MONETARY POLICY AND INFLATION DYNAMICS IN GHANA

By

BORTEY, Isaac Newton

THESIS

Submitted to
KDI School of Public Policy and Management
in partial fulfillment of the requirements
for the degree of

MASTER OF DEVELOPMENT POLICY

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ABSTRACT

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By

BORTEY, ISAAC NEWTON

The study sought to explore the relationship that exists between monetary policy and inflation in Ghana by examining the extent to which inflationary pressures can be attributable to monetary policies. Stylized facts and data on the Ghanaian economy show that, money supply and inflation has shared a similar trend for most years. Quarterly data ranging from 1990q1 – 2013q4 on money supply, CPI and other determinants of inflation were used in the study. Employing impulse response function and variance decomposition in a VAR and VECM model, the paper found the existence of a long-run relationship between inflation and the other variables, also the variations in inflation is the results of money supply, the nominal exchange rate, and shocks to inflation itself. The empirical findings also show that response of inflation to a shock persists for over two years (six quarters), with the adjustment from disequilibrium fairly slow.

Dedicated to; Mary Okai, Moses Bortier and Love Tagoe.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Stemming from the global financial crises, the conduct of monetary policy, a facet of central banking has been at the center of most economic debates. The crises challenged the status-quo in conducting monetary policy, mandating for the use of unconventional policies. Some Economists have argued on how inappropriate monetary policies can affect one of the intractable macroeconomic variables – Inflation.

The often-quoted mantra of monetarists led by Milton Friedman is that "Inflation is always and everywhere a monetary phenomenon". This school of thought argues that excessive supply of money in an economy creates an upward pressure on price levels. Inflation is all about continuous increase in price levels, which cannot be sustained if there is no corresponding increase in the money supply. It is in this regard that inflation becomes a monetary phenomenon. This idea places one of the key macroeconomic variables - inflation in the hands of central banks. The experiences of chronic and hyper-inflation have tendencies of undermining the macroeconomic progress of a country leading to a wide agreement on the major primary goal of monetary policy – price stability. Besides achieving low inflation rates or price stability, monetary policy also aim at high growth rates, high employment, and financial stability. Bernanke, etal (2001), holds that, most macroeconomists agree that in the long run, targeting low inflation rates is the only macroeconomic variable that can be achieved or influenced by monetary policy.

The Bank of Ghana Act 612 (2002) granted the independence of the central bank (Bank of Ghana (BoG)) and mandated it to achieve stable prices (low inflation) as its primary objective through the conduct of monetary policies. Despite the legislation, the country has and is

experiencing volatility in price levels, with inflation above its targets. The country has recorded high double-digit inflation for many years with brief period of single digits in 2012. The rising price level is largely attributed to many factors including monetary growth and fiscal deficit financing. Opoku-Afari, (2005) reckons that, monetary operations in an economy such as Ghana is quite complicated given the relatively shallow financial markets coupled with a history of endemic inflation and inflationary expectations which have been factored into all aspects of economic activity in Ghana. Although stable prices and a likely expectation to remain so, helps limit distortions of other market variables (such as prices of goods and services, labor market decisions) serves as a good basis for economic growth, the conduct of monetary policy faces trade-off between short and longer term goals as well as controlling other macroeconomic situations.

1.1 Statement of the problem

Given the effects of rising price levels on the Ghanaian economy, it has become imperative to find the causes and determinants of inflation in the country. Critics of monetary policy have argued that the excessive growth in money supply is the main driver for the persistent high inflation. Even though economic theory is in support of such argument, the interconnectedness of macroeconomic variables and the unpredictability of monetary policy outcome imply that the argument of money supply being the major cause of inflation should be taken with a grain of salt.

1.2 Justification of the study

In this study, the paper explores the relationship between inflation and other macroeconomic variables such as money supply, interest rate and the exchange rate. Knowledge of how these variables impact inflation in Ghana will be of relevance for the further conduct of monetary

policy of the central bank in achieving their mandate of price stability. Clearly, the monetarists assertion of the relevance of monetary aggregates in a bid to control inflation is an empirical one, hence the need for the study.

1.3 Objective of the study

The study seeks to delve into the relationship between the central banks money supply and its attendant effects on price level. Nonetheless the impact of other macroeconomic factors that can influence inflation will be included in the study. Based on the preceding objective, the following research question will help in establishing the empirical facts:

- Does changes in money supply leads to variations in inflation?
- Does inflation respond to shocks in money supply as well as other macroeconomic variables (exchange rate, interest rate, oil prices)?
- Is there any causality between money supply and inflation in Ghana?

1.4 Organization of the study

The study is organized in six sections. The first section gives a background of monetary policy and inflation arguments in the field of economics. Section two provides an overview of monetary policy and inflation performance in Ghana. In section three, the study presents findings on previous studies and a theoretical framework of inflation determinants in Ghana. Section four considers the data used in the study as well as the econometric technique that will be employed. In sections five and six, the study presents and discusses its findings from the econometric estimations, and draws a conclusion respectively.

2. OVERVIEW OF MONETARY POLICY AND INFLATION IN GHANA

2.1 Monetary Policy Setting in Ghana

Monetary policy is a dynamic process and occasionally adjusted to reflect prevailing macroeconomic conditions. The conduct of monetary policy in Ghana has been through three distinct phases – the control regime, monetary targeting and inflation targeting. Prior to 1983, the Bank of Ghana operated largely by a direct control of monetary management. Under this system, prices, exchange rates, commercial banks' lending rate were all controlled to be consistent with national macroeconomic targets such as growth, inflation and external balance. Due to the ineffectiveness of the system it was abolished in early 1983. Under the regime of monetary targeting, the main task of the central bank, was to target its reserve money. The Open Market Operation (OMO) tool, was adopted as the instrument to achieve the target money supply. Operational difficulties which included excessive liquidity in the economy and the use of OMO to raise revenue for budget financing, made the relationship between money supply and price level highly insurmountable. Kwakye (2012), reckons that, over the era of monetary targeting, monetary growth rates has usually been higher than inflation rates, presumably due to growing money demand amid the structural changes in the economy. According to Narh (2014), decades of changes in economic structure and reforms had impacted on the income velocity. The unstable nature of velocity made it difficult to control the demand for money function. This argument is consistent with the Quantity Theory of Money (QTM), which assumes a constant velocity in order to predict or monitor money growth:

$$MV = PQ \quad (1)$$

Where M = Money growth, V = velocity, P = general price level and Q = output in the economy.

In terms of growth rates: $\Delta M + \Delta V = \Delta P + \Delta Q$ (2)

Assuming a constant velocity, then the growth in money supply can be measured as:

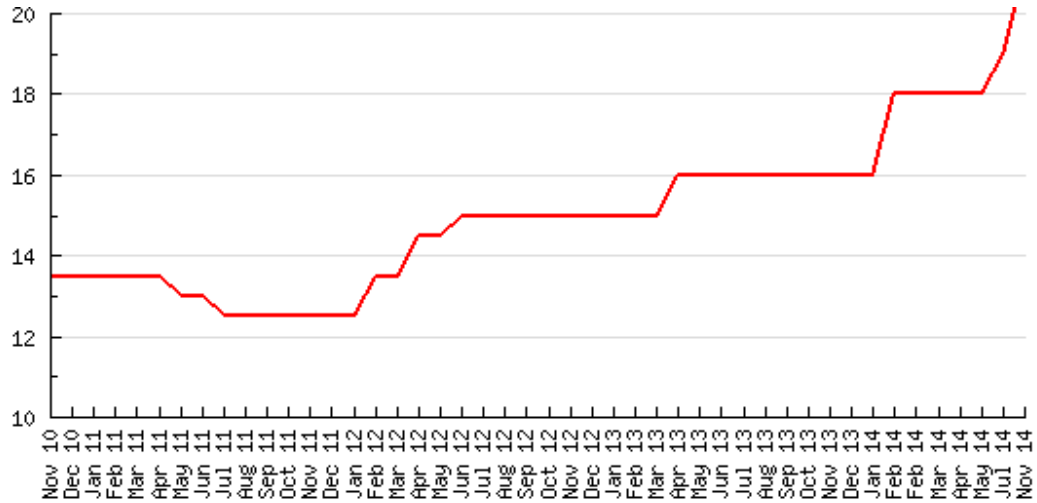
$\Delta M = \Delta P + \Delta Q$ (3)

In the situation of Ghana, where the velocity of money was unstable equation (2) will not hold making it difficult to target monetary aggregates. The difficulty in controlling the money demand function made money growth insignificant in explaining inflation fluctuation in the economy. This implies that focus on money growth alone was not sufficient to predict future inflation and real output.

Following the challenges of monetary aggregates targeting, the Bank of Ghana in 2007 effectively began the Inflation targeting (IT) framework, under which it seeks to achieve an explicit quantitative target range for inflation which is deemed appropriate for the economy within a specified time horizon. With regards to the right price index to use, the BoG uses the CPI all price index, but also monitors core inflation at different levels. Regarding the choice of monetary policy instrument, the monetary policy rate (MPR), which serves as the basis for all other interest rates in the country is used. The choice of using the interest rate (MPR) as a reliable tool under inflation targeting, may be informed by the famous Taylor's Rule, which posits that, in the conduct of monetary policy, policy-makers should adjust the interest rate to respond to development in inflation rates. The fig.1 below, presents a pictorial view on how the MPR has been on a persistent rise since the last month of 2011. The high MPR is an indication of how monetary policy has affected the cost of borrowing in the economy. Given that the interest rate channel is one of the main transmission mechanisms of monetary policy, frequent increase in the MPR can be detrimental to economic growth. Also the high MPR which is geared towards

reducing inflationary pressure explains the difficulty encountered by the BoG in achieving its range of inflation target. It is worth noting that, the BoG has often missed the target rates for most periods, as shown in table1.

Fig 1. Trend of Monetary Policy Rate



Source: Bank of Ghana.

Table1. Inflation targets and Actual performance (% / Year)

	2009	2010	2011	2012	2013	2014
Target	12.5	9.2	8.5	8.5	9.0	9.5
Actual	16.0	8.5	8.6	8.8	13.5	16.5

Source: Target; Government Budget statement, Actual; Bank of Ghana

2.2 Inflation Performance in Ghana

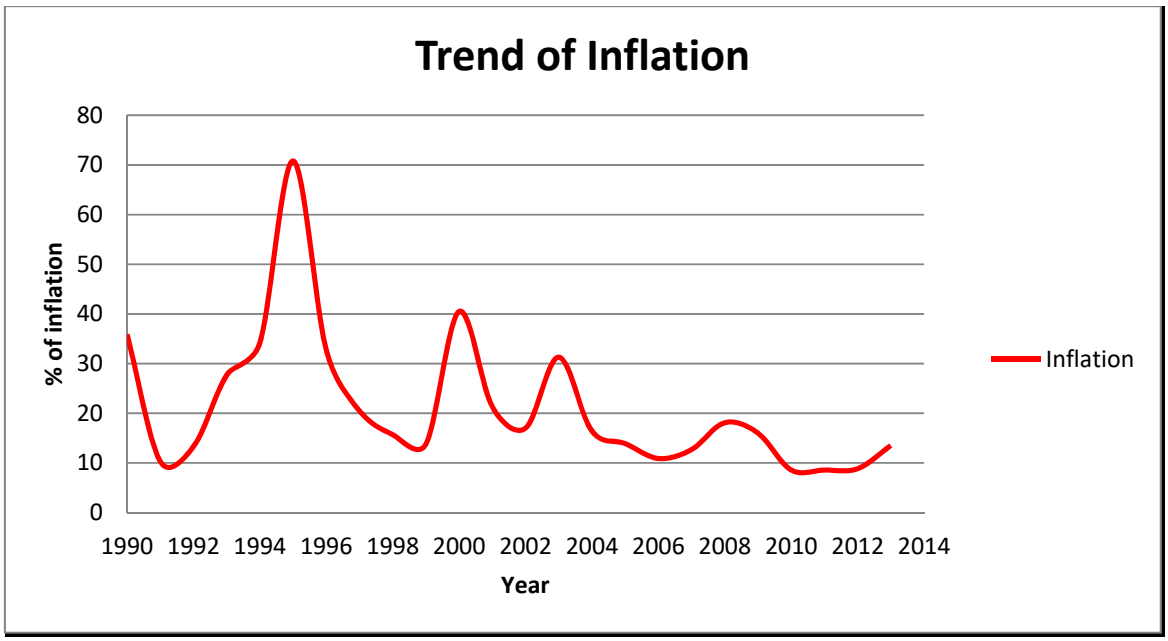
Amidst the adoption of various monetary policy regimes in Ghana, inflation has not been stable and remains volatile for a number of years. Ocran (2007), identified five distinct episodes of inflation in Ghana. The period immediately after independence, this period recorded relatively

low inflation rate averaging 8% per year. The period between 1964 and 1966 which saw inflation rose to 23% per year. Then followed the first IMF sponsored stabilization program, which came with a devaluation policy in order to control inflation. Even though the devaluation policy reduced price levels below the 1966 period there was an attendant economic decline. The fourth episode (1972 – 1982) which was characterized mainly by political instability, recorded a mix of low and high inflation rates. Finally, there was a second stabilization program by the IMF (Economic Recovery Program (ERP-1983)) which in tandem with high agricultural production helped reduce inflation from 123% to 40%.

Fig 2 below shows that for most recent years, annual inflation has remained above 10 percent, with single-digits only between 2010-2012. The single-digit inflation was arguable achieved through a drop in food inflation and provision of subsidies to fuel and other utilities that are weighted in the CPI (Consumer Price Index) basket. Within the range of years (1990 – 2014), inflation peaked in 1995 recording an annual rate of 70.8 percent. This can be due to spill-over from the late 1980's food shortage in the country. Generally, inflation was higher in the 1990's than the 2000's, recording an average rate of 24.49 percent and 16.97 percent respectively. It can be argued that tight monetary policies in terms of high policy rates in the 2000's have accounted for the relatively low rates.

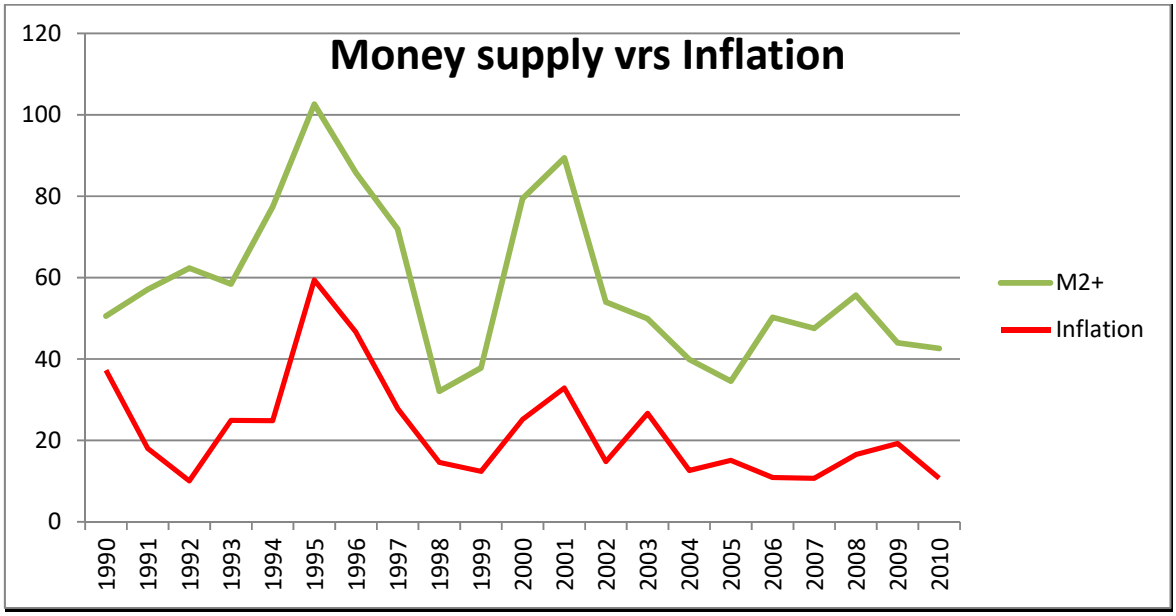
In fig3, the graphical view between inflation and the money supply measured by M2+, shows that, the two variables follow a similar trend for most years. In the mid 1990's where money supply tend to be high, the economy experienced higher rates of inflation, whiles the decline in money supply in the 2000's saw inflation recording lower rates.

Fig2



Source: Author's plot from BoG data.

Fig3.



Source: Author's plot from BoG data.

2.3 Composition and Structure of Ghana's CPI

CPI measures the cost of a basket of goods and services in a given period relative to the cost of the same basket of goods and services in a reference base year. The CPI in Ghana consists of 242 items with a reference base year of 2012. The CPI basket has two broad groups; food & non-alcoholic beverages and non-food. The components of the main groups and their respective weight are presented in Table 2. Non-food items make-up the largest weight in the CPI suggesting that shocks to these components have greater effect on the consumer price index. On individual item basis, agricultural produce (vegetables and others) has the largest weight in the basket. This implies that factors such as cost of agricultural inputs, cost of transport from farmland to markets, climatic conditions (mainly rainfall) that have bearing on agricultural production can cause major movements in the CPI. Precisely, in periods of poor harvest, scarcity of agricultural produce will cause a jump in domestic price levels. Given the low production capacity of the economy, clothing and footwear which also has a large weight are mainly imported finished products, hence volatility in foreign prices can cause movements in the CPI.

Table2. Consumer Price Index Market Basket

Major group & components	**Weight**	**Number of items**
Combined (Food and non-food)	**100**	**242**
Food & Non-alcoholic beverages	**44.91**	**76**
Bread & Cereals	7.97	9
Meat	4.07	10
Fish	10.24	7
Milk, Cheese ,egg	1.69	3
Oil & Fat	2.48	7
Fruits	2.12	8

Vegetables Inc. Potatoes Others.	12.46	18
Sugar, jam, honey, syrups, chocolate and confectionary	1.17	3
Food products n.e.c	1.06	3
Coffee, tea and cocoa	0.69	4
Mineral waters, soft drinks and juices	0.95	4
Non - Food	**55.09**	**166**
Alcoholic beverages, tobacco and narcotic	2.23	11
Clothing and footwear	11.29	59
Housing, water, electricity, gas and other	6.98	10
Furnishings, household equipment etc.	7.83	43
Health	4.33	9
Transport	6.21	9
Communications	0.31	3
Recreation and culture	3.04	6
Education	1.60	2
Hotels, cafés and restaurants	8.28	7
Miscellaneous goods and services	2.99	7

Source: Ghana Statistical Service (GSS).

3. EMPIRICAL OVERVIEW AND THEORETICAL FRAMEWORK.

3.1 Empirical Review

The linkage between monetary aggregates and inflation has generated much interest in monetary economics, regarding whether monetary policies have significant effect on a country's inflation level. The previous works showed different findings based on the economy under study, period of study as well as the choice of monetary aggregates used.

Bawumia and Abradu-Otto (2003),used an Error Correction analysis to study money growth (M2+), exchange rate and inflation in Ghana. Their paper found the existence of a long-run relationship between inflation, money supply, exchange rate and real income. Their results also show that money supply in Ghana exhibits a seasonal pattern. They recommended policies to reduce the growth of money supply. Sowah and Kwakye (1993), studied inflationary trends in Ghana by dividing the time period into the pre-ERP (Economic Recovery Program) and post-ERP. Employing M2 as the main monetary aggregate, their study found that inflation in Ghana is a result of both real and monetary shocks to the economy, but monetary shock had a relatively limited influence as compared to supply factors. In another study by Kovanen (2011), to find out if money matters for inflation in Ghana, the paper confirmed the findings of Sowah and Kwakye (1993) as it found a limited influence of money on future inflation, instead, the exchange rate depreciation and demand pressures were key contributors to inflation in the country. Finally, the paper recognized high inflation expectation in Ghana and called for strengthening the credibility of the central bank.

Zhang (2012), employed a multivariate dynamic models to investigate both the short-run and long-run relationship between monetary growth and inflation in China. The study revealed that

there was a bilateral causal relationship between money growth and inflation in China. This causal relationship was found through asset inflation channel.

In an attempt to find a suitable indicator variable for central banks in controlling inflation, Verheyen (2010) studied whether commodity prices can be used as an indicator for CPI inflation in conducting monetary policy. From a US data set, the study found that, there was a strong link between commodity prices and CPI inflation in the 1970's and 1980's but the relationship has weakened in recent years.

Based on evidence from UK and US data on adjusted monetary base, M2 ,Consumer Price Index (CPI), Batinni and Nelson(2002), argues that irrespective of the monetary policy arrangement in a country, effects of monetary policies on inflation in an economy becomes fully-fledged or fully noticeable after a year. Their findings attest to the existing fact that, monetary policies like all other policies comes with a lag effect, hence policymakers must have a consideration for the long-term consequences of their short-run measures when implementing their current policies.

Analyzing inflation dynamics and monetary policy in the Turkish economy, Us (2004) based on a VAR and IRF methodology, showed that relatively high inflation inertia in Turkey was due to depreciation of the Turkish Iira and increased public sector prices. The paper also found that inflation in the Turkey was not the result of monetary policies but instead fiscal dominance. The paper called for a joint action between the government and central bank to curb the situation.

Melo and Mocerro (2009), conducted a similar research in Latin American countries (Brazil, Chile, Mexico, Colombia). They employed a multiple cointegration analysis and found that there was a long-term relationship between interest rate, expected inflation and the inflation target.

They also showed that greater volatility in the monetary stance was a major factor increasing volatility of expected inflation in Brazil, Colombia and Mexico.

Bhattacharya (2013), sought to find what the drivers of inflation in Vietnam and emerging Asia economies are, as well as the role that monetary policy plays. The study found that, the key drivers of inflation in Vietnam was the movement in nominal exchange rate. Further, there was no significant relationship between inflation and money supply as measured by M2.

Considering the period of macroeconomic stability and growth in the Dominican Republic, Williams and Adedeji (2004), modeled the determinants of inflation, by employing demand for money as the key monetary aggregate. Their findings suggest that in the short-run, inflation is determined by the money demand, real income, exchange rate and foreign prices. Also their study found that disequilibrium in money market exerts significant influence on inflation.

In Nigeria, Akinbobola (2012), studied the dynamics of money supply, exchange rates and inflation. The results of the study confirm that, in the long-run, money supply and exchange rate has a significant inverse relation on inflationary pressures. The study further argues that, the negative effect of money supply may be due to shocks from supply of goods domestically and from foreign outlets.

Ayubu (2013), studied monetary policy and inflation dynamics in the Tanzanian economy using a SVAR and VECM econometric approach. The study found that inflation in Tanzania is more of an output factor than a monetary phenomenon as inflation was more sensitive to GDP growth than to money supply.

3.2 Theoretical Model of Inflation determinants in Ghana.

In modeling a simple theoretical framework of determinants of inflation in Ghana, the study will follow a previous study by Bawumia and Abradu-Otto (2003). In their paper, the general price level in the open economy of Ghana can be expressed as a weighted average of the price of tradable goods (P^T) and non – tradable goods (P^N).

$$LogP_t = \theta(logP_t^N) + (1-\theta)(logP_t^T) \quad (4)$$

Where $0< \theta < 1$.

Tradable goods includes, goods sold or imported from abroad. The prices of tradable goods are then determined on the world market and depend on the existing exchange rate (e) and foreign prices (P^f). The price of tradable goods can be represented below:

$$logP_t^T = loge_t + logP_t^f \quad (5)$$

As proposed by theory, a depreciation of the local currency and a rise in foreign prices will lead to increase in domestic prices. On the other hand, an appreciation of the local currency and a fall in foreign prices will reduce domestic prices.

The model assumes that the demand for non-tradable goods moves in line with overall demand of the economy. As such, the price of non-tradable goods is determined by the real money balances. The real money balances is determined by the equilibrium condition of the money market, where real money supply (M^s) is equal to real money demand (M^d).

$$logP_t^N = \rho(\log M^s - \log M^d) \quad (6)$$

Where ρ is the scale factor, denoting the correlation between the economy-wide demand and demand for non-tradable goods. In theory, demand for real money balances (M^d) is a function of real income (y_t), interest rate (r_t) which measures the opportunity cost of holding money, and expected inflation (π^e).

$$M^d = f(y_t, r_t, \pi^e) \quad (7)$$

If expected inflation is formed adaptively then:

$$\pi^e = \Delta \log P_{t-1} \quad (8)$$

Rearranging and substituting, we derive the inflation equation in the log-linear form below:

$$\log P_t = \log M_t^s + \log y_t + \log r_t + \log P_{t-1} + \log e_t + \log P_t^f \quad (9)$$

Due to challenges in computing the foreign prices of all tradable goods in Ghana, domestic oil prices (oil_t) which depend highly on international oil prices will be used as a proxy for foreign prices. Also, due to unavailable quarterly data on real income (y_t), the study will use cocoa prices (C^p), which contributes a high share of the country's national output. Finally, the study estimates the equation below:

$$\log P_t = \beta_o + \alpha \log M_t^s + \gamma \log C^p_t + \delta \log r_t + \chi \log P_{t-1} + \eta \log e_t + \rho \log oil_t + \varepsilon_t \quad (10)$$

In principle, an increase in money supply (M_t^s), exchange rate (e_t), expected inflation (P_{t-1}), interest rates (r_t), domestic oil prices (oil_t) will increase the domestic price level, whiles an increase in cocoa prices (C^p_t) will reduces domestic prices.

4. DATA AND METHODOLOGY.

4.1 Data

To conduct the empirical study, quarterly time series data on Ghana spanning from 1990q1 – 2013q4 was used. The data used was sourced entirely from the Bank of Ghana.

The variables used for the study includes, inflation rate measured by the overall Consumer Price Index (CPI). The overall CPI takes into account both food and non-food index, given the subsistence nature of the economy, the overall CPI will serve as a good measure of price levels. Money supply (M2), and 91-days Treasury bill which was used as a proxy for nominal interest rate, are the two key monetary policy variables used for the study. The nominal exchange rate quoted as the number of local currency to the dollar (¢ / $), domestic oil prices and cocoa prices were included in the study to capture how these variables influence inflation. Adusei and Kunst (2007), argues that in cocoa exporting countries, the price of cocoa has a strong influence on consumer price inflation. The natural logarithm of the data was taken to standardize and facilitate easy interpretation of results.

4.2 Econometric Methodology

Vector Autoregression (VAR)

Based on theoretical perspective of the relationships that exist among the variables in the study, a four equations VAR model will be used to capture how the current values of one variable are determined by their own past values and past values of other variables in the study. An advantage of VAR model is that, identification requirements in simultaneous equations are not necessary. The VAR model focuses on fitting the model to the data at the expense of theoretical consistency both from a short-run or long-run perspective (Garraatt etal, 1998). In the event that

the VAR models have one or more cointegration equations, the study will run the VECM to ascertain how each variable corrects from the short-run disequilibrium to the long-run. The study will also carry out an impulse response functions and variance decomposition to find out how each variable response to a shock from itself and other variables. In determining the appropriate lag for the test, the VAR lag-order selection statistics which computes for AIC, SHWARZ, LR was used and the lag of four was chosen.

Model :

$$LINF_t = \alpha + \sum_{j=1}^{n} \theta_j LINF_{t-j} + \sum_{i=1}^{n} \chi_i LM2_{t-i} + \sum_{l=1}^{n} \vartheta_\iota LIntRate_{t-l} + \sum_{k=1}^{n} \eta_k LExRate_{t-k} + \sum_{p=1}^{n} \delta_p LOil_{t-1} + \sum_{y=1}^{n} \varphi_y LCocoa_{t-y} + u_t$$

$$LM2_t = \alpha^r + \sum_{j=1}^{n} \theta_j LINF_{t-j} + \sum_{i=1}^{n} \chi_i LM2_{t-i} + \sum_{l=1}^{n} \vartheta_\iota LIntRate_{t-l} + \sum_{k=1}^{n} \eta_k LExRate_{t-k} + \sum_{p=1}^{n} \delta_p LOil_{t-1} + \sum_{y=1}^{n} \varphi_y LCocoa_{t-y} + u_t$$

$$LIntRate_t = \alpha^u + \sum_{j=1}^{n} \theta_j LINF_{t-j} + \sum_{i=1}^{n} \chi_i LM2_{t-i} + \sum_{l=1}^{n} \vartheta_\iota LIntRate_{t-l} + \sum_{k=1}^{n} \eta_k LExRate_{t-k} + \sum_{p=1}^{n} \delta_p LOil_{t-1} + \sum_{y=1}^{n} \varphi_y LCocoa_{t-y} + u_t$$

$$LExRate_t = \alpha^h + \sum_{j=1}^{n} \theta_j LINF_{t-j} + \sum_{i=1}^{n} \chi_i LM2_{t-i} + \sum_{l=1}^{n} \vartheta_\iota LIntRate_{t-l} + \sum_{k=1}^{n} \eta_k LExRate_{t-k} + \sum_{p=1}^{n} \delta_p LOil_{t-1} + \sum_{y=1}^{n} \varphi_y LCocoa_{t-y} + u_t$$

$$LOil_t = \alpha^g + \sum_{j=1}^{n} \theta_j LINF_{t-j} + \sum_{i=1}^{n} \chi_i LM2_{t-i} + \sum_{l=1}^{n} \vartheta_\iota LIntRate_{t-l} + \sum_{k=1}^{n} \eta_k LExRate_{t-k} + \sum_{p=1}^{n} \delta_p LOil_{t-1} + \sum_{y=1}^{n} \varphi_y LCocoa_{t-y} + u_t$$

$$LCocoa_t = \alpha^k + \sum_{j=1}^{n} \theta_j LINF_{t-j} + \sum_{i=1}^{n} \chi_i LM2_{t-i} + \sum_{l=1}^{n} \vartheta_\iota LIntRate_{t-l} + \sum_{k=1}^{n} \eta_k LExRate_{t-k} + \sum_{p=1}^{n} \delta_p LOil_{t-1} + \sum_{y=1}^{n} \varphi_y LCocoa_{t-y} + u_t$$

Where:

LINF = Log of inflation

LM1 = Log of money supply

LIntRate = Log of interest rate

LExRate = Log of nominal exchange rate.

LOil = Log of domestic oil prices

LCocoa = Log of cocoa prices

In the collection of random variables over time, a concept that requires much attention is the stationarity of the variables. Gujarati and Porter (2009), states that, broadly speaking variables are said to be stationary if the mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance between the two time periods and not the actual time at which the covariance is computed. Stationarity of the covariance is crucial in deriving constant coefficients of the model. The unit root test checks the stationarity of data in use for the study. There are various techniques to test for stationarity. The study will use the Augmented-Dickey Fuller test to test for stationarity of the variables.

The classical linear regression Model assumes that the correlation and covariance between the disturbance terms of the observation is zero. Symbolically,

$$Cov(ui,uj \mid xi,xj) = E(ui\ uj) = 0 \quad i \mid = j$$

In order to ensure that the VAR models specified above are free of autocorrelation or serial correlation for forecasting purposes, the study will use the VAR version of LM to test for serial correlation.

For purposes of carrying out an impulse response function analysis, the paper will test for the stability of the VAR model.

After testing for unit root and ensuring that the variables are integrated of the same order and free of autocorrelation, the study proceeded to check for the existence of long-run relationship among the variables in the model. The existence of any long-run relation in the system equations will necessitate carrying out a VECM. In order to test for the long run relationship, the study conducts a Johansen cointegration test to check for the cointegrating vectors in the model. This test has all desirable statistical properties but has a weakness of relying on asymptotic properties (Bo, 2008). The test is used when the variables are integrated of the same order. It follows two tests: Trace test and Max test statistics.

Finally, the paper will conduct a Granger-causality test to test if there is any causality among the variables, particularly to test if the other variables granger-cause inflation. The test is based on the premise that present and past values of variables can cause the future values of the variable under study. The structure of a VAR model provides information about a variable's or a group of variable's forecasting ability for other variables.

5. EMPIRICAL RESULTS

Table3. ADF Unit Root Test Results At 1ST Difference

VARIABLE	ADF TEST STATISTIC	PROBABILITY	CONCLUSION
LINF	-9.486	0.0000	I(1)
LM2	-13.237	0.0000	I(1)
LIntRate	-6.159	0.0000	I(1)
LExRate	-4.736	0.0001	I(1)
LOil	-9.248	0.0000	I(1)
LCocoa	-8.189	0.0000	I(1)

Source: Computed from STATA 13
NOTE: *, **, *** indicates significance at 1%, 5% and 10%. Critical values: 1% = -3.537, 5% = -2.905, 10% = -2.588

The ADF test was applied to determine the order of integration of the variables. When the test was applied to the variables at their levels, the null hypothesis of no unit root was rejected for the entire data. The non-stationary variables were differenced and the test was re-applied. Table 3 shows that the variables were all stationary after the first differencing. Therefore all variables in the model are integrated of order one (I(1)).

Table 4 Johansen Cointegration Test

HYPOTHESISED NO. OF CE (S)	EIGEN VALUE	TRACE STATISTIC	CRITCAL VALUE (5%)
None*	-	148.0235	94.15
At most 1	0.47302	98.0578	68.52
At most 2	0.37341	61.5952	47.21
At most 3	0.29456	34.3789	29.68
At most 4	0.18653	18.2757	15.41
HYPOTHESISED NO. OF CE (S)	EIGEN VALUE	MAX STATISTIC	CRITICAL VALUE (5%)

None*	-	49.9657	39.37
At most 1	0.47302	36.4626	33.46
At most 2	0.37341	27.2163	27.07
At most 3	0.29456	16.1031	20.97
At most 4	0.18653	10.1930	14.07

Source: computed from STATA 13
*denotes rejection of hypothesis at 0.05 level

As shown in Table 4, the trace-test statistic and max-statistic indicates the rejection of the null hypothesis of no cointegration among the variables in the model. This is further confirmed by the Engle – Granger test in table5. The result shows the existence of at least 3 cointegration equations at 5% critical level. This shows the presence of a long-run relationship among the variables. The existence of cointegration also implies that, the variables have a common "stochastic trend": changes in the predicted long-run path of one series are correlated with changes in the predicted long-run path of the other series (Woodford, 2008).

Table5 .Engle – Granger Test of Cointegration

	Test statistic	**1% critical value**	**5% critical value**	**10% critical value**
Z	-6.236	-5.571	-4.918	-4.589
No. Observation 82				

5.1 Analysis of Vector Autoregressive (VAR) Results

According to table 6, the current level of each variable is positively impacted by their own immediate past values. With the exception of cocoa and oil, all immediate past values were significant. By implication the value of each variable follows a time-trend historical generation process (Adenutsi and Ahortor, 2008). Inflation is positively driven by its own three past quarters, first past quarter of interest rate, three past quarters of money supply and all four

quarters of exchange rate. This shows the great influence of money supply by the central bank and changes in the nominal exchange rate on the inflation in the economy. The immediate past quarter of money supply shows that, a 1% increase in money supply will increase inflation by about 24%, while its second quarter raises inflation to about 19%. Cocoa prices had significant positive impact on inflation for two quarters while domestic oil prices had positive impacts but were not significant.

The impact of exchange rate on inflation is of no surprise considering the nature of Ghanaian economy. The economy depends much on imported goods coupled with a depreciating currency at most times, hence goods imported comes at higher prices on the domestic market which creates upward movement in price levels. This suggests that there is the need to monitor and control importation of goods or at best produce most goods locally to help limit the impact of exchange rate on inflation.

The table shows how Ghana's main export (cocoa) influences the nominal exchange rate. In the periods when the price of cocoa rises, the local currency gains on the exchange market. During harvest period of cocoa, the cedi tend to gain marginal appreciation, while the lean period of cocoa production leads to depreciation. Three quarters of cocoa price increases leads to an appreciation of the local currency. A one percentage increase in cocoa price in the third quarter will lead to a 9% appreciation of the local currency.

Exchange rate from the table records a mix of both positive and negative impacts from the past values of the other variables. This trend could be partly explained by an outside factor, thus remittances. Given that the country has high remittance inflows it has the tendencies of

depreciating the currency, the effects of a depreciating currency is normally high interest rates to attract local security investors.

Table 6. Result of VAR Estimation

Variable	**SYSTEM EQUATIONS**					
	LINF	**LExRate**	**LM2**	**LIntRate**	**LCocoa**	**LOil**
L.LINF	0.409***	-0.113	-0.114	1.246**	-0.972**	0.303
	(0.109)	(0.189)	(0.192)	(0.488)	(0.431)	(0.656)
L2.LINF	-0.163	-0.045	0.106	-0.619	0.579	-0.410
	(0.122)	(0.211)	(0.215)	(0.546)	(0.483)	(0.735)
L3.LINF	0.168	0.244	0.309	-0.016	-0.533	1.208*
	(0.113)	(0.195)	(0.199)	(0.504)	(0.445)	(0.678)
L4.LINF	0.085	-0.296*	-0.082	-0.567	0.448	-0.613
	(0.097)	(0.167)	(0.170)	(0.431)	(0.380)	(0.579)
L.LExRate	0.053	0.560***	0.281**	0.100	-0.060	-0.331
	(0.070)	(0.121)	(0.124)	(0.314)	(0.277)	(0.422)
L2.LExRate	0.076	0.319***	-0.097	0.726**	0.354	0.620
	(0.070)	(0.121)	(0.123)	(0.313)	(0.277)	(0.421)
L3.LExRate	0.058	-0.431***	0.020	-0.422	0.087	0.064
	(0.073)	(0.126)	(0.128)	(0.325)	(0.287)	(0.437)
L4.LExRate	0.013	0.145	0.181	-0.149	-0.090	-0.629
	(0.066)	(0.114)	(0.116)	(0.295)	(0.260)	(0.397)
L.LM2	0.243***	0.040	-0.291***	0.241	0.270	-0.414
	(0.052)	(0.090)	(0.092)	(0.233)	(0.206)	(0.314)
L2.LM2	0.192***	0.095	-0.113	0.483*	0.345	0.352
	(0.060)	(0.103)	(0.105)	(0.266)	(0.235)	(0.358)
L3.LM2	-0.091	0.055	-0.221**	0.244	0.530**	-0.138
	(0.063)	(0.109)	(0.111)	(0.281)	(0.248)	(0.378)
L4.LM2	0.063	-0.000	0.388***	0.144	0.304	-0.792**

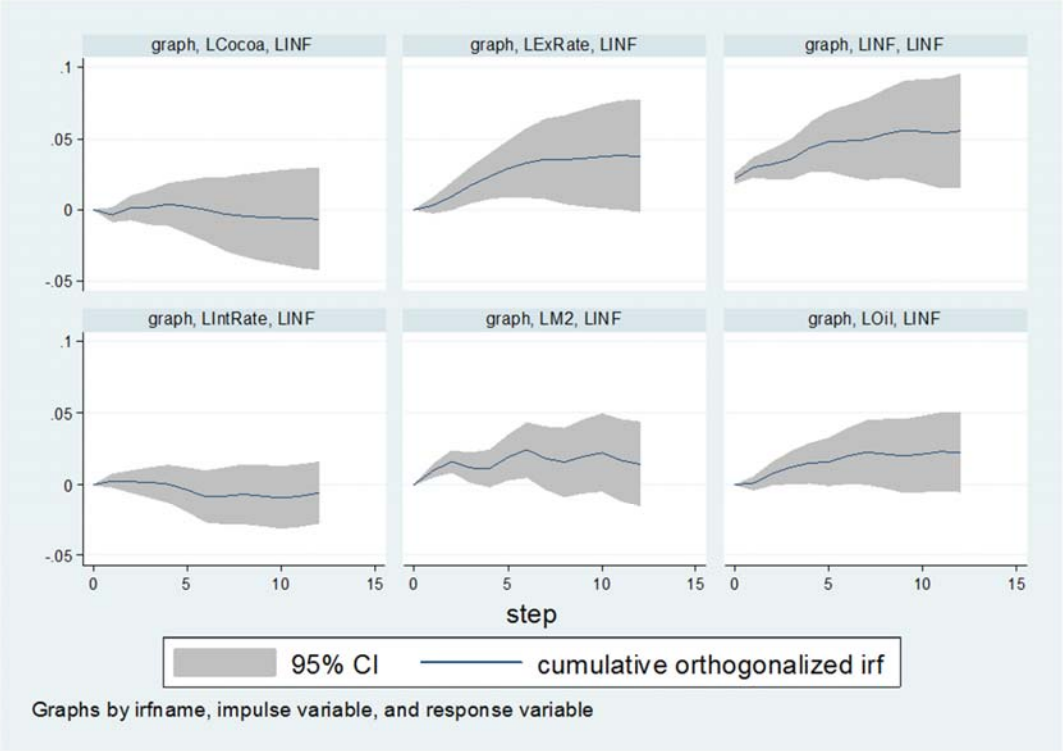
	(0.061)	(0.106)	(0.108)	(0.274)	(0.242)	(0.369)
L.LIntRate	0.027	0.022	-0.097**	0.278**	-0.190*	-0.092
	(0.026)	(0.045)	(0.045)	(0.115)	(0.102)	(0.155)
L2.LIntRate	-0.020	-0.013	0.020	0.010	0.152	-0.306*
	(0.027)	(0.047)	(0.048)	(0.122)	(0.107)	(0.164)
L3.LIntRate	0.034	0.090*	0.036	0.106	0.089	0.058
	(0.029)	(0.049)	(0.050)	(0.127)	(0.112)	(0.171)
L4.LIntRate	-0.044*	-0.020	-0.156***	-0.321***	-0.071	-0.206
	(0.025)	(0.044)	(0.045)	(0.113)	(0.100)	(0.152)
L.LCocoa	-0.040	-0.042	0.059	0.244*	0.163	-0.033
	(0.028)	(0.049)	(0.050)	(0.127)	(0.112)	(0.170)
L2.LCocoa	0.053*	-0.068	0.042	0.055	-0.118	0.010
	(0.028)	(0.049)	(0.050)	(0.126)	(0.112)	(0.170)
L3.LCocoa	-0.041	-0.094*	0.062	-0.060	0.113	-0.508***
	(0.028)	(0.049)	(0.050)	(0.126)	(0.111)	(0.170)
L4.LCocoa	0.068**	0.052	0.075	-0.038	0.059	0.085
	(0.030)	(0.053)	(0.053)	(0.136)	(0.120)	(0.182)
L.LOil	0.008	0.049	0.076**	0.052	0.028	-0.006
	(0.019)	(0.032)	(0.033)	(0.083)	(0.074)	(0.112)
L2.LOil	0.028	0.039	-0.005	0.087	0.041	-0.117
	(0.018)	(0.031)	(0.031)	(0.080)	(0.070)	(0.107)
L3.LOil	-0.005	0.051*	-0.015	0.029	-0.095	0.007
	(0.016)	(0.028)	(0.028)	(0.071)	(0.063)	(0.096)
L4.LOil	0.017	-0.038	-0.054**	-0.053	0.075	-0.010
	(0.015)	(0.026)	(0.027)	(0.068)	(0.060)	(0.092)
_cons	-0.016	0.016	0.060***	-0.108**	-0.092**	0.083
	(0.012)	(0.020)	(0.020)	(0.052)	(0.046)	(0.070)

**** p<0.1; ** p<0.05; *** p<0.01***

No. of obs = 78 Log likelihood = 683.3292

AIC = -13.67511 HQIC = -11.86081 SBIC = -9.142976

Fig 4. Cumulative Orthogonal Impulse Response function of Inflation in VAR



The cumulative orthogonal response function above shows how inflation response to shocks in cocoa prices, exchange rate, inflation itself, interest rate, money supply and oil prices respectively.

The graph shows that response of inflation to shocks in money supply (M2) is significant. Shocks to the money supply causes inflation to rise immediately above its zero line and persist over time. The graph shows a more pronounced significant response of inflation to shocks in the exchange rate, oil prices and inflation itself. A shock to exchange rate quickly raises inflation above its initial levels, with the impact of the shock not disappearing within a twelve quarters horizon. Similar trends can be seen for oil price shocks and own variable shock.

Furthermore, the graph shows that inflation response to shocks in interest rate, a key monetary policy tool has a weak significant impact. A one-percentage shock to interest rate slowly causes inflation to decline, with the shock almost fading out within the twelve quarters horizon. The graph also shows a weak response of inflation to shocks in cocoa prices. This may be evidence that any influence of cocoa prices on inflation might be indirectly through the exchange rate.

Table 7. Variance Decomposition of Inflation in VAR

Period	LINF	LM2	LIntRate	LExRate	LOil	LCococa
4	.608585	.161775	.025202	.099675	.073944	.03082
5	.60261	.143663	.024528	.122023	.076185	.03099
6	.552529	.17968	.02446	.144551	.068232	.030548
7	.514063	.19024	.0289	.15875	.07533	.032717
8	.491314	.20601	.029642	.155507	.07596	.041567
9	.493056	.208136	.029422	.152864	.075266	.041256
10	.488234	.215595	.029076	.150625	.075731	.040738
11	.48364	.219476	.029125	.150887	.076356	.040516
12	.472841	.233178	.03051	.14736	.076077	.040036

The variance decomposition table above measures the contribution of each type of shock to forecast-error variance of the inflation variable. The computation of the variances helps in analyzing how shocks to economic variables reverberate through the entire economic system. According to the table, variations in inflation within one year (four quarters) are largely explained by its own shocks which accounts for 60 percent. Within the same period, money supply and exchange rate had marginal influence on inflation, they accounted for 16% and 9% respectively. The table also shows that inflation accounts for most of its variations even in the long-run (12 quarters), nonetheless the own shocks of inflation is diminishing over time. Also, between the first year to the third year, the influence of money supply and exchange rate becomes more pronounced accounting for 23% and 14% respectively. It is also evidenced that cocoa prices and interest rate accounts for the least variations in inflation both in the short-run

and long-run. Domestic oil prices maintain a steady 7% of the variations in inflation over the entire horizon. The results of variance decomposition has shown that aside own shock from inflation, money supply which is controlled by the monetary policy and the nominal exchange rate accounts for most variations in the country's inflation rates.

Table 8. Granger causality test

Equation	Variable	Chi-Square	Degrees of Freedom	Probability
LINF	LM2	39.898	4	0.000
LINF	LIntRate	4.6843	4	0.321
LINF	LExRate	8.2578	4	0.083
LINF	LOil	3.8883	4	0.421
LINF	LCocoa	8.7604	4	0.067
LINF	All	91.386	4	0.000

Table 8 presents the results of the granger-causality test for the inflation equation. The null hypothesis under the test is that, the other variables (LM2, LIntRate, LExRate, LOil, LCocoa) does not cause inflation. The results show that money supply (LM2) granger-cause inflation at a one percent significance level, with the causality running from money supply to inflation. Furthermore, the nominal exchange rate and cocoa prices have weak causality relationship with inflation at a ten percent significance level. On the whole, the combine effect of the entire variables is seen to granger-cause inflation at a one percent significance level.

5.2 Analysis of Vector Error Correction Model (VECM) Results

The Johansen-cointegration test found the existence of a long-run relationship among variables in the model. The study carries out the VECM to capture the error correction term, to see how

the variables adjust from deviations in their long-run relationship. Another reason for carrying out the VECM is to check if the impulse response outcome and variance decomposition results under the VAR model will change significantly. The results shows that inflation will adjust to any deviation from the long-run as indicated by the significant negative co-efficient of the error correction term (-0.214). This implies that about 20 percent of deviation from the past periods will be corrected in the current period. The restoration of equilibrium in the inflation relationship comes from inflation itself, changes in domestic oil prices and cocoa price. The error terms of the first cointegrating equations in money supply, nominal exchange rate, domestic oil prices do not have an inherent correction from disequilibrium. This can mean that persistent disequilibrium in these variables is likely to influence inflation.

Table 9. Results of VECM Estimation

Variable	SYSTEM EQUATIONS					
	LINF	**LExRate**	**LM2**	**LIntRate**	**LCocoa**	**LOil**
ECT_1	-0.214***	-0.041	0.139	-0.293	-0.434	1.583***
	(0.079)	(0.138)	(0.137)	(0.343)	(0.323)	(0.472)
L.LINF	-0.289**	-0.056	-0.304	1.412***	-0.544	-0.906
	(0.121)	(0.211)	(0.209)	(0.524)	(0.493)	(0.722)
L2.LINF	-0.389***	-0.070	-0.208	0.683	0.183	-1.007
	(0.121)	(0.210)	(0.208)	(0.524)	(0.492)	(0.721)
L3.LINF	-0.153	0.210	0.082	0.576	-0.298	0.482
	(0.114)	(0.199)	(0.197)	(0.495)	(0.466)	(0.682)
L.LExRate	-0.132	-0.061	-0.105	-0.287	0.027	0.221
	(0.083)	(0.145)	(0.144)	(0.361)	(0.339)	(0.497)
L2.LExRate	-0.044	0.260*	-0.209	0.421	0.381	0.894*
	(0.077)	(0.134)	(0.133)	(0.333)	(0.313)	(0.459)
L3.LExRate	0.017	-0.179	-0.205	0.020	0.337	0.918**
	(0.078)	(0.135)	(0.134)	(0.337)	(0.317)	(0.464)

L.LM2	-0.083	-0.407	-0.278	0.061	-1.087*	1.315
	(0.151)	(0.263)	(0.260)	(0.133)	(0.615)	(0.900)
L2.LM2	0.078	-0.229	-0.312	0.105	-0.729	1.426*
	(0.122)	(0.213)	(0.211)	(0.104)	(0.498)	(0.729)
L3.LM2	-0.046	-0.079	-0.450***	0.097	-0.253	0.994**
	(0.073)	(0.127)	(0.126)	(0.073)	(0.298)	(0.436)
L.LIntRate	0.045	-0.043	0.091	0.214	-0.273	0.460*
	(0.042)	(0.072)	(0.072)	(0.180)	(0.169)	(0.248)
L2.LIntRate	0.016	-0.054	0.122*	0.234	-0.089	0.122
	(0.039)	(0.068)	(0.067)	(0.168)	(0.158)	(0.232)
L3.LIntRate	0.043	0.030	0.161***	0.338**	0.036	0.173
	(0.031)	(0.055)	(0.054)	(0.136)	(0.128)	(0.187)
L.LCocoa	-0.085*	0.108	-0.211***	0.151	-0.501***	0.193
	(0.047)	(0.082)	(0.081)	(0.204)	(0.192)	(0.281)
L2.LCocoa	-0.031	0.033	-0.161**	0.162	-0.455***	0.288
	(0.042)	(0.073)	(0.073)	(0.183)	(0.172)	(0.252)
L3.LCocoa	-0.073**	-0.055	-0.085	0.078	-0.210	-0.173
	(0.035)	(0.061)	(0.060)	(0.151)	(0.142)	(0.208)
L.LOil	-0.072**	0.020	0.140***	0.061	-0.096	-0.149
	(0.031)	(0.054)	(0.053)	(0.133)	(0.126)	(0.184)
L2.LOil	-0.031	0.036	0.113***	0.105	-0.028	-0.171
	(0.024)	(0.042)	(0.042)	(0.104)	(0.098)	(0.144)
L3.LOil	-0.027	0.066**	0.078***	0.097	-0.102	-0.084
	(0.017)	(0.029)	(0.029)	(0.073)	(0.069)	(0.100)
_cons	0.000	0.000	0.000	-0.000	0.000	0.000
	(0.003)	(0.005)	(0.005)	(0.014)	(0.013)	(0.019)

***N* 78**

**** p<0.1; ** p<0.05; *** p<0.01*. Log likelihood = 666.1398, AIC = -13.46512**

Fig5. Cumulative Orthogonal Impulse Response Function of Inflation in VECM

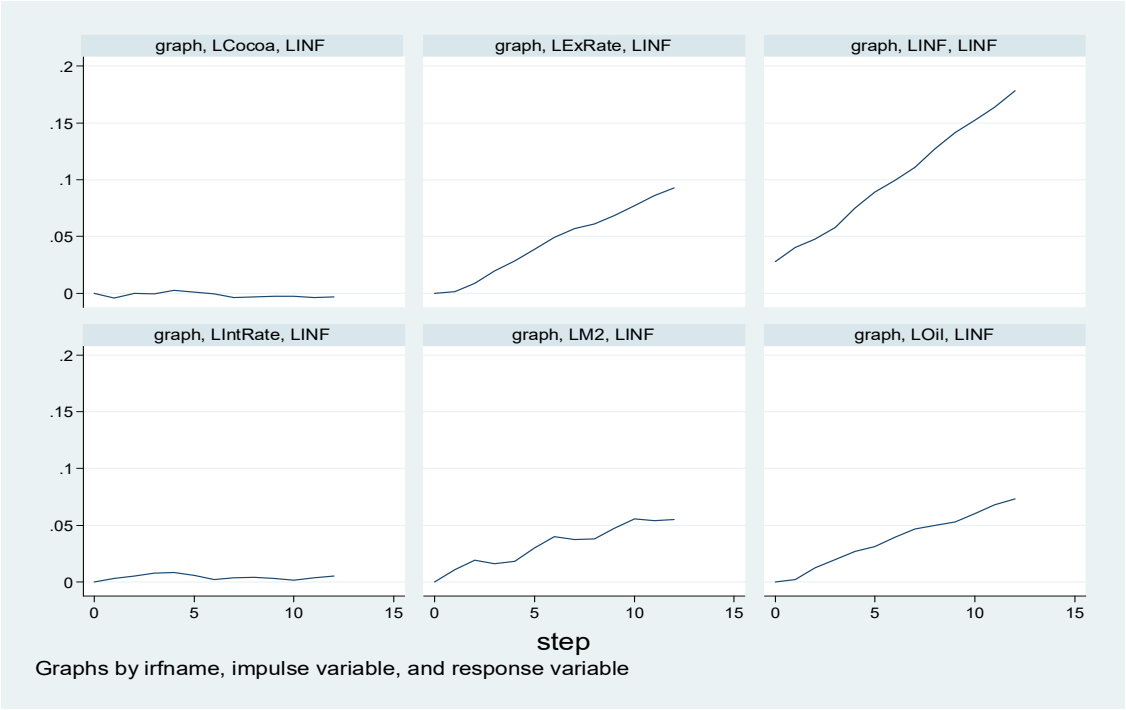


Table 10.Variance Decomposition of Inflation in VECM

Period	LINF	LM2	LIntRate	LExRate	LOil	LCococa
4	.644089	.116136	.012254	.104614	.101326	.021582
5	.650206	.093482	.010115	.119455	.10556	.021182
6	.608548	.130911	.011493	.13823	.092506	.018312
7	.563887	.146058	.014159	.155354	.104094	.016447
8	.563887	.146058	.014159	.155354	.104094	.016447
9	.559758	.136504	.013971	.161742	.110136	.017889
10	.586826	.136192	.012177	.152867	.096947	.014991
11	.569661	.141493	.011689	.160522	.102808	.013827
12	.562471	.133653	.011829	.168578	.110349	.01312

From fig.5 the response of inflation to shocks in the other variables is not too different from the VAR model. The graph evidenced that inflation shows an immediate and positive reaction to

shocks from money supply, which does not die out within a twelve quarters horizon. Further, the estimated graphs detected inflation to have a positive continuous response to shocks in its own, the nominal exchange rate and the domestic oil prices. Similar to the VAR model, inflation does not react significantly to shocks from cocoa prices and the nominal interest rates.

The estimated Variance decomposition of inflation in table 10 connotes that variations in inflation is largely explained by its own shock. Within a short-run (four quarters), 64% of variations in inflation is explained by its own shock, whiles the money supply and nominal exchange rate explains about 11% and 10% respectively. Again, the finding in the VECM framework is not different from its VAR counterpart. The variations due to inflationary shocks diminish over the twelve quarters horizon while the variations due to shocks to money supply and nominal exchange rate increase marginally in magnitude. Unlike in the VAR, nominal exchange rate tends to explain a larger variation in inflation than money supply in the long-run (16% and 13% respectively). Also under the VECM model domestic oil prices contribute 10% and 11% to variations in inflation in the short-run and long-run respectively, which is more than its contribution under the VAR.

The broader empirical evidence from the two frameworks is that inflation dynamics in Ghana, both in the short-run and the long-run can be explained by inflation itself, the money supply of the central bank and the prevailing nominal exchange rate. This finding is in agreement with the study by Bawumiah and Abradu-Otoo (2003), who found money supply and nominal exchange rate as key determinants of inflation in Ghana.

6. CONCLUSION & POLICY IMPLICATIONS

6.1 Conclusion

The study sought to find if monetary policy undertaken by the BoG could explain the volatility and persistent hikes in inflation rates in Ghana. Using the money supply (M2), nominal interest rates as the indicators of monetary policy and other relevant macroeconomic variables, namely the nominal exchange rate, domestic oil prices and cocoa prices that have tendencies to influence inflation, the study applied a VAR and VECM methodology.

Empirical results from the these methodologies shows that apart from inflation itself, the money supply and the nominal exchange rate are the key sources of inflation dynamics in Ghana. Both the impulse response functions and variance decomposition points to the same conclusion, that inflation fluctuation is explained by the money supply and nominal exchange rates. The paper also found that domestic oil prices have a higher impact on inflation than the nominal interest rate and cocoa prices. The Granger-causality showed that money supply precedes inflation, implying causality from money supply to inflation.

6.2 Policy Implications

Owning to the findings of the study, it is clear that to achieve the price stability goal of the central bank of Ghana, money supply and the nominal exchange rate needs to be given greater attention. There is the need to ensure that money supply does not exceed output growth in the economy. With regards to controlling the frequent depreciation of the local currency, measures to end the dollarization of the economy are eminent. In Ghana and other developing economies, the sharp depreciation of the local currencies coupled with dollarization leads to a large burden on dollar-denominated debts, which can lead to systemic crises within the financial system and

compound the existing challenges of monetary policy. Also the domestic production needs to be boosted to curtail imported-inflation due to high import demand in the economy. The study have also shown that, future expectations of the public and their expectations of what monetary policy action will be adopted by the central bank is critical to managing inflation. To ensure that inflation expectation is well managed among firms and consumers, the Bank of Ghana must strengthen its credibility, be more accountable to the general public and improve on their transparency by providing frequent policy briefs, information on target rates and rationale for changes in policy rates. The central bank should also resist or avoid being politically-influenced which may lead to over-manipulating the levers of monetary policy in an attempt to achieve short-term political goals.

6.3 Areas for Further Research

The paper conducted the research without any fiscal factors. Given the fiscal dominance in the economy, it will be appropriate to find out how fiscal factors influence inflation. Also, the changes in monetary policy regimes by the central bank of Ghana were not treated separately, it will be worthwhile for further studies to explore how each regime has performed in controlling inflation in the country.

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