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STATISITICAL ANALYSIS ON SHOCKS TO MONETARY POLICY AND ITS RESPONSE TO COMMODITY PRICES IN GHANA

BY

DAVID YOVO

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DECLARATION

I, David Yovo, hereby declare that this submission is my own work for the BSc. degree, under the supervision of Dr. Ezekiel Nii Noi Nortey, and that it contains no material previously published by another person or material that has been accepted for the award of any other university degree, except where appropriate acknowledgement has been made in the text.

David Yovo (10662881)		**25/08/2021**
Student	Signature	Date

Certified by:

Dr. Ezekiel Nii Noi Nortey		**25/08/2021**
Supervisor	Signature	Date

DEDICATION

This material is dedicated to my mother, Stella Antwiwaa Ofori Ayetey, for her unwavering support and encouragement throughout my studies.

ABSTRACT

Over time, Ghana has witnessed rising levels of inflation. This problem has been validated by (Focus Economics, 2019) and the Institute of Economic Affairs (IEA), (2012). "High domestic demand supported by expansionary fiscal policies and accommodating monetary policies, as well as the economy's high sensitivity to supply shocks, notably with respect to food, which commands a considerable weight in the consumer basket," according to the IEA (2012). Anzuini, Lombardi, and Pagano (2012) and Frankel (2008), pointed out that monetary policy and interest rates are the primary drivers of commodity prices, and monetary policy influences commodity prices through supply and demand forces. Where research works by E. Y. Boateng, P. K. Yeboah, I. C. Otoo and J. Otoo (2020) also attest to these facts by modelling commodity price responses to monetary policy shocks in Ghana. Data on cocoa, gold, crude oil, and MPR prices from 1999 to 2018 was obtained from the Bank of Ghana via the University of Ghana's Department of Statistics in Legon and was used to determine the extent of the relationship between monetary policy and commodity prices in Ghana, as well as to attest to some of the claims made by other research works, using vector auto-regressive models (VAR) by employing the E-VIEW software package. The presence of cointegration in the series of cocoa, crude oil, gold, and MPR prices indicated a long-term relationship between MPR and cocoa, crude oil, and gold commodity prices, according to the analysis. MPR has a negative and insignificant effect on cocoa. The reactions of crude oil and gold to MPR were both unfavourable and significant. Gold and MPR have a smaller link or response than crude oil and MPR. This found that, while monetary policies and interest rates may have an impact on commodity prices, external factors are the most important determinants of commodity prices in Ghana.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

The study's background, problem statement, and objectives are all presented in this chapter. It also includes the study's scope, significance, limitations, and the organization of theories.

1.1 Background of Study

According to Frank and Bernanke (2001), monetary policy is the process of determining the nation's money supply. The central bank, currency board, or other competent monetary authority of a country regulates the quantity of money and the channels through which new money is provided, and hence controls the quantum of money delivered to each economy.

According to Zaney (2019), monetary policy is the way a government uses interest rates and the money supply to influence the economy. There are two types of monetary policy: expansionary and contractionary. When a country has a high unemployment rate or an economic downturn, the monetary authorities cut interest rates purposefully through a variety of ways, causing unfavourable money savings in banks and other financial institutions. As a result, the economy's money supply expands to which businesses and people can obtain loans to develop their productive operations. This boosts employment, which, in turn, leads to economic growth and prosperity in the long run. Expansionary monetary policy refers to the monetary authority's deliberate action. The growing inflation rate is a concern connected with **expansionary monetary policy**. It eventually leads to unemployment; thus, a country's central bank or monetary authority might raise interest rates on purpose to slow down the money supply. **Contractionary money supply** is another term for this action.

The primary goal of central banks is to control inflation and unemployment. Monetary policy by the central government or any competent monetary authority of a country constituted by law is one of the main factors of economic growth and development.

On the 6th of March, 1957, Ghana declared independence from British authority. It was likewise granted republic status on July 1, 1960. In addition to other statutory tasks, the government formed its own central bank, the Bank of Ghana, to conduct independent monetary policy.

Technically, the Bank of Ghana was created on March 4, 1957, two days before Ghana was granted independence by the British Government by the Bank of Ghana Ordinance (No. 34) of 1957. The bank has experienced numerous legislative amendments since 1957. Act 182 of the Bank of Ghana Act (1963) abolished the Bank of Ghana Ordinance (No. 34) of 1957. The Bank of Ghana (Amendment Act) 1965 altered this act later (Act 282). Acts 182 and 282 were repealed by the Bank of Ghana Law, 1992 PNDCL 291.

The Bank of Ghana Act, 2002, is the current statute under which the bank functions (Act 612). The Bank of Ghana performs the following functions:

I. Formulate and implement monetary policy with the goal of attaining the bank's objectives.
II. Encourage the stabilization of the currency's value both within and outside Ghana through monetary measures.
III. Implement policies that are likely to benefit the balance of payments, the state of public finances, and the overall growth of the national economy.
IV. Ensure the smooth operation of the financial sector by regulating, supervising, and directing the banking and credit system.
V. Advancing, regulating, and overseeing payment and settlement systems.
VI. Issuance and redemption of currency notes and coins.
VII. Ensure that Ghana's external financial services are properly maintained and managed.
VIII. License, regulate, promote and supervise non-banking financial institutions.
IX. Act as a banker and offer financial assistance to the government.
X. Promote and maintain relationships with foreign banking and financial institutions and implement international monetary agreements to which Ghana is a party, subject to the Constitution or any other relevant statute, and

XI. Perform any other acts necessary or conducive to the efficient performance of its functions under this Act and any other statute.

Source: Bank of Ghana

Functions (I and II) will be considered for this project.

I.	Formulate and implement monetary policy with the goal of attaining the bank's objectives.
II.	Promote the stabilization of the currency's value both within and outside Ghana using monetary means.

1.2 Statement of the Problem

Over the years, Ghana has seen greater inflation rates. Based on consumer price index (CPI), yearly variation, end of period available numbers from 2013 to 2017 are: 11.67 percent in 2013, 15.49 percent in 2014, 17.15 percent in 2015, 17.46 percent in 2016, and 12.34 percent in 2017. (Focus Economics, 2019). According to the Institute of Economic Affairs (IEA), Ghana has had greater rates of inflation than most of its African counterparts throughout its history. The track record, according to Kwakye (2012), is unenviable. Kwakye (2012) cited robust domestic demand, fuelled by expansionary fiscal policies and accommodating monetary policies, as well as the economy's high propensity to supply shocks, notably in the case of food, which accounts for a substantial portion of the consumer basket.

Inflationary pressures cause prices of commodities to rise, which is bad for any economy. This study aims to examine the relationship between Ghana's monetary policy and commodity prices, as well as forecast the country's future monetary policy and commodities price levels.

1.3 The Study's Objectives

The study's specific goals are as follows:

1. Using vector auto-regressive models (VAR) to determine whether there is a relationship between monetary policy and commodity prices in Ghana.
2. To establish the extent of the relationship between monetary policy and commodity prices in Ghana, using the (VAR) technique.
3. Predict Ghana's monetary policies and commodity prices in the future.
4. To attest to some claims made by other researchers.

It is my interest and desire to investigate the behaviour of the Bank of Ghana's Monetary Policy Rates in relation to the price levels of cocoa, crude oil, and gold in order to determine whether shocks to the country's monetary policy have a significant positive or negative impact on commodity price levels. This would allow me to assess if Ghana as a country is doing well under its democratic regime.

1.4 The Scope of the Study

The study examines the pathways through which Ghanaian monetary policy influences commodity prices. From December 1999 through December 2018, data on Ghana's monetary policies and commodity prices will be collected. This is due to the lack of data on cocoa, crude oil, and gold commodity prices from 1957 to 1998 at the time of authoring this study. In 1993, the fourth republican constitution went into effect. In the same year, Ghana's GDP was re-based by the Ghana Statistical Service. Another re-basing began in 2006, and the most recent re-basing began in 2010. The rationale for the 2010 rebasing is that Ghana began producing and exporting crude oil in 2010, which caused a shift in our GDP's growth and direction.

1.5 Significance of the Study

It is critical to examine the behaviour of various parts of every economy from time to time so that economic managers can use the best options available to them to manage the country's economy and achieve the desired goal at any given time. The study is timely because Ghana has been experiencing increasing inflation, interest rates, and price increases for quite some time. It is therefore critical for economic managers to take practical measures to end this canker to enable the economy to expand towards prosperity in the foreseeable future.

1.6 Limitation of the Study

This dissertation is limited to the study objectives and the research activity is constrained in several ways. Time limits and the difficulty in getting appropriate materials on the issue are two of the impediments.

1.7 The Study's Organization

The study is broken down into five (5) chapters. The background, the problem presentation, the purpose, the relevance, the limits, and the study organization are all covered in Chapter One (1). The introduction, definition, additional subtopics, idea and theories behind the study's variable, and the empirical framework of the work were all included in the literature review in Chapter two (2). Chapter three covers the study's methodology, which includes the research design, data analysis, and data collection methods (3). The data analysis is reported in Chapter four (4). Finally, the summary, findings, recommendations and conclusion, as well as other areas for further investigation, are covered in chapter five (5).

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section contains a review of different writers' work on concept definitions and various research studies. The authors' opinions, as well as research and empirical work, are considered. The review's main points are listed below.

2.1 Monetary Policy and Economy

Monetary policy is a method of controlling the money supply in an economy by a country's central bank, currency board, or any other competent monetary agency. They do so by devising, advertising, and implementing a strategy for injecting a specific quantity of money into an economy in order to achieve the objectives of controlling inflation, consumption, growth, and liquidity. For the purposes of this study, the governing authority, the Bank of Ghana, adjusts interest rates, purchases or sells government bonds, regulates foreign exchange rates, and changes the amount of money banks are required to retain as reserves. Monetary policy can be classified as either expansionary or contractionary.

During a downturn or recession, the Central Bank can pursue an expansionary policy targeted at growing economic activities, which will result in economic growth. It accomplishes so by lowering interest rates, encouraging people to spend money and implementing a variety of policies that make saving money unappealing and uncomfortable for investors. This leads to a rise in the economy's money supply and consumer spending.

High inflation, rising costs of living and greater capital in doing business are some of the key drawbacks of expansionary monetary policy. In an economy with a high rate of inflation and a large money supply, the Central Bank can use contractionary monetary policy to reduce inflation by raising interest rates and decreasing the expansion of the money supply. When taken over a lengthy period, this move has the potential to stifle economic growth and raise unemployment rates.

2.2 Monetary Policy, Monetarist School of Thought

Monetarism is a philosophy proposed by Milton Friedman (1912 - 2006) and members of the old classical school claim that, money supply is the fundamental cause of economic volatility, indicating that, a stable money supply would result in price level stability and employment (Mukherjee, 2007).

Monetarists believe that controlling the amount of money in the economy is more important than influencing other economic tools such as taxes, government spending, and budget deficits. "Inflation is always and everywhere a monetary event with no impact on real variables," according to the monetarist.

Similarly, according to classical and neoclassical schools of thought, money supply leads to inflation in the long run while output remains constant, whereas classical theory proposes that money supply may alter real output in the short term due to unemployment" (Usman et al, 2017).

Mukherjee (2007) identifies four main monetarism propositions:

1. The nominal income is mostly influenced by the money supply.
2. The general price level and other nominal magnitudes are principally influenced by the money supply in the long run. Real factors determine the real variables, such as, real output and employment.
3. In the long run, the money supply has a major influence on real variables. As a result, cyclical fluctuations in output and employment occur.
4. The government, not the private sector, causes economic instability by changing the key determinant of economic activity, namely the quantity of money.

From the four key propositions, Mukherjee (2017) drew two policy conclusions:

a. "It follows from arguments 1 and 3 that a stable money supply growth is critical for economic stability. The greatest method to create consistent economic growth is to adopt a rule rather than use discretion."
b. "If monetary considerations determine nominal income and short-term real income, fiscal policy has a limited autonomous function as an effective stabilization tool."

2.3 Monetary Policy, Keynes School of Thought

A Keynesian believes that aggregate demand is influenced by a variety of economic decisions, both public and private, and that it can be unpredictable at times. According to Keynesian theory, aggregate demand changes, whether expected or unexpected, have the greatest short-term impact on real output and employment rather than prices. We live in the short run, and Keynesians contend that what is true in the short run cannot necessarily be extrapolated to what must occur in the long run.

In other words, due of price and wage rigidity, monetary policy affects real output in the short term, but money supply affects only inflation in the long run, while real output remains constant. Other causes of inflation have been discovered through theoretical debate. Cost push inflation is described as an increase in the price of inputs such as labor, raw materials, and so on. Demand pull inflation is driven by strong consumer demand.

"When a large number of people buy the same thing, the price rises, and when this happens across the economy for all kinds of things, it's called demand-pull inflation." (2019, Chen). Inflation can also be caused by future expectations about the prices of goods and services.

Inflation expectations are influenced by a number of factors, including the current rate of inflation, previous inflation trends, the general economic outlook, wage growth and the credibility of monetary policy.

2.4 Related Articles on Shocks to Monetary Policy and Response of Commodity Prices

Pesenti (2013) offers a non-technical overview of contemporary models of monetary policy responses to commodity price shocks. His key concern is whether to target the headline consumer price index or a gauge of "core" prices that excludes specific categories such as food and energy. “Shocks to commodity price inflation are typically beyond policymakers' control, difficult to predict and often not sustained,” he says. “Central banks seeking to establish credibility are generally better off setting and communicating their monetary policy in terms of underlying inflation rather than headline inflation.” However, if economic actors place a far higher value on headline inflation stability than production stability, a headline framework may be preferred.”

Gelos and Ustyugova (2012) studied how inflation reacts to commodity price shocks in different nations. Over the years 2001 - 2010, they used multiple methodologies to relate the inflationary impact of commodity price shocks across nations to a wide range of structural factors and policy frameworks. They discovered that countries with higher food shares in CPI baskets, higher fuel intensities, and higher pre-existing inflation levels were more likely to see long-term inflationary effects from commodity price shocks. According to them, countries with more independent central administrations and higher governance scores appear to have better absorbed the shocks. However, the focus of this study is on monetary policy shocks and commodity price responses in Ghana.

The influence of monetary policy shocks on commodity prices in the United States of America was investigated by Cabral, Castro, and Joya (2014). According to them, most research shows that expansionary shocks have a favourable impact on aggregate price indices. They used structural VAR models to investigate the effect on individual prices of a sample of four commodities in order to get insight into Colombia's balance of payments. Their findings showed that prices overshot their long-run equilibrium in reaction to a contractionary shock in US monetary policy, and that, contrary to previous research, the response of individual prices is higher than that of aggregate indices. They also discovered that monetary policy is responsible for a significant portion of price volatility. However, the scope of our research is confined to the impact of monetary policy on cocoa, crude oil, and gold prices in Ghana.

Frankel (2006) also looked at how monetary policy affects real commodity prices. His article examines the relationships between monetary policy, agricultural and mineral commodities in the United States and other nations such as Australia, Brazil, Canada, Chile, Mexico and New Zealand. Interest rates have a detrimental effect on the desire to carry commodity inventories, according to a study that used regression analytic methods.

Using the Standard Vector Auto-regressive System, Anzuini, Lombardi, and Pagamo (2010) evaluated the influence of monetary policy shocks on commodity prices in the United States of America. As variables, they employed the federal funds rate, money supply (M2), consumer price index, industrial production index and a commodity price index (in USD). Their findings showed that the broad commodity price index and all of its components rose in response to expansionary monetary policy shocks in the United States. While significant, these effects do not appear to be abnormally large. This conclusion is supported by a variety of monetary policy shock identification methodologies.

Boateng, Yeboah, and Otoo (2020) investigated time series modelling of Dynamic Responses of Commodity Prices to Monetary Policy Shocks in Ghana using a Vector Error Correction modelling framework. Their study was based on data from the Bank of Ghana on cocoa, gold, and crude oil prices from January 2005 to December 2017. In the long run, monetary policy rates are found to be negatively associated to crude oil prices and, to a lesser extent, positively related to cocoa and gold prices, according to their findings. They also discovered that in the near run, the first lag of the monetary policy rate has an adverse relationship with itself, but the second lag has a positive relationship with itself. They discovered that in the short term, the first and second delayed periods of cocoa price have a positive impact on monetary policy rates, while the first and second delayed periods of gold price have a negative impact.

Ghana established its own central bank in 1957 after obtaining political independence, among other things, to conduct autonomous monetary policy. Since then, many frameworks have been implemented to achieve price stability as monetary policy's primary purpose (Kwakye, 2012). According to Kwakye (2012), Ghana's price-stabilization system has evolved from a monetary-targeting to an inflation-targeting strategy.

Using international cocoa, crude oil and gold prices as dependent variables and MPR as an independent variable in Ghana, this work examines shocks to the Monetary Policy Rate (MPR) and its response to commodity prices. By employing a Vector Auto-regressive (VAR) approach to advice policymakers on how to manage shocks for the betterment of the country, I hope to examine how cocoa, crude oil, and gold prices respond to shocks in relation to Ghana's Monetary Policy Rate, as well as ascertain some findings and results of other research on the topic done by other researchers.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This section goes on the procedures that were used to conduct the analysis. Following a brief overview of the research plan, dataset, and data analysis, the concepts of forecasting, as well as the foundation for using this technique, are taught by examining the meaning of a time series and how it is forecasted. I will go over some of the basic principles that are widely used in time series data modeling. This part also goes over the Vector Auto-regression modeling technique that was utilized to analyse the data set. The stages of the analysis, as well as the relevant test statistics employed in the study, are also described.

3.2 Research Design

The study focuses on monetary policy shocks and how it responds to commodity price fluctuations in Ghana. It describes the interaction between Ghana's monetary policy rates (MPR) and cocoa, crude oil, and gold prices. The study looks at how Ghana's monetary policy reacts to commodity price variations and how it responds to monetary policy shocks. It describes the relationship between Ghana's MPR and the prices of cocoa, crude oil, and gold. As a result, the study is descriptive rather than experimental. All the prices were from 1999 to 2018 and are based on International Cocoa price (US$/Tonne), International Brent crude oil (US$/ Barrel), and International Gold (US$/fine ounce) all based on the monthly averages for each commodity and which was used to describe the relationship between MPR and commodity prices of cocoa, gold and crude oil by adopting Vector Auto-regressive approach.

3.3 Source Of data

The information gathered is secondary information compiled by the Bank of Ghana. The data was received from the Bank of Ghana through the Department of Statistics, University of Ghana, Legon, Accra, and covers commodity prices for cocoa, gold, crude oil, and MPR from 1999 to 2018. All of the data was in the form of a time series. Using the E-VIEW software package, vector auto-regressive models were used to analyse the data.

3.4 Data Analysis

The retrieved data were sent into E-View, which generated summary statistics and figures. E-View is a statistical software tool that specializes in time-series econometric research. Quantitative Micro Software (QMS) created it and is known for its predictive analytics, which was utilised in this study.

3.4.1 Stochastic Process:

A stochastic process is a system that evolves over time with random fluctuations. We can define a family of random variables, Xt, to characterize such a system, where Xt measures the aspect of the system that is of interest at time t. The state space of the process, S, is the set of values that the random variables Xt can take.

3.4.2 Stationary Time Series:

Strict or Weakly stationary stochastic processes can be identified. If the joint distributions of Xt1, Xt2,..., Xtn and Xk+t1, Xk+t2,..., Xk+tn are identical for all t1, t2,..., tn in J and all integers n, it is said to be strictly stationary. If the mean and auto covariance do not rely on time, a series is said to be (weakly or covariance) stationary; whereas, non-stationary series do. A popular non-stationary sequence is the random walk. The lag is equal to the time difference t – s in a stationarity test.

3.4.3 Vector Auto-regressive and Error Correction Model:

The vector auto-regressive (VAR) model, which evolved from the univariate auto-regressive (AR) model, is a multivariate time series formulation. Sims (1980) presented it as a way to get over the "huge identification restrictions" of (large scale) structural econometric models, and it has since proven to be a helpful tool in empirical macro econometrics. Following the pioneering work on non-stationarity of variables by Engle and Granger (1987), which has profoundly influenced current time series econometrics, Johansen and Juselius (1990, 1992) extend the VAR model by studying long-run interactions among non-stationary variables using cointegration and error-correction techniques. This method is known as the vector error-correction model (VECM) or the cointegrated VAR (CVAR) mode.

In a typical unlimited VAR specification, each variable has its own equation. As a result, all variables are considered endogenous, eliminating the requirement for arbitrary endogenous-exogenous distinctions. All assumptions concerning endogeneity and causal effects can be tested using the VAR framework (and hence substantiated). Furthermore, each endogenous variable has a set of explanatory variables that includes its own lags as well as the lags of all other variables in the model, allowing complicated dynamic effects to be captured. In the unconstrained version, all of the variables in the system are treated symmetrically using the same set of regressors.

The main characteristics of the reduced form VAR and the VECM representation will be explained in the following paragraphs.

Consider the simplified form of an nth order vector auto-regressive model with p variables, sometimes known as a p-dimensional VAR(n):

$$\mathbf{y_t = \sum_{i=0}^{n} \pi_i y_{t-i} + \emptyset D_t + \varepsilon_t}$$

where y_t is a $\mathbf{p \times 1}$ vector of endogenous variables with t = 1, 2, …, T; Π_i are $\mathbf{p \times p}$ matrices of parameters (i.e., coefficients to be estimated) with i = 1, 2, …, n; D_t is a vector of deterministic components (e.g., intercept, trend and dummy variables), with a vector of coefficients ϕ; and ε_t is a **p × 1** vector of (unobservable) error terms. The parameters of the VAR(n) model are linear and assumed to be constant across time. Furthermore, we assume that the error terms are distributed equally and independently, i.e., they are serially uncorrelated. ($E(\varepsilon_t \varepsilon'_{t-n}) = 0$ for $n \neq 0$), have zero mean ($E(\varepsilon_t) = 0$), and have a time-invariant positive definite covariance matrix ($E(\varepsilon_t \varepsilon'_t) = \Omega$). Hence, the error terms follow a Gaussian (normal) distribution (or white-noise process): $\varepsilon_t \sim$ iid $N_p(0, \Omega)$. The residual covariance matrix (Ω) has dimensions **p × p** and contains information about possible contemporaneous effects. These assumptions are "compatible with rational economic agents who do not make systematic errors when making plans for time t based on the available information at time t – 1." (Juselius, 2007:46). These qualities must be met in order to make credible statistical and economic inferences. Several misspecification tests can be performed to determine whether these assumptions are reasonable.

Because VAR processes are simply a reformulation of the data covariances, they are an appropriate class of models for characterizing the data producing process of a limited collection of variables (Lütkepohl and Krätzig, 2004:86). (Juselius, 2007:46). The dynamic and stability features of the process can be explored by looking at the process's roots. Exponentially falling behaviour is generated by a real root inside the unit circle (|j| 1). If the modulus of a complex pair of roots (|j| = |real iρcomplex|) is within the unit circle, the cyclical behaviour will be exponentially declining. Both sorts of roots are consistent with stationary processes (all variables are stationary), but their dynamics are different. Furthermore, a real root on the unit circle (|j| = 1) causes non-stationary behaviour, but a complex pair of roots with a modulus of one generates non-stationary seasonal behaviour (Juselius, 2007:49). Finally, we have an explosive process if any of the roots are outside the unit circle (|j| > 1).

Inferences based on the VAR may be incorrect, and the correlations between the variables may be deceptive, if the process has non-stationary behavior (at least one variable is non-stationary). A cointegration methodology will be better appropriate for data analysis in this case. For this, we apply the general Vector Error Correction Model (VECM). Due to the clear separation of long-run and short-run consequences, the VECM is a simple formulation that allows for intuitive interpretation of the estimations. Because the first differences of the variables are more "orthogonal" than the levels, the specification decreases the influence of multicollinearity. It is important to note that the reformulation of the VAR model into a VECM imposes no binding limitations on the original parameters (Juselius, 2007:60-1). As a result, the value of the maximised likelihood function remains unchanged, and the estimated parameters of both versions are identical.

The VAR model, as previously stated, is an effective tool for summarizing data attributes. Due to the fact that the calculated VAR is simply a reduced form model, the estimated parameters cannot be given a meaningful economic interpretation. This means that all variables on the right-hand side are either predetermined or exogenous, and the residual covariance matrix (Ω) will capture any contemporaneous effects in the data. This reflects the fact that, in order to estimate the endogenous variables, the underlying structural form VAR (from which the reduced form was derived) has to be solved. The VAR technique suffers from many of the same estimation and identification issues as (conventional) structural macro econometric models. In reality, several economic models can be considered as a subset of the unconstrained structural VAR, which is a broader category of models. As a result, the problem is to recover knowledge about structural factors that will allow us to analyse crucial economic issues.

3.4.4 Criteria for Model Selection (Optimal Lag Order Selection):

The VAR order that minimizes them over a set of alternative orders k= 0,..., pmax is chosen via the regular model selection criteria employed in this framework.

A set of such criteria takes the following general form:

$$\mathbf{H(k) = log\ det}\left(\mathbf{U^{-1}\sum_{u=1}^{U} V_u}\right) + \mathbf{cT_{p(k)}}$$

Where $\boldsymbol{U^{-1}\sum_{u=1}^{U} V_u}$ is the residual covariance matrix estimator for a model of order ***k, p(k)*** is a function of order k that penalizes large VAR orders, and $\boldsymbol{cT}$ is a sequence that specifies the specific criterion and may depend on the sample size.

The term $\mathbf{log\ det}\left(\mathbf{U^{-1}\sum_{u=1}^{U} V_u}\right)$ is a non-increasing function of order u, whereas $\boldsymbol{\rho(k)}$ increases as $\mathbf{k}$ increases. The lag order is designed to best balance these two forces. The goal of determining the best lag is to eliminate residual correlation. For picking the best lag, literature suggests using Akaike, Hanna-Quin, and Schwarz information criteria, as well as Sim's Likelihood test. The AIC always recommends the greatest order, the SC the lowest order, and HQ somewhere in the middle (Lutkepohl 2005, Chapters 4 and 8). Without a doubt, this does not rule out the possibility that all three criteria agree on the VAR order. If p max surpasses the genuine order, the HQ and SC criteria are both trustworthy, meaning that the order estimated with these criteria converges in probability or practically to the true VAR order p under relative conditions. The AIC criterion, on the other hand, tends to overestimate the order asymptotically.

3.4.5 Cointegration Rank:

We can test for the presence of unit roots in the multivariate framework once a well-specified statistical model has been created. The cointegration rank is determined using the rank test for both the Trace and Maximum eigenvalues. It's a likelihood ratio test based on the R-form of the

VAR model, which implies it concentrates short-run dynamics and (some) deterministic components.

The test compares the null hypothesis's log likelihood function (H0: rank = p) against the value for the alternative where rank = r. The test doesn't tell us how many unit roots there are.

As a result, a ‘top-to-bottom' sequential procedure is used to determine the cointegrating rank (r), which is asymptotically more accurate than the ‘bottom-to-top' option (Juselius, 2007:133).

The Johansen test statistic has a non-standard distribution that has been discovered through simulations (Johansen, 1996). It's also worth noting that the test's asymptotic distribution is influenced by the deterministic components used. Furthermore, short-run effects were believed to be insignificant asymptotically (thus, focused out), which may not be true in small samples.

The cointegrating rank is a challenging decision that might have a big impact on the analysis. As a result, especially in light of the shortcomings of formal test techniques, Juselius (2007:142) advises that supplementing the standard analysis with other relevant data is frequently beneficial. The following are examples of robustness tests:

1. investigation of the distinctive roots
2. iterative graphs of the trace statistic importance of the adjustment coefficients
3. plots of cointegration relationships; and
4. the results' economic interpretability

3.4.6 Stability:

The stability of a VAR(p)-process is one of its most notable characteristics. Given adequate beginning values, the stability creates stationary time series with time invariant means, variances, and covariance structure. The characteristic polynomial can be used to verify this.

3.5 Diagnostic testing (VAR)

3.5.1 Statistical Tests

Causality Test:

There are a variety of techniques to conduct causality tests, but the Granger causality test is the focus of this research. The Granger causality test is a statistical hypothesis test for assessing whether one time series may be used to predict another. It was first published in 1960. In time series analysis, it's used to see if changes in one variable influence changes in others. VAR models also allow you to investigate the relationship between the variables.

The study of causal relationships is particularly interesting. According to Granger (1969), causality in the setting of time series has become increasingly common in practical work. If the information in y_{1t} is useful for enhancing the forecasts of y_{2t}, he calls the variable y_{1t} causative for the variable y_{2t}.

According to Granger, there are two types of causation: long-run and short-run causality. This may necessitate the use of error correction models, depending on the mechanism of causality determination. Long-run causality is determined by the error correction term, which, if significant, indicates evidence of long-run causality from the explanatory variable to the dependent variable. The Wald test is used to assess short-run causation by looking at the combined significance of the lagged explanatory variables.

Normality Test (Residual Analysis):

Normality tests are used in statistics to examine if a data set can be well-modelled by a normal distribution and how likely a random variable underlying the data set is to be normally distributed. Multivariate normality test displays the χ^2**-statistics** associated with the skewness and kurtosis of the residuals which may be used for tests of non-normality. Most normality tests compare empirical cumulative distributions to theoretical normal cumulative distributions

(Kolmogorov-Smirnov, Anderson-Darling, etc.) or empirical quantiles to theoretical normal based on sample skewness and sample kurtosis.

Serial correlation (Portmanteau Test):

The portmanteau test is a statistical hypothesis test in which the null hypothesis is well defined, but the alternative hypothesis is not. By checking the null hypothesis that all residual autocorrelations are zero, this test is designed for residual autocorrelation tests, that is, **H_0:** $\boldsymbol{E(v_t\, v'_{t-1}) = 0}$ **(i = 1, 2,)**. It is tested against **H_1:** $\boldsymbol{E(v_t\, v'_{t-1}) \neq 0}$ for at least one auto-covariance and, hence one autocorrelation is non zero. The residual auto-covariances serve as the basis for the test statistic.

When there are many ways for a model to stray from the underlying data generation process, the portmanteau test is a reasonable approach to proceed as a broad assessment of a model match to a dataset.

3.5.2 Impulse Response Function

An impulse response function defines the evolution of the variable of interest over a given time horizon after a shock in a specific moment. Impulse response analysis is a common approach for analysing the relationships between the variables in a VAR model. This makes them highly useful tools for evaluating economic policies enabling tracking the transmission of a single shock within an otherwise noisy system of equations.

CHAPTER 4

PRESENTATION AND DISCUSSION OF DATA ANALYSES

4.1 Introduction

The analyses of Ghana's monetary policy rates (MPR) and cocoa, crude oil, and gold prices are presented in this segment. Using the E-VIEW software package, vector auto-regressive models were used to analyse the data. On the cocoa, crude oil, gold, and MPR series, descriptive statistics graphs displaying trends and stationarities, lag order selection criteria, roots of characteristic polynomial, testing of some hypotheses and co-integration studies were performed.

4.2 Cocoa, Crude Oil, Gold, And MPR Descriptive Statistics

Table 4. 1: Shows Descriptive Information for Cocoa, Crude Oil, Gold and MPR Prices

	COCOA	CRUDE	GOLD	MPR
Mean	2146.197	64.80314	907.7248	19.34716
Median	2180.180	60.90000	942.5800	18.50000
Maximum	3430.350	134.7900	1770.130	27.50000
Minimum	701.4300	19.17000	257.8200	12.50000
Std. Dev.	716.5074	30.82399	465.3154	4.996062
Skewness	-0.164124	0.355676	0.011159	0.318348
Kurtosis	1.991153	1.972557	1.647868	1.683545
Observations	229	229	229	229

Each variable, cocoa, crude oil, gold, and MPR, received a total of 229 observations. The table's mean monthly average prices for cocoa, petroleum, and gold are US$2,146.20 per tonne, US$64.80 per barrel, and US$907.72 per fine ounce, respectively, while MPR is 19.35 percent. The skewness values for cocoa, crude oil, gold, and MPR are -0.1641, 0.3557, 0.0112 and 0.3183, respectively. Gold has a positive skewness, which is closer to zero than cocoa, crude oil and MPR. This indicates that data for gold data is distributed more regularly, followed by cocoa, MPR, and crude oil, in that order.

4.3 Stationarity Test

Table 4. 2: Stationarity Test with Enhanced Dickey-Fuller

Null Hypothesis: COCOA has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.215689	0.2014
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

Null Hypothesis: CRUDE Oil has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.269177	0.1830
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

Null Hypothesis: GOLD has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.161700	0.6911
Test critical values:	1% level	-3.459101	
	5% level	-2.874086	
	10% level	-2.573533	

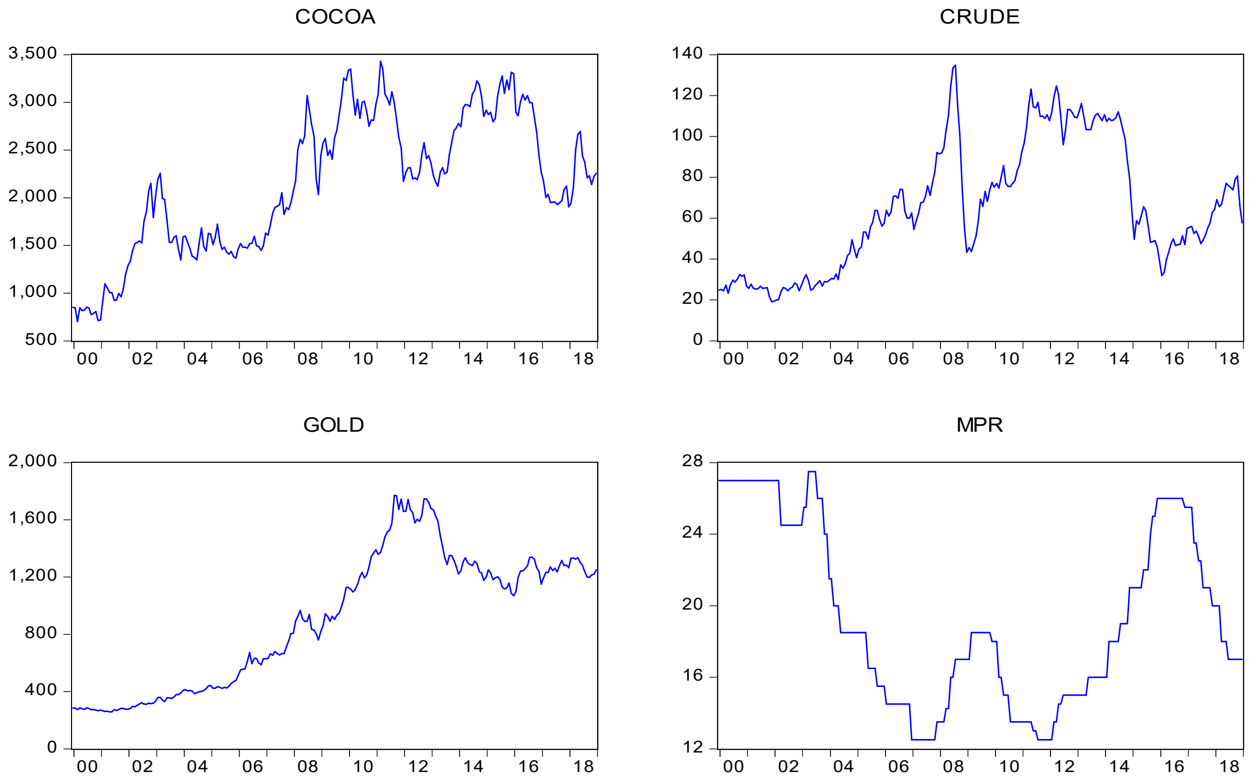
Null Hypothesis: MPR has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.147705	0.2264
Test critical values:	1% level	-3.459627	
	5% level	-2.874317	
	10% level	-2.573656	

*MacKinnon (1996) one-sided p-values

The values obtained from the foregoing stationarity tests on **(Table 4.2)** show the null hypotheses at various significance levels, hence we keep the null hypotheses at various significance levels. These results indicate that the series does indeed have a unit root, indicating that cocoa, crude oil, gold, and MPR are non-stationary.

Figure 4. 1: Trends in Cocoa, Crude Oil, Gold, and MPR



The graphs of cocoa, crude oil, gold, and MPR are shown in **Figure 4.1**. Cocoa, crude oil, and gold exhibit non-stationary and trended behaviour in the graphs, whereas MPR exhibits non-stationary and untrended behaviour. This finding confirms that our series does indeed have a unit root; as a result, cocoa, crude oil, gold and MPR exhibit non-stationary behaviour.

4.4 Model Selection Criteria

As Lutkepohl (1991) pointed out, choosing a greater order lag length than the genuine lag length increases the VAR's mean square prediction errors, whereas choosing a lower order lag length than the true lag length frequently creates auto correlated errors. As a result, choosing the correct lag lengths has a considerable impact on the accuracy of VAR model forecasts.

Table 4. 3: Choosing the Best Lag Order

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4865.187	NA	1.61e+14	44.06504	44.12655	44.08988
1	-3383.119	2897.075	2.79e+08	30.79745	31.10498*	30.92163
2	-3343.080	76.81680	2.24e+08	30.57991	31.13345	30.80342*
3	-3325.623	32.85965*	2.21e+08*	**30.56672***	31.36629	30.88957
4	-3316.443	16.94843	2.36e+08	30.62844	31.67403	31.05063
5	-3304.573	21.48346	2.45e+08	30.66582	31.95743	31.18735
6	-3296.559	14.21498	2.64e+08	30.73809	32.27572	31.35896
7	-3284.424	21.08561	2.74e+08	30.77307	32.55672	31.49327
8	-3277.634	11.55201	2.98e+08	30.85641	32.88609	31.67596

* Indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

The minimum value of LR, FPE, AIC, SC, and HQ is discovered using this study. The AIC, on the other hand, is lower than the SC at order three lag lengths, indicating that the Vector Auto-regressive model of order three is the best option for the analysis.

4.5 Cointegration Rank and Stability Determination

The unconstrained rank test, matrix roots of the characteristic polynomials and the inverse root of AR characteristic polynomial potential cointegrating relations are shown in the tables and graphs below, demonstrating the long-run and stability of the variables.

Table 4. 4: Johansen Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.118125	52.90857	47.85613	0.0156
At most 1	0.064877	24.62493	29.79707	0.1753
At most 2	0.025484	9.532621	15.49471	0.3184
At most 3	0.016417	3.724464	3.841466	0.0536

Table 4. 5: Johansen Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.118125	28.28364	27.58434	0.0407
At most 1	0.064877	15.09231	21.13162	0.2825
At most 2	0.025484	5.808157	14.26460	0.6380
At most 3	0.016417	3.724464	3.841466	0.0536

Both Max-eigenvalue 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

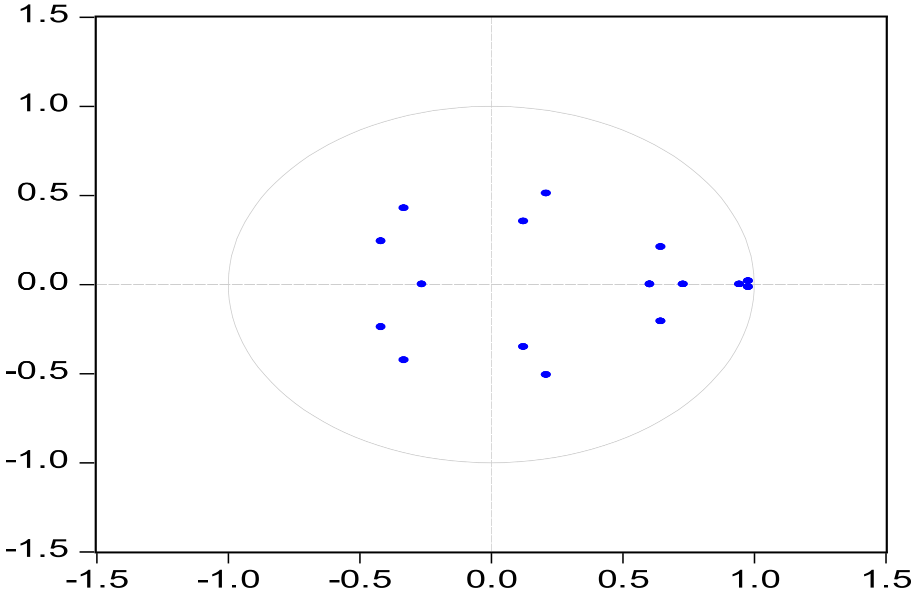
The Johansen Unrestricted Cointegration Rank Test at a 5% alpha level indicates evidence of a long-run relationship between the variables, especially cocoa, crude oil, gold, and MPR prices, for both Trace and Maximum Eigenvalues. This is consistent with E. Y Boateng P. K. Yeboah, I. C. Otoo, and J. Otoo (2020). Both their Trace test and Max-eigenvalue suggest only one co-integrating eqn(s) at the 5% level, indicating evidence of a long run-link between their variables.

Table 4. 6: Roots of Characteristic Polynomial

Root	**Modulus**
0.980577 - 0.016986i	0.980724
0.980577 + 0.016986i	0.980724
0.945892	0.945892
0.732203	0.732203
0.647659 - 0.209083i	0.680571
0.647659 + 0.209083i	0.680571
0.606241	0.606241
0.211339 - 0.508995i	0.551127
0.211339 + 0.508995i	0.551127
-0.328762 - 0.426067i	0.538162
-0.328762 + 0.426067i	0.538162
-0.415460 - 0.240554i	0.480076
-0.415460 + 0.240554i	0.480076
0.124839 - 0.352268i	0.373735
0.124839 + 0.352268i	0.373735
-0.260087	0.260087

VAR meets the stability criteria because no root is outside the unit circle, as shown in the table above.

*Figure 4. 2**:** Inverse Root of AR Characteristic Polynomial*



The roots of the characteristic polynomial indicate that after differencing the variables, namely the prices of cocoa, crude oil, gold, and MPR, the variables are now stationary after differencing and that no spurious regression will result when establishing the relationship between any two of the variables.

4.6 Structural Evaluation

This section's major goal is to provide a useful economic interpretation of the CVAR or VECM results. To accomplish this, I must handle two distinct (but connected) identification issues:

1. the determination of long-term relationships, and
2. the discovery of the short-term structure

In practice, the cointegrating relations must be constrained, and the system's differenced equations must be subjected to a dynamic adjustment framework. These limitations are required to simply identify the system, allowing a more relevant inference to be made afterwards

4.7 Vecm Granger Causality / Block Exogeneity Wald Test

Table 4. 7: Dependent variable COCOA

Excluded	Chi-sq	df	Prob.
CRUDE	0.539877	3	0.9100
GOLD	4.055800	3	0.2555
MPR	11.63254	3	0.0088
All	15.84308	9	0.0702

Table 4. 8: Dependent variable: CRUDE

Excluded	Chi-sq	df	Prob.
COCOA	2.439858	3	0.4863
GOLD	13.89033	3	0.0031
MPR	22.24323	3	0.0001
All	31.26025	9	0.0003

Table 4. 9: Dependent variable: GOLD

Excluded	Chi-sq	df	Prob.
COCOA	15.03735	3	0.0018
CRUDE	3.592271	3	0.3090
MPR	9.470242	3	0.0237
All	27.67665	9	0.0011

Table 4. 10: Dependent variable: MPR

Excluded	Chi-sq	df	Prob.
COCOA	6.120093	3	0.1059
CRUDE	1.017258	3	0.7971
GOLD	6.290400	3	0.0983
All	11.84655	9	0.2221

Block Exogeneity / Granger Causality Vecm A p-value of 0.0088 suggests a significant association between cocoa and MPR, whereas a p-value of 0.0702 indicates no significant relationship between cocoa and all other variables, including crude oil, gold, and MPR, according to Wald tests **(Table 4.7)**. A significant link between crude oil and gold, crude oil and MPR, crude oil and all other variables is indicated by P-values of 0.0031, 0.0001, and 0.0003, respectively **(Table 4.8).** A p-value of 0.3090 indicates that gold and crude oil have no significant relationship, whereas p-values of 0.0237 and 0.0018 suggest that gold and MPR, and gold and cocoa, respectively, have significant relationships **(Table 4.9)**.

Table 4. 11: Error Correction Criteria Test

	Coefficient	Std. Error	t-Statistic	Prob.
C (1)	0.011729	0.011548	1.015618	0.3110
C (2)	-0.066535	0.070570	-0.942827	0.3468
C (3)	0.192887	0.071654	2.691929	0.0077
C (4)	0.133532	0.072454	1.842979	0.0667
C (5)	0.000422	0.000323	1.306805	0.1927
C (6)	0.000251	0.000325	0.773032	0.4404
C (7)	0.000374	0.000326	1.148663	0.2520
C (8)	-0.001460	0.008427	-0.173212	0.8627
C (9)	0.001879	0.009229	0.203547	0.8389
C (10)	-0.007820	0.008722	-0.896552	0.3710
C (11)	-0.000956	0.001129	-0.846712	0.3981
C (12)	-0.001379	0.001130	-1.221156	0.2234
C (13)	-0.000923	0.001119	-0.824552	0.4106
C (14)	-0.024341	0.040831	-0.596153	0.5517

R-squared	0.125312	Mean dependent var	-0.044444
Adjusted R-squared	0.071421	S.D. dependent var	0.621169
S.E. of regression	0.598576	Akaike info criterion	1.871674
Sum squared resid	75.59978	Schwarz criterion	2.084232
Log likelihood	-196.5634	Hannan-Quinn criterion	1.957464
F-statistic	2.325295	Durbin-Watson stat	2.025703
Prob(F-statistic)	0.006601		

In the lag 3 model, the error correction criterion test (**Table 4.11**) finds no significant difference between cocoa and MPR, crude oil and MPR, or gold and MPR. That is, there is no long-term correlation between cocoa, crude oil, and gold, and MPR.

*Table 4. 12**:** Cocoa Causality Wald Test*

Test Statistic	Value	df	Probability
F-statistic	0.060451	(2, 211)	0.9414
Chi-square	0.120903	2	

Null Hypothesis: C(5) =C(6)=C(7)
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5) - C(7)	4.78E-05	0.000430
C(6) - C(7)	-0.000123	0.000497

Restrictions are linear in coefficients.

The Wald test **(Table 4.12)** suggests that there is no short-run causality between cocoa and MPR in the lag 3 model, implying that cocoa does not induce MPR in the short run.

*Table 4. 13**:** Crude Causality Wald Test*

Test Statistic	Value	df	Probability
F-statistic	0.255170	(2, 211)	0.7750
Chi-square	0.510339	2	0.7748

Null Hypothesis: C(8) =C(9) =C(10)

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(8) - C(10)	0.006360	0.012141
C(9) - C(10)	0.009699	0.014580

Restrictions are linear in coefficients

The Wald test (**Table 4.13**) demonstrates that there is no short-run causation from crude oil to MPR in the lag 3 model, implying that crude oil does not cause MPR in the short run.

*Table 4. 14**:** Gold Causality Wald Test*

Test Statistic	Value	df	Probability
F-statistic	0.042763	(2, 211)	0.9581
Chi-square	0.085527	2	0.9581
Null Hypothesis: C(11)=C(12)=C(13)			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
C(11) - C(13)		-3.30E-05	0.001556
C(12) - C(13)		-0.000457	0.001686

Restrictions are linear in coefficients.

The Wald test (**Table 4.14**) at a 5% significance level suggests that there is no short run causation from gold to MPR, implying that gold does not cause MPR in the lag 3 model in the short run.

4.8 Structural Moving Average Model

This section aims to provide additional evidence on shock dynamics. I did this by looking at the variance decomposition representation and using impulse response functions to simulate the effects of shocks on our system. In the table and figure below, the variance decompositions and impulse response functions of the variables are used to help us find the model's common patterns with the cumulated disturbances. It's easier to notice how the variables react to typical patterns when you do this. The 'long-run effect matrix' depicts the long-term interactions of the variables MPR, Cocoa, Crude, and Gold.

Table 4. 15: Variance Decomposition of Cocoa, Crude, Gold and MPR

Variance Decomposition of MPR:

Period	S.E.	MPR	COCOA	CRUDE	GOLD
1	0.596443	100.0000	0.000000	0.000000	0.000000
2	0.827479	99.28185	0.327753	0.005389	0.385005
3	1.096175	97.34107	1.070297	0.003173	1.585457
4	1.319966	95.96419	1.779225	0.010849	2.245740
5	1.530441	94.69522	2.614009	0.047310	2.643463
6	1.721359	93.60649	3.369837	0.128751	2.894917
7	1.897996	92.63806	4.044821	0.253096	3.064025
8	2.061623	91.75629	4.650294	0.409073	3.184339
9	2.214113	90.95317	5.194831	0.580841	3.271155
10	2.356305	90.22991	5.682972	0.754913	3.332209
11	2.488971	89.58689	6.118547	0.921505	3.373061
12	2.612698	89.02174	6.505335	1.074858	3.398067
13	2.728076	88.52906	6.847952	1.212291	3.410693
14	2.835686	88.10154	7.151506	1.333264	3.413693
15	2.936106	87.73110	7.421165	1.438508	3.409226
16	3.029903	87.40977	7.661832	1.529417	3.398982
17	3.117616	87.13013	7.877950	1.607639	3.384283
18	3.199749	86.88558	8.073421	1.674838	3.366165
19	3.276768	86.67039	8.251598	1.732567	3.345443
20	3.349096	86.47972	8.415314	1.782204	3.322758
21	3.417117	86.30950	8.566938	1.824945	3.298617
22	3.481175	86.15633	8.708438	1.861806	3.273425
23	3.541581	86.01742	8.841435	1.893641	3.247503

24	3.598611	85.89046	8.967266	1.921167	3.221109
25	3.652514	85.77354	9.087029	1.944981	3.194451
26	3.703515	85.66509	9.201626	1.965585	3.167698
27	3.751814	85.56382	9.311799	1.983399	3.140987
28	3.797593	85.46863	9.418159	1.998777	3.114428
29	3.841017	85.37865	9.521211	2.012021	3.088114
30	3.882237	85.29313	9.621370	2.023384	3.062119
31	3.921388	85.21143	9.718982	2.033088	3.036504
32	3.958596	85.13303	9.814331	2.041322	3.011318
33	3.993976	85.05749	9.907654	2.048249	2.986602
34	4.027634	84.98445	9.999149	2.054014	2.962388
35	4.059666	84.91358	10.08898	2.058741	2.938702
36	4.090164	84.84462	10.17728	2.062543	2.915565

Variance Decomposition of COCOA:

Period	S.E.	MPR	COCOA	CRUDE	GOLD
1	132.4018	0.077495	99.92250	0.000000	0.000000
2	204.3830	2.104499	97.86052	0.025198	0.009782
3	250.1154	1.992163	97.49367	0.049975	0.464187
4	284.9505	1.835001	97.23083	0.087358	0.846811
5	311.7278	1.627707	97.10555	0.148852	1.117893
6	333.6647	1.445596	96.98305	0.236584	1.334769
7	352.3548	1.297970	96.83600	0.345306	1.520721
8	368.5728	1.188457	96.65577	0.468626	1.687149
9	382.8148	1.116227	96.44402	0.599659	1.840091
10	395.4472	1.078873	96.20771	0.732870	1.980542

11	406.7439	1.073614	95.95295	0.864260	2.109174
12	416.9176	1.097387	95.68464	0.991225	2.226744
13	426.1335	1.147366	95.40624	1.112262	2.334133
14	434.5219	1.221033	95.12002	1.226683	2.432264
15	442.1871	1.316241	94.82738	1.334343	2.522040
16	449.2148	1.431166	94.52910	1.435432	2.604298
17	455.6762	1.564254	94.22562	1.530324	2.679800
18	461.6318	1.714158	93.91714	1.619476	2.749223
19	467.1335	1.879688	93.60379	1.703361	2.813165
20	472.2263	2.059767	93.28566	1.782431	2.872145
21	476.9498	2.253395	92.96288	1.857104	2.926616
22	481.3386	2.459630	92.63565	1.927748	2.976969
23	485.4239	2.677567	92.30420	1.994689	3.023542
24	489.2330	2.906326	91.96884	2.058206	3.066630
25	492.7906	3.145049	91.62992	2.118543	3.106492
26	496.1189	3.392891	91.28785	2.175908	3.143354
27	499.2376	3.649026	90.94307	2.230484	3.177418
28	502.1648	3.912639	90.59607	2.282428	3.208864
29	504.9167	4.182930	90.24733	2.331880	3.237855
30	507.5077	4.459119	89.89738	2.378963	3.264539
31	509.9512	4.740441	89.54672	2.423787	3.289054
32	512.2591	5.026153	89.19587	2.466453	3.311523
33	514.4423	5.315533	88.84535	2.507052	3.332065
34	516.5106	5.607883	88.49566	2.545668	3.350788
35	518.4730	5.902528	88.14730	2.582379	3.367796
36	520.3375	6.198821	87.80073	2.617261	3.383186

Variance Decomposition of CRUDE:

Period	S.E.	MPR	COCOA	CRUDE	GOLD
1	4.786176	0.051428	8.874314	91.07426	0.000000
2	7.658261	0.025498	9.524854	90.40654	0.043110
3	9.768596	0.021026	10.99707	88.91877	0.063132
4	11.11054	0.143592	11.64105	88.03727	0.178087
5	11.91281	0.671200	11.67186	87.13937	0.517571
6	12.40146	1.886663	11.28609	85.67147	1.155781
7	12.76004	3.974293	10.71714	83.20615	2.102417
8	13.10637	6.876169	10.18173	79.66026	3.281836
9	13.49559	10.32613	9.796757	75.31092	4.566187
10	13.93867	13.98185	9.579048	70.60698	5.832122
11	14.42341	17.55732	9.486360	65.96000	6.996318
12	14.93007	20.87712	9.461670	61.64049	8.020720
13	15.44014	23.86654	9.458327	57.77503	8.900103
14	15.93975	26.51671	9.447029	54.38965	9.646614
15	16.42002	28.85259	9.413456	51.45524	10.27871
16	16.87614	30.91204	9.353330	48.91946	10.81518
17	17.30621	32.73456	9.268024	46.72482	11.27259
18	17.71021	34.35632	9.161533	44.81746	11.66469
19	18.08920	35.80842	9.038671	43.15041	12.00250
20	18.44477	37.11687	8.904106	41.68423	12.29480
21	18.77874	38.30307	8.761939	40.38643	12.54856
22	19.09295	39.38462	8.615564	39.23045	12.76937
23	19.38914	40.37591	8.467680	38.19467	12.96174
24	19.66890	41.28883	8.320370	37.26143	13.12937

25	19.93368	42.13322	8.175199	36.41627	13.27532
26	20.18474	42.91728	8.033315	35.64727	13.40214
27	20.42323	43.64791	7.895530	34.94454	13.51202
28	20.65015	44.33093	7.762396	34.29985	13.60683
29	20.86639	44.97130	7.634264	33.70627	13.68816
30	21.07272	45.57330	7.511330	33.15793	13.75744
31	21.26985	46.14059	7.393672	32.64984	13.81590
32	21.45839	46.67636	7.281281	32.17774	13.86462
33	21.63892	47.18341	7.174080	31.73794	13.90458
34	21.81192	47.66416	7.071947	31.32725	13.93664
35	21.97785	48.12080	6.974725	30.94289	13.96159
36	22.13713	48.55521	6.882233	30.58245	13.98010

Variance Decomposition of GOLD:

Period	S.E.	MPR	COCOA	CRUDE	GOLD
1	36.26635	0.639452	2.744862	0.375935	96.23975
2	55.37978	0.326710	5.930691	0.837733	92.90487
3	67.84152	0.385463	4.921015	0.821862	93.87166
4	78.38420	0.934767	4.133957	0.659756	94.27152
5	87.52465	1.476705	3.867118	0.533775	94.12240
6	95.88695	2.062386	3.820672	0.528904	93.58804
7	103.7450	2.652423	3.910622	0.656149	92.78081
8	111.1925	3.244040	4.096446	0.887676	91.77184
9	118.2724	3.822076	4.361132	1.186499	90.63029
10	125.0211	4.378024	4.701389	1.519089	89.40150
11	131.4670	4.904414	5.116353	1.860590	88.11864

12	137.6368	5.398822	5.602368	2.194615	86.80420
13	143.5553	5.861589	6.153453	2.511604	85.47335
14	149.2449	6.295076	6.761605	2.806836	84.13648
15	154.7261	6.702612	7.417533	3.078737	82.80112
16	160.0168	7.087922	8.111340	3.327617	81.47312
17	165.1325	7.454724	8.833095	3.554805	80.15738
18	170.0863	7.806520	9.573267	3.762107	78.85811
19	174.8893	8.146474	10.32304	3.951472	77.57901
20	179.5507	8.477378	11.07450	4.124807	76.32331
21	184.0780	8.801638	11.82074	4.283884	75.09374
22	188.4776	9.121298	12.55584	4.430297	73.89256
23	192.7547	9.438076	13.27487	4.565459	72.72159
24	196.9139	9.753393	13.97380	4.690601	71.58221
25	200.9590	10.06842	14.64940	4.806799	70.47538
26	204.8932	10.38410	15.29917	4.914984	69.40175
27	208.7196	10.70120	15.92123	5.015964	68.36161
28	212.4408	11.02031	16.51423	5.110441	67.35502
29	216.0594	11.34189	17.07729	5.199028	66.38179
30	219.5775	11.66630	17.60990	5.282258	65.44154
31	222.9975	11.99378	18.11189	5.360599	64.53373
32	226.3214	12.32450	18.58332	5.434463	63.65772
33	229.5513	12.65854	19.02451	5.504212	62.81274
34	232.6894	12.99593	19.43592	5.570167	61.99798
35	235.7375	13.33666	19.81819	5.632611	61.21253
36	238.6978	13.68066	20.17205	5.691796	60.45549

Cholesky Ordering: MPR COCOA CRUDE GOLD

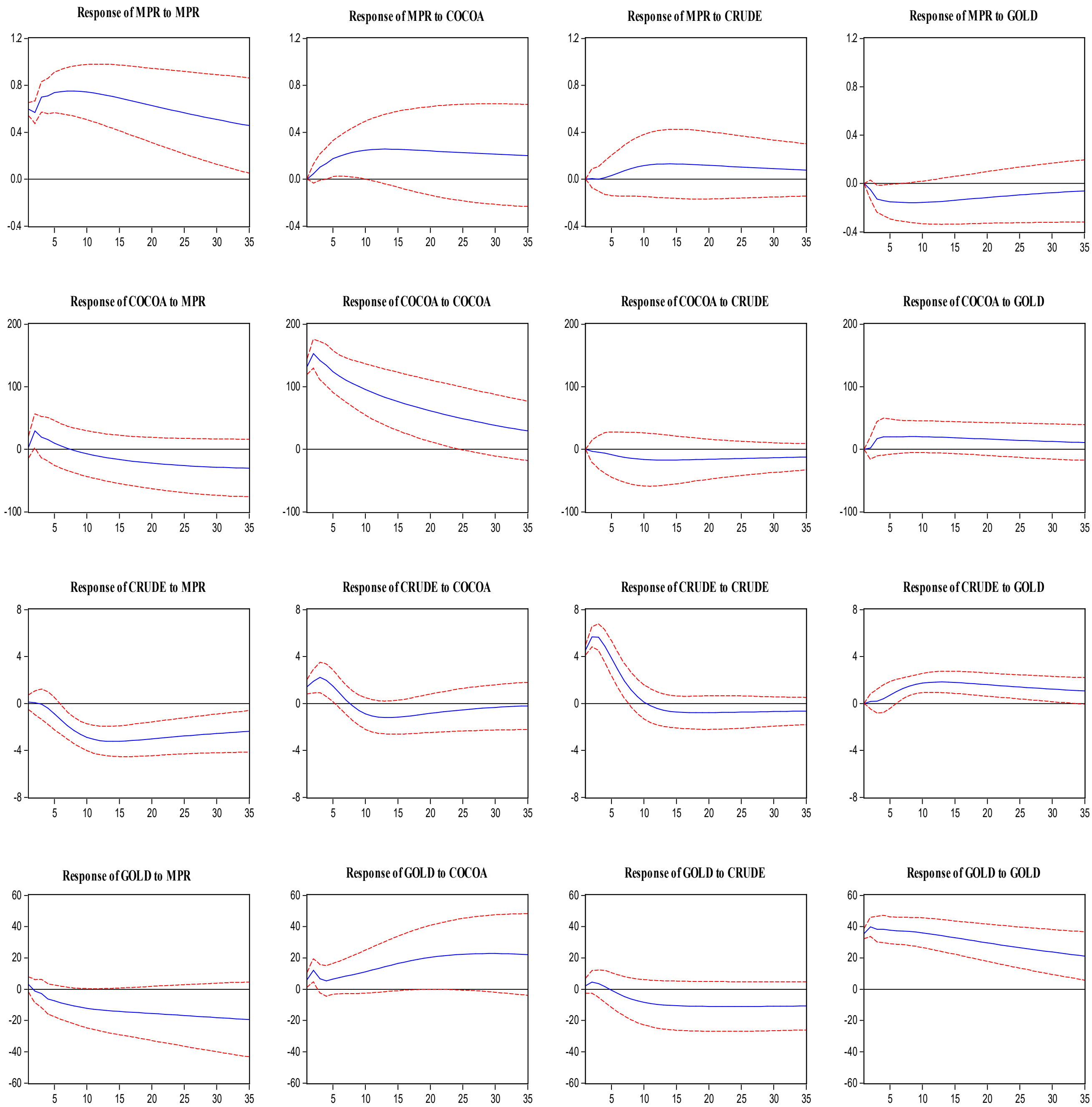
Table 4.15 shows the variance decomposition of MPR, cocoa, crude oil and gold from period 1 to period 36. In period 1, the variance decomposition of MPR to MPR is 100 percent, but 0 percent for MPR to cocoa, MPR to crude oil and MPR to gold, however the variance decomposition of MPR to cocoa is 0.33 percent in period 2 and 10.2 percent in period 36. This indicates that MPR and cocoa have a broad relationship that fades over time. While the variance decomposition of MPR to MPR has constantly dropped from period 1 to period 36, from 100% to 84.85%, this implies that MPR has a significant influence directly from forecasting into the future, implying that MPR has a substantial endogenous impact.

In period 1, the variance decomposition of cocoa to cocoa is 99.92 percent, cocoa to MPR is 7.75 percent, cocoa to crude oil and cocoa to gold are both 0%. From period 2 (97.9%) to period 36 (87.8%), the variance decomposition of cocoa to cocoa shows a steady drop, indicating that cocoa is a significant influencer of itself from forecasting to the long run.

In period 1, the variance decomposition is 91.1 percent for crude oil to crude oil, 8.9 percent for crude oil to cocoa, 0 percent for crude oil to gold, and 0.05 percent for crude oil to MPR. From period 2 (90.4%) to period 36 (30.6%), the variance decomposition of crude oil to crude oil shows a steady drop, implying that crude oil has a large influence on itself through time. Meanwhile, the variance decomposition of crude oil to MPR shows a constant increase from period 2 (0.02%) to period 36 (48.6%), indicating that there is a relationship between MPR and crude oil that has become significant over time, implying that MPR will have an impact on crude oil in the future. This is due to the fact that crude oil is imported into Ghana and importers may be forced to take up bank loans with high interest rates, which could have an impact on crude oil price dictation in the long run.

The variance decomposition of gold to gold shows a general decline from 96.23 percent in period 1 to 60.5 percent in period 36, indicating that gold has a weak influence on itself from forecasting to the long run, whereas the variance decomposition of gold to MPR shows a general increase from period 1 (0.64 percent) to period 36, indicating that gold has a weak influence on itself from forecasting to the long run (13.7 percent). The tendency suggests that MPR and gold have a long-term link, but the strength of that association is not as strong as it is for MPR and crude oil, thus MPR may have no impact on gold in the future.

Figure 4. 3: Cholesky's Reaction



Red lines indicates the confidence interval at one standard deviation

Blue lines indicates the response to shocks

Figure 4.3 depicts how the variables MPR, cocoa, crude oil and gold react to shocks, or the impact of one variable on another. As a result, I focused on the reactions of cocoa, crude oil, and gold to MPR.

From period 1 through period 5, the reaction of cocoa to MPR is positive, but after period 5, it drops very little below zero (0). This response gradually decreases until it reaches its steady state value, after which it remains in the negative zone from period 15 through the long run, demonstrating that cocoa's response to MPR is negligible. The reason for this is because the price of cocoa is determined by the global market and because we export cocoa as a raw material, the MPR shock to cocoa in Ghana will have little or no long-term impact on the price of cocoa.

After period 1, the crude oil's reaction to MPR reveals a negative response. The degree of reactivity is both high and negative, implying that crude oil will react badly to MPR over time. Gold's response to MPR is also negative in the long term, but it is less responsive than crude oil. Because crude oil and gold are primarily extracted by foreigners in Ghana, the response to MPR in Ghana may have little or no impact on the prices of these items in Ghana.

Pesenti (2013), Gelos and Ustyugova (2012) used consumer price index, inflation, etc to reveal how inflation and interest rate react to commodity price shocks in different nations. It is only Frankel (2006) who used monetary policy, agricultural and mineral commodities in the United States and other nations such as Australia, Brazil, Canada, Chile, Mexico and New Zealand. According to the study that used regression analytic methods, "interest rates have a negative effect on the motivation to carry commodity inventories," according to Frankel.

Using cocoa, crude oil, and gold, this study discovered that, according to the vector auto-regressive model, cocoa and gold prices in Ghana are set externally. We buy petroleum, despite the fact that the price is set outside and the amount we import is decided by Ghana's interest rate and external price shocks. That is why, in the long run, the association between MPR and cocoa and MPR and gold may be inconsequential. MPR and crude oil, on the other hand, are significant.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter includes the study's summary and results, as well as some policy recommendations for Ghana's policymakers.

5.1 Summary and Conclusion

Over time, Ghana has witnessed rising levels of inflation. This problem has been validated by (Focus Economics, 2019) and the Institute of Economic Affairs (IEA), (2012). “High domestic demand supported by expansionary fiscal policies and accommodating monetary policies, as well as the economy's high sensitivity to supply shocks, notably with respect to food, which commands a considerable weight in the consumer basket,” according to the IEA (2012). Monetary policy and interest rates, according to Anzuini, Lombardi, and Pagano (2012) and Frankel (2008), are the primary determinants of commodity prices, and monetary policy influences commodity prices through supply and demand pressures. Modeling commodity price reactions to monetary policy shocks in Ghana by E. Y. Boateng, P. K. Yeboah, I. C. Otoo, and J. Otoo (2020) attests to these facts.

This research used vector auto-regressive models (VAR) to determine the extent of the relationship between monetary policy and commodity prices in Ghana, as well as to attest to some of the claims made by other research works. The goal of this work was to determine whether or not there is a relationship between monetary policy and commodity prices of cocoa, crude oil, gold, and MPR in Ghana, as well as to attest to some of the claims made by other research works.

Data on cocoa, gold, crude oil, and MPR prices from 1999 to 2018 was received from the Bank of Ghana via the University of Ghana's Department of Statistics in Legon, Accra.

On the variables, cocoa, crude oil, gold, and MPR commodity prices, the E-VIEW software package was used to perform descriptive statistics, stationarity, cointegration, root of characteristic polynomial, and Vec Granger Causality / Block Exogeneity Wald tests. The same software application was used to look into error correction, variance decomposition and Cholesky response.

The presence of cointegration in the series of cocoa, crude oil, gold, and MPR prices implies a long-term association between MPR and cocoa, crude oil and gold commodity prices. Cocoa had a negative and negligible response to MPR. Crude Oil and Gold responses to MPR were both negative and significant. Gold and MPR have a smaller link or response than crude oil and MPR. This found that, while monetary policies and interest rates may have an impact on commodity prices, external factors are the most important determinants of commodity prices in Ghana.

The study found that cocoa and gold prices in Ghana appear to be set by outside forces. Despite the fact that the price of crude oil is set externally, we import it and the amount we import is determined by Ghana's interest rate and external price shocks. That is why, in the long run, the association between MPR and cocoa may be inconsequential. MPR and crude oil, on the other hand, are important.

5.2 Recommendations

- When the pricing of goods and services remain steady for a longer period of time, every economy prospers. External pressures are the key predictor of Ghana's commodity prices, according to the study, hence the country may not be performing well in terms of price stability of commodities and services.
- This study should be repeated on a regular basis to provide information to our policymakers so that the economy can be guided towards stability and prosperity. This can be accomplished by tracking how commodity prices respond to monetary policy over time and decreasing external influences on our commodities.

- The study should be repeated to include new commodities produced in the country that are acquiring international reputation, such as coffee and shea butter.
- The government, the Ghana Statistical Service and the Bank of Ghana should make data easily accessible to institutions of higher learning so that additional research like this can be performed to create accurate data that would allow our policymakers to better manage the economy.

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