \{\beta_t\}, \delta$ are unknown and ε_t is a mean-zero disturbance. The qLL test rejects the null hypothesis of stability for smaller computed values (values more negative) than the critical values. According to Elliot and Muller (2006), "qLL tests whether the coefficient vector that links the observables to y_t, X_t remains stable over time, while allowing for other stable links between y_t and the observables through Z_t".

3.3.2 Unit root tests

It is important to ensure that variables in a regression model are stationary to avoid spurious regressions results (Granger and Newbold, 1974). This is achieved through the use of unit root tests. Unit root analysis is the univariate time series analysis, which seeks to find out whether the series are stationary or not. A stochastic process is said to be stationary if it has time invariant first and second moments. That is, an econometric series is stationary if its mean, variance and auto-covariance are time invariant, that is, constant over time (Enders, 2004). If variables in a model are not stationary, there is always a danger of the regression model resulting in spurious results. A spurious regression model is one which provides statistical evidence of a linear relationship between independent non stationary variables. To avoid this case of running into "nonsensical" regression results, it is important to carry out unit root tests to establish whether variables are stationary or not. If a variable is not stationary in levels, it can be made stationary by differencing. If it is differenced once and found to be stationary, then it is referred to as being integrated of order one, *I (1)*. If it is differenced twice, it is said to be integrated of order two, *I*

(2). Econometric literature is rife with a number of unit root tests. In this paper, we use four popular tests.

Owing to the different powers of unit roots tests, different tests give varying results especially for macroeconomic variables. Therefore, we adopt the Dickey Fuller Generalised Least Squares method (DF-GLS0 as opposed to a number of use a battery of unit roots tests namely Augmented Dickey Fuller or ADF (Dickey and Fuller, 1981), PP (Phillips and Perron, 1988), KPSS (Kwiatkowski, Phillips, Schmidt and Shin, 1992). The DF-GLS (Elliott, Rothenberg and Stock, 1996) method is considered to be superior to the other methods (Chibwe, 2014). In the following paragraphs, we show how the various tests are modelled.

The ADF model, as presented by Dickey and Fuller (1981), is formally expressed as follows:

$$\Delta y_t = c_0 + \delta_{t-1}\sum_{i=1}^{p}\Delta y_{t-1} + u_t \tag{3.4}$$

$$\Delta y_t = c_0 + c_1 t + \delta y_{t-1} + \beta\sum_{i=1}^{p}\Delta y_{t-1} + u_t \tag{3.5}$$

where c_0 is the constant term and c_1 is a trend term, p is the number of lagged terms and u_t is white noise. Equation (3.4) refers to the case with intercept only while equation (3.5) refers to the case with both an intercept and a trend. The DF-GLS (Elliott, Rothenberg and Stock, 1996) is modelled as an OLS regression as follows:

$$d(y_t / \alpha) = d(z_t / \alpha)\,{}'\delta(\alpha) + \eta_t \tag{3.6}$$

where z_t contains either a constant only or both a constant and a trend. The DF-GLS (Elliott, Rothenberg and Stock, 1996) statistic is computed from,

$$\Delta y_t = \alpha y_{t-1} + \beta_1\Delta y_{t-1} + ... + \beta_p\Delta y_{t-p} + \upsilon_t \tag{3.7}$$

where y and y_{t-1} are detrended terms. The PP (Phillips and Perron, 1988) is a non-parametric methodology. It has the further advantage of controlling for serial correlation in unit root test by modifying the t-ratio of the estimated coefficient and the test statistic is modelled as,

$$\tilde{t}_{\alpha} = t_{\alpha}\left(\frac{\gamma_0}{f_0}\right)^{1/2} - T\left(\frac{(f_0 - \gamma_0)(se(\hat{\alpha}))}{2 f_0^{1/2} s}\right) \qquad (3.8)$$

where γ is the error variance estimate and t_{α} is the t-ratio of α , $\hat{\alpha}$ is the estimate coefficient, se is the standard error of the coefficient, f is residual and s is the standard error of the test regression. The KPSS (Kwiatkowski, Phillips, Schmidt and Shin, 1992) is a residual based test from OLS regression of y_t on an exogenous variable x_t hence,

$$y_t = x_t^{'}\delta + u_t \qquad (3.9)$$

with a lagrange multiplier (LM) based test statistic which is defined as,

$$LM = \sum_{T} \frac{s(t)^2}{T^2 f_0} \qquad (3.10)$$

where the cumulative residual function is represented by $s(t)$ and f_0 is the residual. It is important to note that unit root tests stated above have different null hypotheses. For the ADF, DF-GLS, PP and NP the null hypothesis is that the series is non-stationary, that is, the series contains a unit root whilst the null for the KPSS tests for stationarity. It is also important to note that the different results from unit roots tests on the integration orders of the variables could result in false results from the conventional cointegration results (Nieh and Wang, 2005). Whilst the approach of adopting the four unit root tests is meant to address the problem of different power of the tests, we adopt the ADF method to carry out unit root test as in Chibwe (2014).

3.4 Cointegration

In economic theory, a substantial part focuses on examining long-run equilibrium relationships between macroeconomic variables. To run regressions that are non-spurious, variables should be stationary. However, macroeconomic variables such as interest and inflation rates, money supply and gross domestic product are rarely stationary in level forms. However, certain relationships can be modelled even though the variables are not stationary in level forms given that their linear combination is stationary. A long-run equilibrium combination of non-stationary variables is known as cointegration. In the long-run, if two or more series move closely together even though the series themselves are not stationary, the difference between them is constant and they are cointegrated (Dickey and Fuller,1979). Once variables have been made stationary, it is possible to set up a models that lead to stationary relationships between the variables, for which standard statistical inferences can be made. It is important to test for cointegration in order to verify if the modelling process is empirically valid. If variables in a model follow different trend processes, they cannot maintain a fixed long-run relationship without wandering far apart, which makes it impossible to model a valid long-run relationship and standard inferences cannot be drawn. In the basic ordinary least squares formulation, there are different ways of testing for cointegration. These methods include Cointegrating Regression Durbin-Watson (CRDW), autoregressive distributed lag approach to cointegration (ARDL), Johansen test and Augmented Engle-Granger (AEG) test. In this study, we utilize the Johansen Cointegration Test to test for cointegration relationship.

3.4.1 Johansen Cointegration Test

This study utilizes the Johansen Cointegration Test to examine if there is cointegration relationship between the variables. The Johansen cointegration method tests for cointegration in a multivariate context in which there is the possibility of having more than one cointegrating vector. The test uses maximum likelihood procedure and has been selected to a number of desirable statistical properties. According to Lütkepohl and Saikkonen (2001), this method has been found to be useful in a number of comparative studies and performs better. The Johansen Cointegration Test tests the restrictions imposed by cointegration on the unrestricted vector autoregressive model. The specification as developed by Johansen (1995) is formally expressed in form of a VAR of order *p* as,

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + \mathrm{B} x_t + \varepsilon_t \qquad (3.11)$$

where:

$$\Pi = \sum_{i=1}^{p} A_i - I \text{ and } \Gamma_i = -\sum_{j=i+1}^{p} A_j \qquad (3.12)$$

Based on Granger's representation theorem, if the coefficient matrix Π has a reduced rank, r <k, then there exists k x r matrices α and β each with rank r, such that $\Pi = \alpha\beta'$ and $\beta' y_t \, is \, I(0)$, r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. However, If all variables in y_t are integrated of order 1, the matrix Π has rank 0 < r < K, where r is the number of linearly independent cointegrating vectors. If the variables are cointegrated (r > 0) the VAR in first differences is mis-specified as it excludes the error correction term.

The Johansen methodology produces two statistics namely the likelihood ratio test based on maximum eigenvalue test and the trace test of the stochastic matrix. The eigenvalue test conducts tests on the individual eigenvalues, and the null hypothesis is that the number of cointegrating vectors is *r*, against an alternative of (*r*+1) whilst the Trace test is a joint test with null hypothesis that the number of cointegrating vectors is less than or equal to r against the alternative that there are more than r. The two tests are formally defined as,

$$\lambda_{Max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1}) \tag{3.13}$$

$$\lambda_{Trace}(r) = -T\sum_{i=r+1}^{g} in(1-\hat{\lambda}_i) \tag{3.14}$$

The Johansen Test assumes that the cointegrating vector is constant throughout the period under study. However, it is possible that the long-run relationships between the underlying variables do change over time. For this reason, other tests have been introduced such as Gregory, Nason and Watt (1996). In this study, we use the Johansen Test in order to enable comparisons with and extend prior studies on the Zambian economy, which have utilized the Johansen Test. In the presence of cointegration we run the vector error correction model (VECM) which enables us to run a model which captures the disequilibrium from steady state and the speed of adjustment to long-run equilibrium. However, if cointegration is rejected, we run a vector autoregressive (VAR) model.

3.5 Vector Error Correction Model (VECM)

In a bivariate model, it is possible to have a long-run relationship if each series in the model is integrated of the same order or both variables have the same stochastic trend. If It and Yt are cointegrated, the first difference of It and Yt can be estimated in a VAR model and augmented by including Yt-1-πIt-1 as an additional regressor in the model. For cointegrated series, this is estimated by using a VEC model with two time series variables as:

$$\Delta Y_t = \beta_{10} + \beta_{11}\Delta Y_{t-1} + ... + \beta_{1p}\Delta Y_{t-p} + \alpha_{11}\Delta I_{t-1} + ... + \alpha_{1p}\Delta I_{t-p} + \delta_1(Y_{t-1} - \pi I_{t-1}) + \mu_{1t} \tag{3.15}$$

$$\Delta I_t = \beta_{20} + \beta_{21}\Delta Y_{t-1} + ... + \beta_{2p}\Delta Y_{t-p} + \alpha_{21}\Delta I_{t-1} + ... + \alpha_{2p}\Delta I_{t-p} + \delta_2(Y_{t-1} - \pi I_{t-1}) + \mu_{2t} \tag{3.16}$$

Where Δ, the difference operator, is the error correction term and μ_t is a random error term.

This is the VEC model specification. In VEC model, past values of the error correction term help to predict future values of ΔY_t and ΔI_t. This model describes how variables behave in the short run and the convergence to long-run equilibrium. Significant coefficient of the error correction term indicates that any short term fluctuations between the independent variable and dependent variable will converge to equilibrium in the long-run. To assess the effect of inflation on growth in Zambia, this is the model that we adopt.

3.6 Granger Causality Test

Granger causality test was developed by Granger (1969). This has been a workhorse in economic literature and used to describe the relationship between variables. Correlation between two variables indicates co-movement but Granger causality statistics examine whether lagged values of one variable helps to predict another variable. Under Granger Causality, four different results are possible under the relationship between inflation and output growth in Zambia. Unidirectional Granger causality from INF to GDP implies that the rate of inflation rate increases the prediction of output growth and not the other way round. Unidirectional Granger causality from GDP to INF implies that output growth increases the prediction of inflation rate and not the other way round. Bidirectional Granger causality implies that the rate of inflation increases the prediction of output growth and that output growth increases the prediction of inflation rate. Finally, independence between output and inflation implies that there is no granger causality between the two variables and hence one variable cannot increase the prediction of the other variable.

3.7 Output Elasticity

To measure the responsiveness of output to changes in inflation, we employ a double-log model. This is an extension to the work by Ramanathan (2002) who specified elasticity using a non-linear regression equation of the form,

$$\ln(Y) = \alpha + \beta \ln(X) + \varepsilon \qquad (3.17)$$

Ramanathan interprets β as elasticity. In this paper though, we adopt the model by Kasidi and Mwakanemela (2013) in which they employed the logarithmic approach to measure the responsiveness of output to changes in inflation using a double-log model. The representation is as follows;

$$\ln GDP = \alpha + \beta \ln CPI + \varepsilon \qquad (3.18)$$

In the model above, the β represents the responsiveness of output to changes in cpi (inflation). In other words, a percentage change in CPI leads to β percentage change in output. We use this formulation in this paper to measure the responsiveness of output to changes in CPI. The interpretation of the slope coefficient becomes,

$\frac{\partial \ln GDP}{\partial \ln CPI}$, that is relative change in GDP divided by relative change in CPI. The slope coefficient is also the elasticity,

$$\beta = \frac{\Delta(\ln GDP)}{\Delta(\ln CPI)}$$

$$= \frac{\Delta(\ln GDP)}{\Delta(\ln CPI)} \frac{\Delta GDP * CPI}{\Delta CPI * GDP} \qquad (3.19)$$

The expression for elasticity of output to inflation is given in equation (3.19) by the average of the dependent variable.

3.8 Impulse Response Function

It is important to know how variables in a model respond to a one time shock to one of the VEC disturbances. Impulse response refers to a reaction in a given dynamic system to external shocks. Impulse response functions capture and trace out the response of present and future values of each variable to a one unit increase in the current value of one of the VEC errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero (Girma, 2012). However, a weakness of this method is that if the disturbances are contemporaneously correlated, these functions do not explain how one variable reacts to a one-time increase in the innovation of another variable after a given period, holding everything else constant. However, limitation is overcome by using orthogonalized innovations so that the constancy assumption is valid (Chibwe, 2014).

3.9 Forecast Error Decomposition

Forecast error decomposition shows how much information each variable contributes to the effect on other variables in a VEC model. While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VEC, variance decomposition separates the variation in an endogenous variable into the component shocks to the VEC. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting each variable in the VEC model. The importance of this method is that it helps to measure the forecast error of one variable on the other in the VEC model. That is, how much the rate inflation is explained by exogenous shocks to output and vice versa. It is important to carry out diagnostic checks to ensure the model stability. Tests for autocorrelation and normality of the disturbances are carried out using the Lagrange Multiplier (LM) and skew-ness and kurtosis respectively.

Chapter 4: Empirical Results and Analysis

4.1 Introduction

This chapter presents the findings and discussions of the empirical results. The first section presents the data properties and shows the descriptive statistics, unit root tests as well as cointegration tests. The following sections present results from the vector autoregressions tests, Granger causality test, impulse response, forecast error results and the results of the output elasticity to inflation results. The last section discusses the empirical findings.

4.2 Data Properties

Table 4.1: Summary statistics

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque Bera	Prob	Obs
CPI	26.30	0.22	144.04	0.00	41.87	1.47	3.80	19.65	0.00	51
GDP	22,910.55	17,648.40	57,273.90	11,035.70	11,755.00	1.68	4.67	30.04	0.00	51

Table 4.1 shows the descriptive statistics of the variables used in the analysis. For both CPI, and GDP skew-ness is positive implying that the mode is less than the median. It is therefore inferred that for both variables, most observations are below the expected value of the series. The kurtosis is greater than three implying that our data is peaked than a normal distribution with longer tails. For a VECM study of this nature, our focus is on the relationship between inflation and output and to assess whether there is cointegration relationship between these variables so as to derive necessary conclusions. Normality tests of the VECM model are estimated after running the model regressions and hence skewness and kurtosis results based on individual variables do not have a significant effect on the VECM model estimates and relationships.

4.3 Elliot-Muller's qLL Structural Break Test

The Jargue-Bera test shows that both CPI and GDP are not normally distributed. Table 4.2 shows the Elliot-Muller qLL test results. Absolute value of the computed statistic is less than the critical values for any level of significance.

Table 4.2: Elliot-Muller's qLL Structural break test

Tests Statistic	1% critical value	5% critical value	10% critical value
-3.781	-11.05	-8.36	-7.14

Elliott-Müller qLL test statistic for time varying coefficients in the model of gdp, 1966 - 2015. Allowing for time variation in 1 regressors. H0: all regression coefficients fixed over the sample period (N = 50).

We therefore fail to reject the null hypothesis of parameter stability; and conclude that there isn't enough evidence in favour of a structural break. We can therefore conclude that the parameters used are constant over the sample period. From 1964 to 2015, the Zambian economy has given through different economic and political regimes. The results of the parameter stability though show a different picture. This is surprising. Perhaps, the results speak to the power of the test.

4.4 Unit Root Tests

Table 4.3 presents unit root tests results based on ADF. Results from the structural break test indicate that our data span doesn't have a structural break. As pointed out by Perron (1989), conventional unit root tests are biased towards a false unit root null when there is presence of a structural break. Since our data doesn't have a structural break, we present results based on ADF. The results indicate that both log GDP and log CPI are difference stationary, that is integrated of order one $I(1)$, but there is a presence of a unit root in levels form for both variables.

Table 4.3: Unit Root Test Results for LGDP and LCPI based on ADF

Variable		**With Intercept**	**Lags**	**Without Intercept**	**Lags**
LCPI	Lvls	-0.681	1 [SIC]	-1.084	1 [SIC]
	Diff	-2.564	0 [SIC]	-1.810*	0 [SIC]
LGDP	Lvls	-1.488	0 [SIC]	2.149	0 [SIC]
	Diff	-2.647**	3 [SIC]	-2.097**	3 [SIC]

** significant at 5%, * significant at 10%
Lvls refer to levels while Diff refers to differences. SCI: Schwarz information criteria

4.5 Johansen Cointegration Test

Unit roots tests have shown that both LCPI and LGDP are difference stationary, that is, integrated of order one, $I(1)$. We can therefore carry out a test of cointegration to test if there is a long-run relationship between inflation and output. The results are presented in Table 4.4. Both the trace and max-eigenvalue test statistic indicate that we have one cointegrating relationship. Both models based on no intercept and no trend and intercept and no trend indicate the presence of a cointegrating relationship. These results are shown in the summary of all the five models in Table 4.4. Only model one and two show the presence of cointegration. Both AIC and SIC indicate that the optimal lag selection is one.

Table 4.4: Johansen Cointegration Test (summary) results

Selected (0.05 level*) Number of Cointegrating Relations by Model

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

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

In performing the Johansen Cointegration test, care should be taken as it is sensitive to the number of lags used. From the summary of all the five models, we selected model one with no intercept or trend in cointegration equation to reflect the data characterizes. We then proceed to estimate the Johansen Test of Cointegration. We estimate a VAR (1) to determine the existence of cointegration between output and inflation. The optimal lag length is chosen based on the Akaike and Schwarz information criteria. The trace and max-eigenvalue results are shown in Table 4.5. The null of zero cointegrating equation is rejected based on the trace statistic test statistic of 22.182 which exceeds the critical value of 20.262. However, the test of atmost one cointegrating relationship is not rejected since the trace test statistic of 2.504 is less than the critical value of 9.165. The max eigenvalue test results confirm this. Max eigenvalue test for zero cointegrating relationship is rejected since the statistic of 19.678 exceeds the critical value of 15.892. However, the test of atmost one cointegrating relationship is not rejected since the max eigenvalue test statistic of 2.504 is less than the critical value of 9.165.Thus we accept the null hypothesis that there is one cointegrating equation in the bivariate model. We can therefore state that there is a long-run relationship between inflation and output in Zambia over the period under review and hence a linear combination of these two variables will be stable in the long-run. This implies that deviations from the long-run relationship are self-correcting.

4.6 Vector Error Correction Model (VECM)

The Johansen Cointegration Test result has shown that output and inflation are cointegrated for the period under study. A VECM model fits a bivariate time-series regression of each dependent

Table 4.5: Johansen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(S)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.331	22.182	20.262	0.027
At most 1	0.050	2.504	9.165	0.677

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(S)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.331	19.678	15.892	0.012
At most 1	0.050	2.504	9.165	0.677

variable on lags of itself and on lags of all the other dependent variables in the model. Table 4.5 presents the fit and summary statistics of the VECM model.

4.6.1 Error Correction Model (ECM) results.

The ECM has two parts. The first part is the estimated short-run coefficient and second is the error correction term (ECT) that provides the feedback mechanism or the speed of adjustment through which the short-run dynamics converge to the long-run equilibrium path.

$$\mathrm{lgd}p_t = 10.204 + 0.263 lcpi_t + u_t \qquad (3.18)$$

The estimated results show that the coefficient of the regressor is statistically significant at the five per cent level (table 4.6). The long-run coefficient is shown in equation (3.18). The estimated coefficient is 0.263. This value captures the long-run coefficient in the error correction model. The value of 0.263 means that the system corrects the divergence between inflation and output at a speed of 26.3%. The second part of the error correction model is the short-run speed of adjustment to equilibrium and shows that there is a negative relationship between inflation and output.

Table 4.6: Estimated VECM for Output and Inflation

	Cointegration Equation 1
Contegrationg Eq:	
LGDP(-1)	1.000
LCPI(-1)	-0.263 (0.061) [-4.298]
C	-10.204
Error Correction:	D(LGDP)
CointEq1	-0.022 (0.007) [-3.229]
D(LGDP(-1))	0.106 (0.132) [0.806]
D(LCPI(-1))	-0.061 (0.024) [-2.467]
C	0.041 (0.010) [4.113]

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

The coefficient on the U_{t-1} term is one period lag error correction term. This is the term which corrects the short-term disequilibrium in the system. This term needs to be negative and significant. The coefficient as shown in equation (3.19) is -0.022 and is significant at five per cent level meaning that system corrects its previous period disequilibrium at a speed of 2.2% annually.

$$\Delta \mathrm{lgd}p_t = 0.041 - 0.022u_{t-1} + 0.106\Delta \mathrm{lgd}p_{t-1} - 0.061\Delta lcpi_{t-1} \qquad (3.19)$$

The error correcting term reflecting the disequilibrium output indicates a slow speed of adjustment whereby about 2.2% of a disequilibrium value of the output is removed every year.

To ensure validity of the VEC results, it is important to carry out model adequacy checks. The first stability check is the eigenvalue stability check. For the VECM to satisfy stability condition, the eigenvalues need to lie inside the unit circle meaning that the modulus of the eigenvalues need to be less than one. Table 4.7 presents results of the eigenvalue stability condition. All the eigenvalues have a modulus of strictly less than one meaning that our estimated VEC model is stable.

Table 4.7: VECM Stability Test

Eigenvalue	Modulus
1	1
0.933	0.933
0.818	0.818
0.084	0.084

The VECM specification imposes a unit modulus

Another test done to check on the validity of a VECM model is the normality test. This test checks the residuals of the VECM model for normality. If the residuals are normal, then we can conclude that our model is correctly specified and results can be relied upon for interpretation. The results of the normality test are presented in table 4.8 and evidence shows that the residuals of the VEC model are not normally distributed since the null of normality in the Jarque Bera test cannot be rejected.

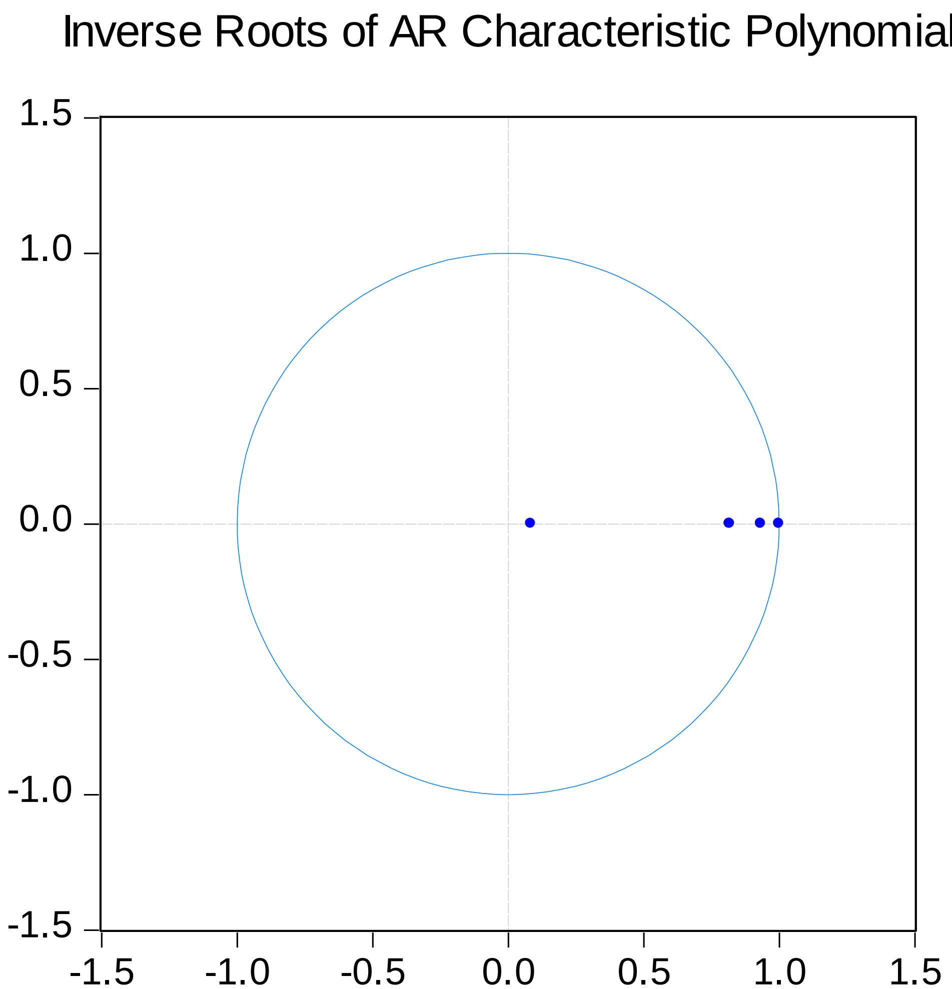

Figure 2: Stability condition test

All the equations individually have non-normal residuals including both equations combined (joint) and hence the normality doesn't hold. Whilst normality in VECM residuals is desired, however it is not a major problem if the normality of the residuals fails to hold.

Table 4.8: VECM Normality Test

Component	Jarque-Bera	df	Prob.
1	13.912	2	0.001
2	4.268	2	0.118
Joint	18.180	4	0.001

For instance, Lutkepohl (2011) argues that though normality tests are often used for model checking, normality in itself is not a necessary condition for the validity of statistical procedures related to VECM/VAR models.

Table 4.9: LM Test for Autocorrelation

Lags	LM-Stat	Prob
1	3.756883	0.4399

H0: no autocorrelation at lag order. Probs from chi-square with 4 df

The calculated chi-square values for lag one are presented in table 4.9. This is the LM test for serial correlation in the residuals of the VECM model. Lag one shows no evidence of autocorrelation as the null of no autocorrelation is not rejected hence the lag order used in our model. This is evidence that the residuals of our VEC model are not autocorrelated hence we can conclude that our model is correctly specified.

4.7 Granger Causality Test

In order to assess whether past values of one variable are important in predicting the values of another, we use Granger causality test. Granger causality examines whether lagged values of one variable help to predict movements and changes in another variable. If past values of variable Y are significant in predicting the values of X, then we conclude that Y granger causes X. The results of the granger causality test are presented in table 4.10 and evidence indicates that lagged values of output do not granger cause inflation and that lagged inflation granger causes output. The implication is that past values of inflation are significant in predicting output and that past values of output are not significant in predicting inflation. In other ways, there is unidirectional causality from inflation to output.

Table 4.10: Granger Causality Test

Dependent variable: D(LGDP)

Excluded	Chi-sq	df	Prob.
D(LCPI)	6.087	1	0.013
All	6.087	1	0.013

Dependent variable: D(LCPI)

Excluded	Chi-sq	df	Prob.
D(LGDP)	0.219	1	0.639
All	0.219	1	0.639

These results are in agreement with findings by Chibwe (2014) who finds evidence in favour of a unidirectional causality from inflation to economic growth in Zambia.

4.8 Output Elasticity

To measure the responsiveness of output to changes in inflation, we employed a double-log model popularly known log-linear model. In a log-linear model, the slope coefficient expresses the elasticity. We utilised the first differences of the log of real GDP and the log of inflation to estimate the elasticity of output to changes in inflation. Results are shown in table 4.11 and indicate that for a one percent increase in inflation, the average value of output decreases by five point four percent. This shows that inflation has a negative effect on output.

Table 4.11: Output elasticity to inflation changes

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0449***	0.008761	5.133032	0
DLCPI	-0.053**	0.026146	-2.05825	0.045

Standard errors in parentheses, *** p<0.01, ** p<0.05

The results indicate that persistent increases in the rate of inflation has a negative impact on output in Zambia. Whilst the VECM is a much powerful test than the OLS, this further supports the results in the ecm which shows a negative relationship between output and inflation.

4.9 Impulse Response

Results of impulse response functions are presented in table 4.12 and figure 3 shows the graph. The response of output to its own shock is shown in the second column.

Table 4.12: Impulse response functions

Response of LGDP:			**Response of LCPI:**		
Period	LGDP	LCPI	Period	LGDP	LCPI
1	0.040	0.000	1	-0.007	0.167
2	0.043	-0.009	2	-0.021	0.293
3	0.044	-0.016	3	-0.033	0.389
4	0.043	-0.020	4	-0.041	0.462
5	0.042	-0.022	5	-0.046	0.516
6	0.041	-0.021	6	-0.049	0.556
7	0.040	-0.020	7	-0.051	0.584
8	0.039	-0.018	8	-0.051	0.602
9	0.037	-0.014	9	-0.050	0.613
10	0.036	-0.011	10	-0.048	0.618

Cholesky Ordering: LGDP LCPI

Results indicate the persistence of output shocks on itself and these do not die out even at ten periods ahead. The third column shows response of output to shocks in inflation. Results review the growing persistence of inflation shocks on output.

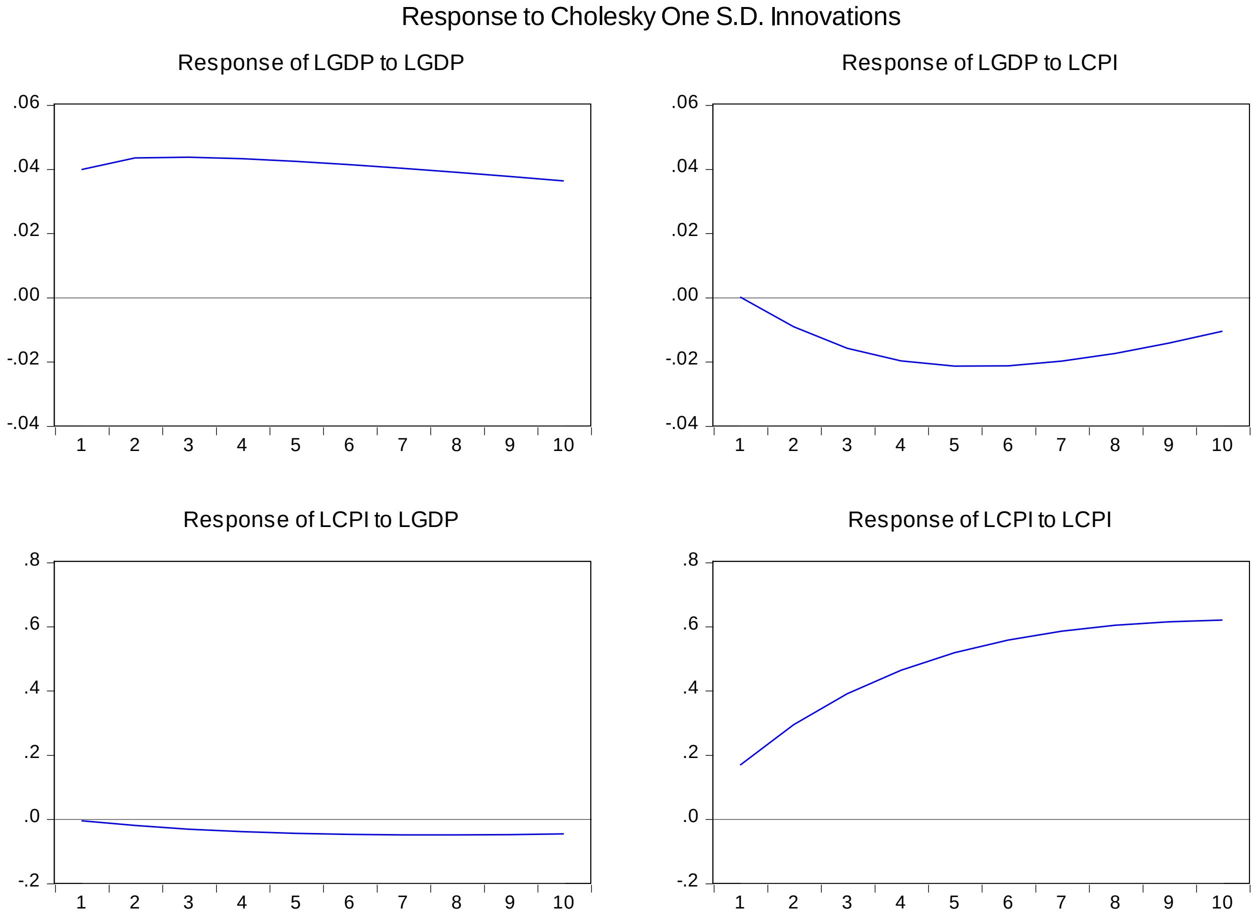

Figure 3: Impulse responses

The negative response of output to changes in inflation confirm the results in the cointegration equation where we found that inflation has a negative effect on output in the short-run but is statistically insignificant. In the long-run inflation boosts output. Need to explain the vecm results in detail. Column five shows the response of inflation to output shocks and reveals the persistence of shocks even at ten periods ahead. Finally, column six shows the response of inflation to own shocks. Results indicate the persistence of inflation to its own shocks. The response of inflation from its own shock is highly persistent and does not die out even up to twenty periods (horizons) ahead.

4.10 Forecast Error Variance Decomposition

The results of the forecast-error variance are presented in table 4.13. Colum three reports the FEVD for output. In this model, the ordering for the forecast error variance places output first, 100% of the forecast-error variance in the first step is attributed to the error in output equation. Four steps ahead, 90.7% percent of the variance is still attributed to the error in the output equation. The results show that forecast error variance attributed to inflation increases with an increase in the periods ahead.

Table 4.13: Forecast Error Variance Decomposition (FEVD)

Variance Decomposition of LGDP:				**Variance Decomposition of LCPI:**			
Period	S.E.	LGDP	LCPI	Period	S.E.	LGDP	LCPI
1	0.040	100.000	0.000	1	0.167	0.153	99.847
2	0.059	97.586	2.414	2	0.337	0.436	99.564
3	0.075	94.016	5.984	3	0.516	0.591	99.409
4	0.089	90.730	9.270	4	0.694	0.675	99.325
5	0.101	88.222	11.778	5	0.866	0.717	99.283
6	0.111	86.559	13.441	6	1.030	0.736	99.264
7	0.120	85.648	14.352	7	1.185	0.739	99.261
8	0.127	85.349	14.651	8	1.330	0.731	99.269
9	0.133	85.512	14.488	9	1.466	0.718	99.282
10	0.139	85.987	14.013	10	1.592	0.700	99.300

Cholesky Ordering: LGDP LCPI

This implies that inflation indeed affects output both in short and long-run confirming the results in the cointegration equation. Our interest however is to see how the forecast-error variances are distributed between inflation and output. Column six reports the FEVD for the response of inflation to shocks in the output. In the first step, about 0.15% of the foreacst-error variance is attributed to the error in output equation. At four steps ahead, only 0.675% of the forecast-error variance is attributed to the error in the output equation whilst 97.5% is attributed to the error in the inflation equation. At ten steps, only 0.7% of the forecast-error variance is attributed to the error in the output equation whilst 99% is attributed to the error in the inflation equation. The results indicate that the error variance in inflation forecast is almost entirely due to uncertainty in the inflation equation. This is evidence that variance in the output forecast is attributed to uncertainty in inflation uncertainty. These results support the Granger causality test which shows that past values of inflation are significant in predicting output. However, it should be noted that forecast error variance decomposition and Granger causality are two different concepts and can therefore not be compared. Granger causality is a uniquely defined property of two subsets of variables of a given process while the forecast error variance decomposition is not uniquely defined over the same subset (Lutkepohl, 2005). The results indicate that previous values of inflation are important in explaining output albeit small. In spite of the smaller impact though, it remains important to monitor inflation as it affects output for the economy.

Chapter 5: Conclusions and Policy Recommendations

5.1 Introduction

This chapter summarises the main findings of this study and highlights the policy recommendations. The chapter concludes with the presentation of some limitations to the study and suggestions for further research in this area.

5.2 Findings, Conclusion and Policy Recommendations

This study set out to assess the effects of inflation on output in Zambia. Specifically, the study sought to: (i) Establish the direction of causality, if any, between output and inflation; (ii) Establish whether there is a short-run or long-run relationship between output and inflation and (iii) Establish the nature of the response of output and inflation to changes within the system. The objectives have been met based on the results which indicate that (i) there is a cointegrating relationship between inflation and output in Zambia, (ii) for a 1% increase in inflation, the average value of output growth decreases by 5.4% and (iii) a unidirectional causality running from inflation to output. On the basis of empirical evidence presented here, policy makers need to monitor and control inflation because of its negative effect on output. It is also important for monetary authorities to understand the composition of inflation in terms of food and non-food inflationary causes so that policy is directed at capturing the sources of the inflation.

In the attempt to achieve the objectives, this study conducts an assessment of the long and short-run effects of inflation on output in Zambia over the period 1964-2015 using a bivariate VEC and cointegration test. The study utilizes inflation (CPI) and output (real GDP). In addition, the study uses Granger causality tests to evaluate the magnitude and direction of causal relationships between inflation and output in Zambia. Owing to the data span used, we carried out a structural stability test to assess if data used in the model suffers from structural breaks. The results indicate that parameters have been constant for the period under study. Unit roots tests have revealed that the data series is difference stationary of order one. The results indicate that there is no positive long-run relationship between output and inflation and that inflation affects output negatively.

This result is in line with the evidence found in other countries for instance; Khan and Senhadji (2000), Hodge (2006), Bittencourt, van Eyden and Seleteng (2015), Samimi and Kenari (2015), Chibwe (2014) and Thanh (2015). However, this is against evidence in Mallik and Chowdhury (2001), Umaru and Zubairu (2012), Osuala, Osuala and Onyeike (2013) and Phiri (2013) who find a positive relationship between inflation and output growth. Cointegration test was also conducted and results show that, for the period under study, there is a cointegrating relationship between inflation and output in Zambia. This necessitated the use of VEC model. Results from the VEC model shows that the coefficient of the error correction mechanism is significant implying the possibility of inflation and output convergence to equilibrium level in the long-run. This causal relationship finds a significant coefficient of speed of adjustment to restore long-run equilibrium. The error correcting term reflecting the disequilibrium output indicates a slow speed of adjustment whereby about 2.2% of a disequilibrium value of the output is removed every year. The results further indicate that inflation does granger cause output implying that there is unidirectional causality running from inflation to output. The responsiveness of output to inflation changes shows that output decreases by 5.4% for a 1% change in inflation. This confirms that negative effect that inflation has on output in Zambia. A key finding of our study is that past values of inflation help in predicting future output trajectory.

5.3 Recommendations for further studies

This study attempts to address a number of issues regarding the relationship between inflation and output. There is a plethora of literature on the relationship between inflation and output using different methods. This therefore entails a single study cannot address all the challenges associated with estimation and analysis of the relationship between inflation and output. Therefore, it is worth suggesting some of these areas that need further study to add to literature on this area.

One of the limitations of this study has been lack of data on gross fixed investments and labour productivity to enable a full study of the relationship between inflation and output in the wider economy. Whilst the bivariate studies are common in this kind of research, the recommendation is that future studies include more variables to improve the analysis. It is also worthwhile to use non-linear models to assess the threshold level of inflation on output and the other variables. In addition, it is also recommended that future studies consider using granger non-causality and non-linear VEC to ascertain the causality and the short and long-run relationship between inflation and output.

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Appendices

Appendix 1: Unit Root Tests

LCPI Lvls

Null Hypothesis: LCPI has a unit root

Exogenous: None

Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.084374	0.2482
Test critical values:	1% level	-2.613010	
	5% level	-1.947665	
	10% level	-1.612573	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LCPI)

Method: Least Squares

Date: 06/08/17 Time: 08:26

Sample (adjusted): 1967 2015

Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCPI(-1)	-0.005783	0.005333	-1.084374	0.2837
D(LCPI(-1))	0.866650	0.071051	12.19763	0.0000

R-squared	0.567250	Mean dependent var	0.228259
Adjusted R-squared	0.558043	S.D. dependent var	0.252539
S.E. of regression	0.167887	Akaike info criterion	-0.691086
Sum squared resid	1.324752	Schwarz criterion	-0.613869
Log likelihood	18.93160	Hannan-Quinn criter.	-0.661790
Durbin-Watson stat	2.704147		

Null Hypothesis: LCPI has a unit root
Exogenous: Constant

Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.680527	0.8420
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LCPI)
Method: Least Squares
Date: 06/17/17 Time: 14:06
Sample (adjusted): 1967 2015
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCPI(-1)	-0.003694	0.005428	-0.680527	0.4996
D(LCPI(-1))	0.768162	0.094780	8.104728	0.0000
C	0.050656	0.032848	1.542117	0.1299

R-squared	0.588523	Mean dependent var	0.228259
Adjusted R-squared	0.570632	S.D. dependent var	0.252539
S.E. of regression	0.165479	Akaike info criterion	-0.700676
Sum squared resid	1.259631	Schwarz criterion	-0.584850
Log likelihood	20.16655	Hannan-Quinn criter.	-0.656732
F-statistic	32.89617	Durbin-Watson stat	2.567948
Prob(F-statistic)	0.000000		

LCPI Diff

Null Hypothesis: D(LCPI) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.809765	0.0672
Test critical values:	1% level	-2.613010	
	5% level	-1.947665	
	10% level	-1.612573	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LCPI,2)
Method: Least Squares

Date: 06/08/17 Time: 08:24
Sample (adjusted): 1967 2015
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCPI(-1))	-0.128572	0.071044	-1.809765	0.0766

R-squared	0.063754	Mean dependent var	0.001964
Adjusted R-squared	0.063754	S.D. dependent var	0.173827
S.E. of regression	0.168195	Akaike info criterion	-0.707191
Sum squared resid	1.357895	Schwarz criterion	-0.668583
Log likelihood	18.32619	Hannan-Quinn criter.	-0.692543
Durbin-Watson stat	2.662681		

Null Hypothesis: D(LCPI) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.564609	0.1072
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LCPI,2)
Method: Least Squares
Date: 06/17/17 Time: 14:17
Sample (adjusted): 1967 2015
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCPI(-1))	-0.239822	0.093512	-2.564609	0.0136
C	0.056234	0.031627	1.778051	0.0819

R-squared	0.122761	Mean dependent var	0.001964
Adjusted R-squared	0.104097	S.D. dependent var	0.173827
S.E. of regression	0.164531	Akaike info criterion	-0.731475
Sum squared resid	1.272312	Schwarz criterion	-0.654257
Log likelihood	19.92113	Hannan-Quinn criter.	-0.702178
F-statistic	6.577220	Durbin-Watson stat	2.528156
Prob(F-statistic)	0.013584		

LGDP Lvls

Null Hypothesis: LGDP has a unit root

Exogenous: None

Lag Length: 2 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.149515	0.9916
Test critical values:	1% level	-2.613010	
	5% level	-1.947665	
	10% level	-1.612573	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LGDP)

Method: Least Squares

Date: 06/08/17 Time: 08:34

Sample (adjusted): 1967 2015

Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP(-1)	0.001775	0.000826	2.149515	0.0369
D(LGDP(-1))	0.231930	0.141083	1.643928	0.1070
D(LGDP(-2))	0.175866	0.136995	1.283741	0.2057

R-squared	0.144694	Mean dependent var	0.030933
Adjusted R-squared	0.107507	S.D. dependent var	0.045947
S.E. of regression	0.043407	Akaike info criterion	-3.377121
Sum squared resid	0.086672	Schwarz criterion	-3.261295
Log likelihood	85.73946	Hannan-Quinn criter.	-3.333177
Durbin-Watson stat	2.051483		

Null Hypothesis: LGDP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.488046	0.9991
Test critical values:	1% level	-3.565430	
	5% level	-2.919952	
	10% level	-2.597905	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDP)
Method: Least Squares
Date: 06/17/17 Time: 14:25
Sample (adjusted): 1965 2015
Included observations: 51 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGDP(-1)	0.025382	0.017057	1.488046	0.1431
C	-0.216939	0.169157	-1.282472	0.2057

R-squared	0.043236	Mean dependent var	0.034576
Adjusted R-squared	0.023710	S.D. dependent var	0.048582
S.E. of regression	0.048003	Akaike info criterion	-3.196681
Sum squared resid	0.112910	Schwarz criterion	-3.120923
Log likelihood	83.51536	Hannan-Quinn criter.	-3.167731
F-statistic	2.214282	Durbin-Watson stat	1.310721
Prob(F-statistic)	0.143146		

LGDP Diff

Null Hypothesis: D(LGDP) has a unit root
Exogenous: None
Lag Length: 3 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.096966	0.0358
Test critical values:	1% level	-2.615093	
	5% level	-1.947975	
	10% level	-1.612408	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDP,2)
Method: Least Squares
Date: 06/08/17 Time: 08:38
Sample (adjusted): 1969 2015
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.

D(LGDP(-1))	-0.302804	0.144401	-2.096966	0.0419
D(LGDP(-1),2)	-0.413634	0.153503	-2.694640	0.0100
D(LGDP(-2),2)	-0.253693	0.153281	-1.655086	0.1052
D(LGDP(-3),2)	-0.287473	0.131524	-2.185705	0.0343

R-squared	0.402203	Mean dependent var	-7.20E-05
Adjusted R-squared	0.360497	S.D. dependent var	0.053044
S.E. of regression	0.042419	Akaike info criterion	-3.401170
Sum squared resid	0.077373	Schwarz criterion	-3.243710
Log likelihood	83.92749	Hannan-Quinn criter.	-3.341917
Durbin-Watson stat	1.877933		

Null Hypothesis: D(LGDP) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.646857	0.0911
Test critical values:	1% level	-3.577723	
	5% level	-2.925169	
	10% level	-2.600658	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LGDP,2)
Method: Least Squares
Date: 06/17/17 Time: 14:28
Sample (adjusted): 1969 2015
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGDP(-1))	-0.529407	0.200014	-2.646857	0.0114
D(LGDP(-1),2)	-0.264491	0.177045	-1.493919	0.1427
D(LGDP(-2),2)	-0.153664	0.162905	-0.943270	0.3509
D(LGDP(-3),2)	-0.230061	0.134022	-1.716589	0.0934
C	0.013812	0.008597	1.606617	0.1156

R-squared	0.436815	Mean dependent var	-7.20E-05
Adjusted R-squared	0.383179	S.D. dependent var	0.053044
S.E. of regression	0.041660	Akaike info criterion	-3.418259
Sum squared resid	0.072894	Schwarz criterion	-3.221435
Log likelihood	85.32910	Hannan-Quinn criter.	-3.344193
F-statistic	8.143977	Durbin-Watson stat	1.809256
Prob(F-statistic)	0.000059		

Appendix 2: Johansen Cointegration Test

Summary Option 6

Date: 06/18/17 Time: 14:52
Sample: 1964 2015
Included observations: 48
Series: LGDP LCPI
Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

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	1	1	1	0
Max-Eig	2	1	1	1	0

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

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	105.5779	105.5779	110.6967	110.6967	122.2610
1	122.0827	122.7487	124.9670	124.9728	127.2666
2	124.1741	125.3266	125.3266	128.3717	128.3717
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	-4.065746	-4.065746	-4.195695	-4.195695	-4.594208
1	-4.586778	-4.572861	-4.623623	-4.582202	-4.636108*
2	-4.507256	-4.471943	-4.471943	-4.515488	-4.515488
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	-3.753879	-3.753879	-3.805862	-3.805862	-4.126408*
1	-4.118978	-4.066077	-4.077856	-3.997451	-4.012375
2	-3.883522	-3.770243	-3.770243	-3.735821	-3.735821

Appendix 3: Johansen Cointegration Test: Selected Model

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.330739	22.18158	20.26184	0.0269
At most 1	0.049820	2.504062	9.164546	0.6767

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

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.330739	19.67751	15.89210	0.0121
At most 1	0.049820	2.504062	9.164546	0.6767

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

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LGDP	LCPI	C
-0.858393	0.215018	10.41439
0.538868	-0.228317	-4.966119

Unrestricted Adjustment Coefficients (alpha):

D(LGDP)	0.025697	-0.002378
D(LCPI)	0.026476	0.035607

1 Cointegrating Equation(s): Log likelihood 109.7646

Normalized cointegrating coefficients (standard error in parentheses)

LGDP	LCPI	C
1.000000	-0.250489	-12.13243
	(0.06094)	(0.45186)

Adjustment coefficients (standard error in parentheses)

D(LGDP)	-0.022058
	(0.00482)
D(LCPI)	-0.022727
	(0.02075)

Appendix 4: Vector Error Correction Estimates (model 1, lag 1 1)

Date: 06/18/17 Time: 17:49
Sample (adjusted): 1967 2015
Included observations: 49 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
LGDP(-1)	1.000000	
LCPI(-1)	-0.263248	
	(0.06124)	
	[-4.29862]	
C	-10.20484	
Error Correction:	D(LGDP)	D(LCPI)
CointEq1	-0.022969	0.012909
	(0.00711)	(0.02996)
	[-3.22903]	[0.43092]
D(LGDP(-1))	0.106911	-0.261517
	(0.13257)	(0.55830)
	[0.80645]	[-0.46842]
D(LCPI(-1))	-0.061421	0.756323
	(0.02489)	(0.10483)
	[-2.46736]	[7.21446]
C	0.041317	0.065706
	(0.01004)	(0.04230)
	[4.11362]	[1.55340]
R-squared	0.301742	0.590069
Adj. R-squared	0.255192	0.562740
Sum sq. resids	0.070757	1.254899
S.E. equation	0.039653	0.166993
F-statistic	6.482038	21.59149
Log likelihood	90.70981	20.25877
Akaike AIC	-3.539176	-0.663623
Schwarz SC	-3.384742	-0.509189
Mean dependent	0.030933	0.228259
S.D. dependent	0.045947	0.252539
Determinant resid covariance (dof adj.)		4.38E-05
Determinant resid covariance		3.69E-05
Log likelihood		111.0061
Akaike information criterion		-4.122698
Schwarz criterion		-3.736613

Appendix 5: Estimated Equation

Dependent Variable: D(LGDP)
Method: Least Squares
Date: 06/18/17 Time: 18:39
Sample (adjusted): 1967 2015
Included observations: 49 after adjustments
D(LGDP) = C(1)*(LGDP(-1) - 0.263248293176*LCPI(-1) - 10.2048433507)
+ C(2)*D(LGDP(-1)) + C(3)*D(LCPI(-1)) + C(4)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.022969	0.007113	-3.229026	0.0023
C(2)	0.106911	0.132570	0.806446	0.4242
C(3)	-0.061421	0.024893	-2.467363	0.0175
C(4)	0.041317	0.010044	4.113615	0.0002

R-squared	0.301742	Mean dependent var	0.030933
Adjusted R-squared	0.255192	S.D. dependent var	0.045947
S.E. of regression	0.039653	Akaike info criterion	-3.539176
Sum squared resid	0.070757	Schwarz criterion	-3.384742
Log likelihood	90.70981	Hannan-Quinn criter.	-3.480584
F-statistic	6.482038	Durbin-Watson stat	2.301864
Prob(F-statistic)	0.000968		

Appendix 6: VEC Residual Normality Tests

Orthogonalization: Cholesky (Lutkepohl)

Null Hypothesis: residuals are multivariate normal

Date: 06/18/17 Time: 21:41

Sample: 1964 2015

Included observations: 49

Component	Skewness	Chi-sq	df	Prob.
1	-0.101498	0.084132	1	0.7718
2	0.169010	0.233275	1	0.6291
Joint		0.317407	2	0.8532

Component	Kurtosis	Chi-sq	df	Prob.
1	5.602447	13.82766	1	0.0002

2	4.405748	4.034593	1	0.0446
Joint		17.86226	2	0.0001

Component	Jarque-Bera	df	Prob.
1	13.91179	2	0.0010
2	4.267868	2	0.1184
Joint	18.17966	4	0.0011

Appendix 7: VEC Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Date: 06/18/17 Time: 21:56

Sample: 1964 2015

Included observations: 48

Lags	LM-Stat	Prob
1	3.756883	0.4399

Probs from chi-square with 4 df.

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 06/18/17 Time: 22:27
Sample: 1964 2015
Included observations: 49

Dependent variable: D(LGDP)

Excluded	Chi-sq	df	Prob.
D(LCPI)	6.087880	1	0.0136
All	6.087880	1	0.0136

Dependent variable: D(LCPI)

Excluded	Chi-sq	df	Prob.
D(LGDP)	0.219417	1	0.6395
All	0.219417	1	0.6395

Appendix 8: Output elasticity

Dependent Variable: DLGDP
Method: Least Squares
Date: 06/18/17 Time: 23:00
Sample (adjusted): 1966 2015
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.044972	0.008761	5.133032	0.0000
DLCPI	-0.053816	0.026146	-2.058245	0.0450

R-squared	0.081100	Mean dependent var	0.032934
Adjusted R-squared	0.061956	S.D. dependent var	0.047626
S.E. of regression	0.046127	Akaike info criterion	-3.275671
Sum squared resid	0.102128	Schwarz criterion	-3.199190
Log likelihood	83.89177	Hannan-Quinn criter.	-3.246546
F-statistic	4.236373	Durbin-Watson stat	1.449751
Prob(F-statistic)	0.045018		

Appendix 9: Impulse Response

Response of LGDP:

Period	LGDP	LCPI
1	0.039653	0.000000
2	0.043344	-0.009240
3	0.043521	-0.015964
4	0.043049	-0.019881
5	0.042259	-0.021540
6	0.041249	-0.021446
7	0.040086	-0.020013
8	0.038819	-0.017576
9	0.037488	-0.014400
10	0.036125	-0.010697

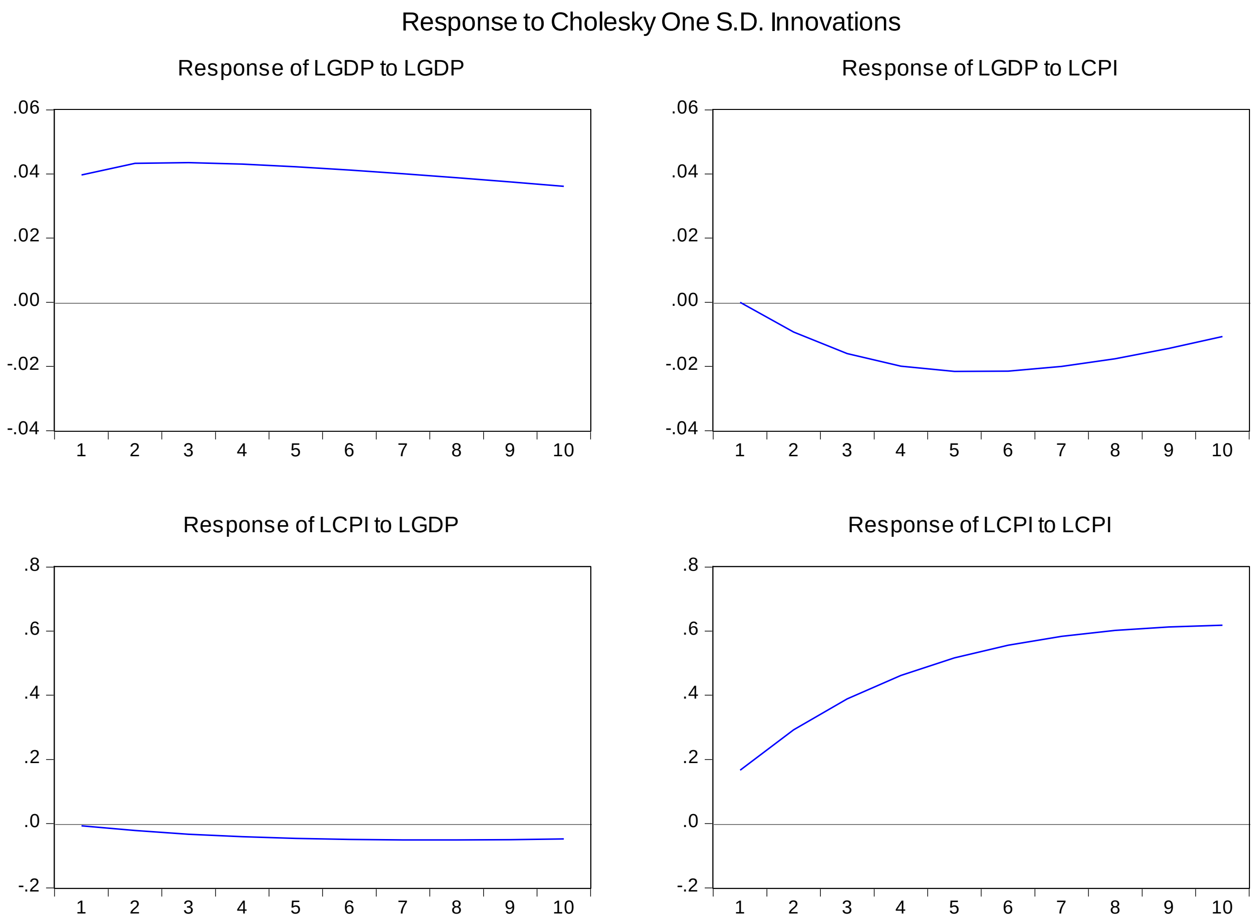
Response of LCPI:

Period	LGDP	LCPI

1	-0.006533	0.166865
2	-0.021311	0.292502
3	-0.032820	0.388827
4	-0.040899	0.461911
5	-0.046190	0.516385
6	-0.049283	0.555985
7	-0.050658	0.583745
8	-0.050705	0.602123
9	-0.049735	0.613113
10	-0.048001	0.618325

Cholesky Ordering:
LGDP LCPI

Appendix 10: Impulse Response graph



Appendix 11: Variance Decomposition

Variance Decomposition of LGDP: Period	S.E.	LGDP	LCPI
1	0.039653	100.0000	0.000000
2	0.059468	97.58573	2.414271
3	0.075402	94.01583	5.984169
4	0.089073	90.72975	9.270248
5	0.100914	88.22190	11.77810
6	0.111109	86.55861	13.44139
7	0.119802	85.64790	14.35210
8	0.127155	85.34914	14.65086
9	0.133346	85.51180	14.48820
10	0.138566	85.98688	14.01312
Variance Decomposition of LCPI: Period	S.E.	LGDP	LCPI
1	0.166993	0.153071	99.84693
2	0.337488	0.436213	99.56379
3	0.515909	0.591377	99.40862
4	0.693683	0.674717	99.32528
5	0.866016	0.717382	99.28262
6	1.030306	0.735642	99.26436
7	1.185266	0.738534	99.26147
8	1.330405	0.731438	99.26856
9	1.465729	0.717751	99.28225
10	1.591537	0.699724	99.30028
Cholesky Ordering: LGDP LCPI			

Appendix 12: qll Stability Test

Elliott-Muller qLL test statistic for time varying coefficients
in the model of d.rgdp inf, 1965 - 2015
Allowing for time variation in 1 regressors
H0: all regression coefficients fixed over the sample period (N = 50)

Test stat.	*1% Crit.Val.*	*5% Crit.Val.*	*10% Crit.Val.*
-3.781	*-11.05*	*-8.36*	*-7.14*