DECLARATION

I hereby declare that this submission is my own work towards the degree of Master of Philosophy (Economics) and that, to the best of my knowledge it contains no material previously published by another person, or material which has been accepted for the award of any other degree of the University, except where acknowledgement has been made in the text.

…… Date:…….…… ……

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SUPERVISOR'S DECLARATION

I declare that I have supervised the student in undertaken the study submitted herein and I confirm my permission to present it for assessment.

…… Date:……

Dr. John Bosco Dramani

(Supervisor)

CERTIFIED BY:

……... Date:……...

Dr. Hadrat Yusif

(Head of Department / Internal Examiner)

DEDICATION

I dedicate this paper to GOD ALMIGHTY, for his grace and favor to embark on this study. I also dedicate this thesis to my family, most especially my parents, Mr. and Mrs. Buah for their encouragement and support and my son, NANA Kojo Pamfo Eshun for giving me the morale to embark on this study.

ACKNOWLEDGEMENTS

I am very grateful to God for giving me the strength and ability to embark on this research. I express my gratitude to my supervisor, Dr. John Bosco Dramani, who from the very inception of this program to the final session has always been enthusiastic and encouraging. His intelligible, interesting and valuable lessons have been an important motivation for my love to work on this topic.

I would also like to thank Dr. George Adu, Mr. Prince Frimpong, and all the other lecturers in the Economics Department, KNUST for their useful lectures. To them, I say God richly bless you.

Appreciation and gratitude is also given to Prosper Awuni, Akoto Linda, Kojo Baiden Eshun and Samuel Tawiah Baidoo for their support and contribution. I cannot complete my acknowledgement without showing my gratitude to the role played by the 2014\2016 batch of MPhil Economics students of KNUST. To all those who in one way or the other have supported me to complete this study, I say thank you and may God richly bless you.

ABSTRACT

The main purpose of this study is to examine the effect of commodity prices on exchange rate using Ghana as a case study. Monthly data on exchange rate, cocoa, gold, interest rate and inflation from the periods 1999 to 2014 were employed. The study first adopted Custav Cassels's absolute version of the PPP model to establish a relationship between commodity prices and the exchange rate. The Johansen cointegration technique and the Vector Error Correction Model (VECM) were used to test if cointegration exists among the variables of interest and measure the long run relationship among the variables of interest respectively. The study further proceeded to test if the commodity prices are volatile using the GARCH methodology. The results indicated that the commodity prices are volatile and therefore have stochastic shocks. The study finally used the Impulse Response Function to examine the stochastic shocks of the commodity prices on the exchange rate. The study however found out that all the variables are positively related with the exchange rate except for inflation.

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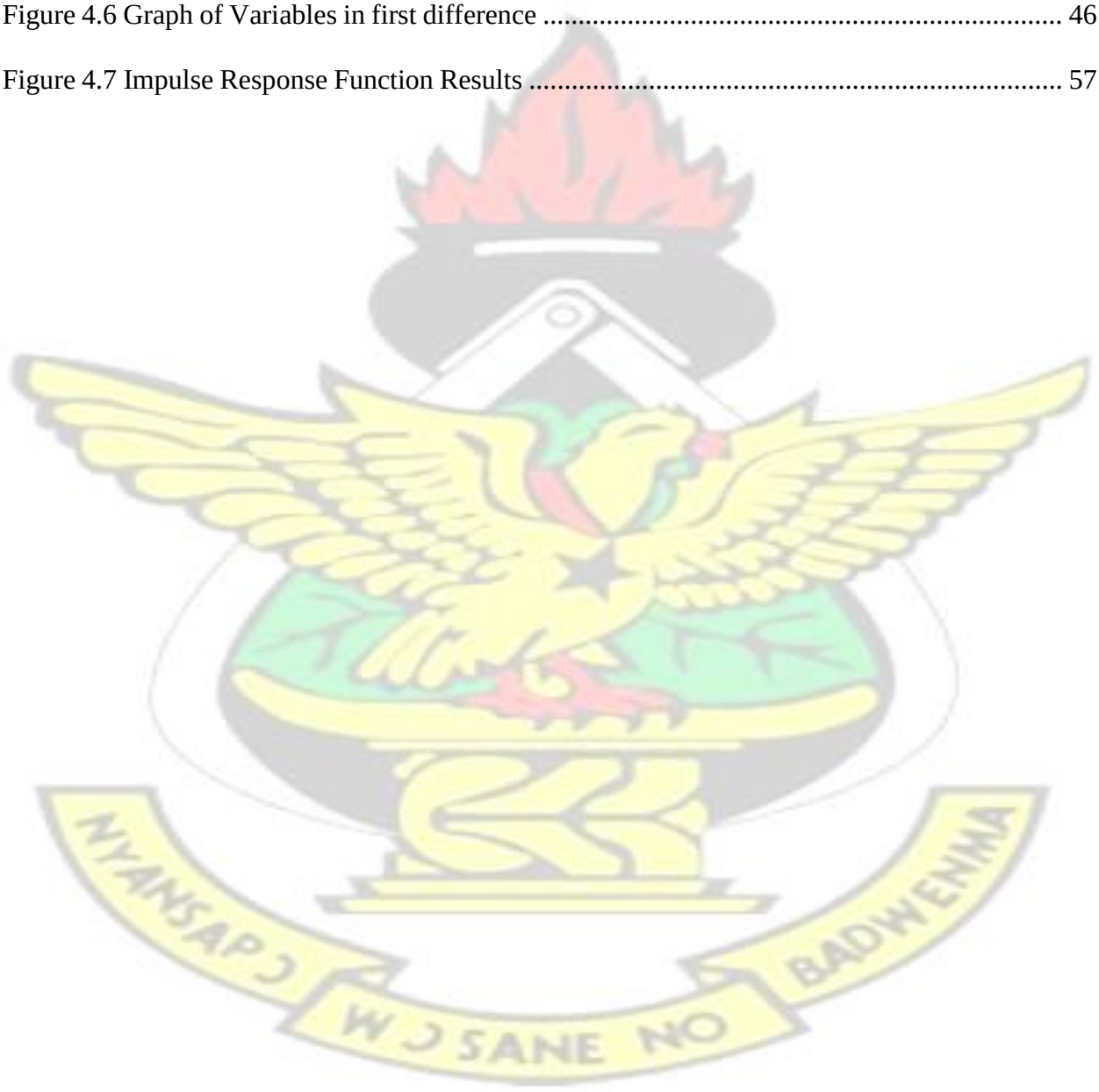


CHAPTER ONE

INTRODUCTION

1.1 Background to the study

A commodity can simply be defined as a marketable item produced to satisfy needs or wants (Sheffrin, 2004).The exact definition of the term commodity describes a collection of goods which have value and is demanded across different market. There are two main types of commodities and these are soft commodities and hard commodities. Soft commodities are goods that are grown; they include agricultural products such as, cocoa, coffee, soybeans, wheat, sugar, tea, etc, where as hard commodities are those commodities which are usually obtained through mining, talk of, gold, iron ore, copper, silver, etc. Commodities play a significant role in the growth and development of nations. Most countries generate revenue from commodities they export to other countries and in most cases these goods are their primary domestic export goods.

Ghana, like most of these countries has her primary domestic export commodities as well, for example, cocoa, timber, gold, and recently oil. Others include tuna, aluminum, diamond, manganese ore and horticulture. This gives the Ghanaian economy a rich and diverse resource base, giving the country one of the highest GDP's per capita in Africa (Dontoh, 2013).Ghana's major export commodities are cocoa and gold and it earns most of its foreign exchange from the exportation of these commodities. Ghana's major export partners are Netherland, Burkina Faso and U.K and it generates lots of revenue from them.

Cocoa is one significant export crop in Ghana. In total it makes up about 8.2% of the GDP of the country and 30 % of total export earnings in 2010 (Ghana Statistical Service, 2010). Ghana is the

world's third largest producer of cocoa and the second largest exporter after Cote D'Ivoire. Cocoa production has increased over the years, growing from 450,000 tons in 2000 to 900,000 tons in 2010 (Ghana Statistical Service, 2010). Recently the finance ministry priced cocoa at GHC 345 per bag of 64kg indicating an increase over the 2013/2014 season price, which was GHC 212 per bag of 64kg.

Gold is another major Ghanaian export commodity which brings in nearly 48 percent of the country's revenue making it the largest gold producer in Africa after South Africa and in the year 2005, the production of gold generated close to 95% of the overall mining export proceeds (Jorion, 1990). The mining industry of the economy generated a yearly income of about GH 80 billion in the year 2014. Gold therefore contributes over 90% of the total export earnings. Ghana earned around 1.5 billion dollars in the first quarter of 2012 through gold exportation and it accounted for 5% of total GDP. Revenue generated from the exportation of gold averaged 35%, making that sector of the economy one of the largest contributors of national income (Clark, 2006).

Theoretically commodity prices affect the value of the exchange rate. Most studies discuss how differences in the price of the commodity affect the exchange rate other alternatively look at how differences in exchange rate affect prices of commodities. This is very essential because commodity price–exchange rate relationship has a explicative effect on economic growth and development (Elekdag, 2008).

Earlier studies have shown that changes in commodity currencies serve as major predictors of commodity prices and as such fluctuations in the currencies can forecast price changes. Alternatively, movement in commodity prices can be used to forecast exchange rate movement as

well. The extent and volatility of swings in commodity prices goes a long way to affect the exchange rate and economic growth and development.

1.2 Problem Statement

Factors that determine the exchange rate include interest rate, money supply and money demand, fluctuations in prices and balance of payment. However the exact cause of the continued decline in the value of most currencies has not been brought to light (Aguiar, 2007). It has been argued that if a country depends so much on its primary export commodity for its revenue generation then there will be a strong correlation between that country's national currency and the commodity prices (Adjasi, 2007). This is because when the price of the commodities increases, more revenue is generated in the country thus the exchange rate appreciates.

According to Frederic (2008) Canadian dollar for instance exhibits a relationship with the price of oil, thus when there is an increase in the price of oil, the Canadian dollar gains value and it appreciate against other major currencies. This is mainly because oil is Canada's primary export commodity and as such when the price of oil increases Canada generates lots of revenue from the exportation of oil. The Canadian dollar therefore gains value giving it a boost on the foreign exchange market. The Brazilian Real and coffee prices are also strongly correlated as well. This is because Brazil produces one of the best coffees in the world and with demand for Brazil coffee on the rise Brazil is the world's largest producer of coffee (Robert et-al 1999). When the price of coffee goes up, Brazil generates more revenue from its coffee exports, the Brazilian real appreciates against other major currencies and the reverse is true. When the price of coffee falls, the Brazilian real tends to depreciates over other currencies.

Ghana as a country depends mostly on its primary domestic industries to generate revenue (Clark, 2006). Cocoa from Ghana is considered to be among the finest cocoa in the world and hence demand for Ghana cocoa is very high. With this high demand it is expected that the price of cocoa will shoot up, which will in turn help boost Ghana's revenue thereby increasing the value of the cedi. However, the Ghanaian economy has performed poorly in terms of sustainability of the value of cedi in comparism with resource poor countries (Pindyck, 1994). While we cannot attribute the poor performance of the Ghanaian cedi to her rich mineral resources and other commodities, it remains unacceptable why a country with abundant export commodities should have such a poor show on the stability of her currency. For instance, in 1990

GHs 0.03423 was equivalent to US$1. This amount rose to GHC 0.6846 and 1.4510 in 2000 and 2010 and currently respectively. Currently US$1 is equivalent to 3.87 (Ghana Statistical Service, 2015).This shows that from the year 2000 to 2010 the currency depreciated by about 112% and from 2010 to 2015 the currency depreciated by 116. 7% (Shashi 2009). On average, the currency has depreciated by 139.35% from 2000 to 2015. This trend indicates that the value of the Ghanaian cedi has been dwindling over the past three decades.

In the light of this major problem, this study intends to investigate further into the relationship between commodity prices and exchange rate in Ghana.

1.3 Research questions

The study seeks to find solutions to the following questions:

1. What are the effect of commodity prices on exchange rate?
2. Are the commodity prices volatile?

3. What are the effects of commodity prices volatility on the exchange rate?

1.4 Objectives of the study

The main objective of the study is to access the contribution of commodity prices to the variations in the exchange rate in Ghana. Specifically, the research seeks to investigate the following objectives:

1. To examine the effect of commodity prices on exchange rate.
2. To examine if the commodity prices are volatile.
3. Investigate the effect of commodity-price volatility on exchange rate.

1.5 Significance of the Study

The goal of every economy is to achieve persistent economic growth and development. To accomplish this goal however there is the need for government to set good policies. Since past literature have shown that there is a positive relationship between high export commodities prices and appreciation of the national currencies, the results of this study will direct policymakers on the need to boost output more during the event of falling commodity prices. Again the sources of fluctuations in commodity prices will also reveal to policy makers on the need to put in measures like adding value and finding alternative uses for their commodities domestically so as to reap in more revenue during falling prices.

Also most extant literature has examined the determinant of the fluctuations in the Ghana cedi with only macroeconomic variables to the neglect of commodity prices. This therefore represents a substantive omission from the literature which this study intends to fill.

The issue of commodity shocks and commodity – price movements and the effects it has on the economy at large has been captured in this study as well. The study therefore employs volatility issues which earlier studies have rejected and investigates further on how commodity-price movements affect exchange rates.

1.6 Scope of the Study

Countries that depend mostly on their primary domestic product for a greater part of their revenue generation tend to have some sort of relationship between changes in the prices of these commodities and their exchange rates. Ghana is therefore chosen from the many countries in the world because it is considered to be one of the countries which depend mostly on its primary domestic product for its revenue generation.

The selected commodities are gold and cocoa since they are Ghana's major primary export commodities and as such data is readily available.

1.7 Organization of the study

The study is grouped into five main chapters. Chapter One is the introduction and it presents the statement of problem, objectives, research questions, importance of the study and scope of the study. This is also a component of the research proposal. Chapter two is made up of the concepts and definition and reviews relevant theories and empirical literature on the topic, chapter three contains the methodology and chapter four is made up of data analysis and the results of the. The last chapter looks at the summary, recommendations and conclusion of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The main idea behind this chapter is to review already existing works in relation to this topic. The chapter is broken down into two sections. The first section talks about theories in relation to the topic and the subsequent section talks about the empirical review.

2.2 Theories of exchange rate and commodity prices

Several theories which explain how commodity prices and exchange rates are related have been outlined and models which were used to analyze data to obtain results are also looked at.

2.2.1 Purchasing Power Parity Theory (PPP)

Purchasing Power also known as price adjusted for inflation is a theory which aims to determine the adjustment needed to be made in the exchange rates of two currencies to make them at par with purchasing power of each other (Daneskhu, 2007). Hence the expenditure on a similar commodity must be same in both countries when accounted for exchange rate.

PPP is a technique in economics which helps to find the relative value of different currencies and economists often use the concept of PPP as the starting point for predicting exchange rate changes (Cheung et al, 2009).

The Purchasing Power Parity theory was first developed by David Ricardo and Gustav Cassel, a Swedish economist, made it popular in 1920 by introducing the absolute and the relative versions (Rogoff, 1996).Cassel stated that there is a positive relationship between the nominal exchange rate and the purchasing power. Cassel in his work used PPP to access how the exchange rate and domestic prices are related.

He explains the PPP in absolute terms and in relative terms. The absolute version of the Purchasing Power Parity simply states that relative price of a common basket of goods will be equal when it is stated in the same currency where as the relative version places emphasis on how inflation affects the exchange rate across time.

2.2.1.1 Absolute Purchasing Power Parity

Cassel's absolute version of the PPP simply states that a bundle of tradable items must have the same price in two countries once the exchange rate is taken into consideration. He predicts that

the exchange rate between two countries will be determined at where the internal purchasing power of the respective countries will be equalized.

Algebraically this can be expressed as;

$$AV\ EX = \frac{P_G}{P_U}\frac{Q_W}{Q_W} \quad \text{.....(2.1)}$$

where EX represents exchange rate, P_G denotes prices in the first country (say Ghana), P_U denotes price in second country (say United States), and Q_W is the corresponding weights.

From equation 2.1, it can be noted that in both countries the respective bundle of goods with equal weights are related to the prices. Hence, the ratio of the domestic currency and the internal purchasing power of the foreign currency is what determine the equilibrium exchange rate.

2.2.1.2 Relative Purchasing Power Parity Theory

Cassel (1996) propounded the relative version of the PPP in order to find the magnitude of differences in equilibrium exchange rate. To him a slight shift from the equilibrium will lead to disequilibrium which is due to changes in internal purchasing power of a particular currency.

This is algebraically expressed as;

$$RV\ R\ R = \sqrt[n]{\quad} \quad {}_{n1}((P\ PP\ P_{ab11}//\ {}_{ba00}))$$

……(2.2)

where R_n is the exchange rate at the new equilibrium, R_{n-1} is the exchange rate for the base period, P_{b0} denotes price index of the second country (say country B) in base period, P_{b1}denotes price index of nation b in recent period,P_{a0} represents price index of the first country (say country A) in base period and P_{a1}represents price index of nation a in current period.

Cassel's argument here was a simple one. To him, the relative purchasing power parity forecasts how the rate of inflation among two countries and the exchange rate between their currencies change over a given period of time. When the price levels in country 'A' changes, it implies that the internal purchasing power of the currency of country 'A' changes as well until equilibrium exchange rate is attained. Persistent increase in the prices of tradable goods will reduce the real purchasing power of a nation's currency.

Modern versions of the PPP theory which have been developed trace its routes to Cassel's great work. Akomobi et al,(2010) indicated in their study that the parity condition assumes that there is perfect inter-country goods arbitrage. It is therefore the core of most theoretical and empirical models of how exchange rate is determined. Their argument here was that the PPP doctrine, be it in its absolute or relative version means that a common bundle of tradable items which is stated in the same currency cost the same in all countries however countries whose prices are higher than their trading partners will have a depreciation of their currency. In the modern versions of the PPP theory long run real exchange effects are considered (Wu, 1996).

2.2.2 The Law of One Price (LOP)

The Law of One Price is another economic theory which explains how the prices of tradable goods are related to the exchange rate. It simply states that in a competitive market, absence of

transportation cost and restrictions to trade will cause identical goods sold in different economies to sell at the same price when expressed in terms of a common currency (Pilbeam, 1992). According to Gorton, (2007) the concept of the 'Law of One Price' basically talks about how arbitrage and trade on the prices of similar goods are exchanged across market. The law of one price and the purchasing power parity theory seem to be the same however there is one major underlining factor which separates the two. The major difference however is that the law of one price takes individual commodities into consideration where as the PPP considers general price levels (Stoll, 1983). The LOP performs a very significant role in international trade model and the determination of exchange rate (Sherwin, 1985). If one price is available over different markets, it simply means that the markets are integrated as a single market. How market integration is measured can be seen as the foundation to understand how specific markets work (Ravallion,2006). Commodity markets integration plays a vital role when it comes to the formulation of government policies and government regulation.

The Law of one price is built upon the arbitrage pricing theory (APT), and it states that two identical items will sell for the same price, otherwise an abnormal profit could be made from arbitrage (Goodwin, 1992). That is, purchasing the item cheaper and offering it for sale in a much more expensive market. Arbitrageurs will continue to do this until prices eventually fall, this is because purchasing on a cheaper exchange will make the demand go up, and therefore the price on that exchange would increase supply with an increase in the demand. Prices of commodities can be in equilibrium without arbitrage being possible, however for the strict version of the law of one price to hold arbitrage must be possible (Philips, 2003).

2.2.3 Balassa's Theory of Exchange Rate

Balassa's theory usually referred to as Balassa-Samuelson effect is a reappraisal of the purchasing power parity. This theory was propounded by Bela Balassa and Paul Samuelson who were great economists (Israd, 1997). Their theory basically depends on inter-country differences in the productive and tradable and non-tradable sectors. The theory was a simple one which stated that countries which have high productivity growth have a high tendency of experiencing a high wage and with a higher wage the exchange rate will be high as well.

The Balassa-Samuelson theory suggests that in developing countries when the wages in the tradable (goods) sector increases then the wages in non tradable (services) that sector will increase as well. This effect suggests that the optimum inflation rate for developing countries is higher than that of the developed countries. An emerging economy grows by being more productive and using the factors of production, that is, land, labor and capital more efficiently.

This results in wage growth in both the tradable and non tradable component of an economy. The basic intuition is that people consume more goods and services as their income increases, and this in turn pushes prices. With price increasing, the value of a countries currency will also increase. When the wages grow at a rate which is slower than productivity, countries produce more than they consume and this leads to current account surplus. When the wages grow at rate which is faster than productivity, labor consumes more and current account surplus falls.

Bela Balassa and Paul Samuelson however noted that the outcome of an appreciating real exchange rate has on developing economies depend on two things; if the country has a fixed or a floating exchange rate. Their conclusion here was that, fixed exchange rate economies tend to see an

increase in overall prices, whereas floating exchange rate economies tend to see increase in the exchange rate.

The Balassa-Samuelson effect is usually discussed vis-à-vis the Penn effect, which basically states that, there is a strong positive relationship between price levels and GDP. It is referred to as the Penn effect because it was first documented in the University of Pennsylvania (Samuelson, 2004), and it has been acknowledged widely as a simple but realistic theory. Despite the simplicity and appeal of the theory, it has been criticized by Devereux (2014). According to him, the Balassa-Samuelson theory does not do well in explaining real exchange rates, except over very long time horizons. He argues that in most empirical studies, especially in time-series data, the evidence for the effect of productivity growth on real exchange rate is weak. To him, the problem is apparent in the study of real exchange rate movements among high income, financially developed countries with floating exchange rate.

2.2.4 Price theory of Demand and Supply

The price theory talks about the simple notion of supply and demand and it can be adopted in explaining the exchange rate and commodity price relation. Supply and demand is a model used to understand the determination of the price of quantity of a good sold on the market (Bryne et al, 2013). Two groups are always considered when looking at the price theory, that is, buyers and sellers and how they interact. The buyers are those who demand the commodities being produced where as the sellers are those who supply the commodities.

Demand is the rate at which consumers want to buy a product where as supply is the willingness and ability of producers to supply goods to consumers, (Whelan et al, 1996). The rate of exchange

like commodity prices, determines its price by responding to the forces of demand and supply and as such when people increase their demand for a specific currency then the price of that particular currency will increase, alternatively if the supply is increased the price of that particular currency will decline (Anastopoulos, 2000).Relating this simple theory to the topic it can be deduced that when the demand of a currency increases, the value of the currency also increases and hence that currency tends to appreciate against other major currencies.

All other things being equal buyers will demand a given amount of a commodity given certain conditions, talk of, the price of the commodity in question, price of other commodities, change in future prices, to mention a few. If the price of a commodity falls more of the commodity will be demanded and if the price of the commodity rises less of it will be demanded. In the same vein if the price of Ghana's major primary commodities falls on the international market more will be demanded. With an increase in demand suppliers will want to produce more which will eventually lead to an increase in the price of the commodities. With an increase in the prices these commodities the value of the Ghanaian cedi will appreciate against other major currencies.

2.3 Relationship between exchange rate and commodity prices

Following the works done by Bashar et al (2013), how commodity prices are related with the exchange rate can be assessed. Within the context of their work they find major causes of the fluctuations in the Australian dollar. They used quarterly data for 30 years to find a long run relationship between exchange rate and commodity prices. In their study they concluded that it is more advisable for economies to maintain weak exchange rate since weaker exchange rate is capable of increasing exports. Exchange rate is likely to appreciate with increase in exports of

commodities by keeping the price of commodity low. This relationship between the exchange rate and commodity prices when maintained properly will go a long way to foster economic growth and development.

Most works which assess how commodity prices are related with exchange rate found out that there was a positive relationship. Chen et al. (2008) used the Granger causality test to find out how the exchange rate predicts commodity prices. Their results revealed that indeed there was a positive relationship between commodity prices and exchange rate. However the magnitude of the effect was weak.

Simpson (2002) also used the ordinary least square (OLS) method to study how commodity prices are related with the Australian dollar. They found out that commodity prices greatly influence the fluctuations in the exchange rate. Arezki et al (2012) employed cointegration tests and Vector Error Correction model to establish a relationship between South African Rand and gold price volatility. Their outcome showed that when price of gold keeps on changing the value of the Rand falls and when the price is stabilized over a period of time the value of the Rand goes up. Edwards (1985) studying the relationship between exchange rate and world coffee prices reported that coffee price changes had been negatively related to devaluation of Colombian currency.

The relationship between exchange rate and stock prices has also attracted a lot of attention in economics. A stronger relationship between the two would have important implications for economic policies and international capital budgeting decisions (Walid, 2014). Existing literature in financial economics has provided two potential theoretical explanations for the interactions between the exchange rate and stock prices. These two basic approaches are the “flow oriented”

models and the "stock oriented" models. Earlier studies by Dornbusch and Fisher (1980) use the flow oriented model to show that domestic currency depreciation improves the competiveness of local firms. The flow model assumes that the exchange rate is determined largely by a country's current account or trade balance performance. The model represents a positive relationship between prices and exchange rate and it posit that changes in exchange rate affect international competiveness and trade balance. Thus, prices will move up in respond to increase in cash flow.

2.4 Sources of Commodity Price Fluctuation

Fluctuations in commodity prices play a very important role in the growth and development of every economy and hence much attention is paid to it Harvey et al (2010). Most countries try to stabilize prices and stabilize their currency as well yet prices keep on fluctuating. Some of the sources of the fluctuations in the prices are outlined below.

Frankel et al (2008) have outlined 3 competing theories which explain the fluctuations in commodity prices. First, they stated 'global demand growth' as one major theory which explains the fluctuations in commodity prices. They argued that global demand growth increased particularly with high demand countries like China and India on the international market, causing prices to increase. However their work was criticized by some researchers who were looking at the early effects of the sub-prime mortgage crisis that hit the U.S in 2007. Economic growth degraded for many countries lowering the production for commodities globally during the time of crisis, while commodity prices were still on the rise in the first three quarters of the recession. Wolf et al (2008) also noted that the shifts in global demand and supply also cause fluctuations in commodity. They basically argue that changes in world demand will cause changes in commodity

prices and hence when high-demand countries like China and India increase their demand for a particular commodity the price of that commodity will increase and if their demand for that commodity falls then the price will fall as well.

The second theory developed by Frankel and Rose mainly talked about financial markets. They argue that 'speculation' is the main cause of fluctuation in commodity price. Thus if consumers speculate that prices of commodities will go up they will hold on with their purchases. If prices are not expected to increase then more will be purchased in the current period and this will inflate the prices of commodities Krugman (2008).

The third theory developed by Frankel and Rose was 'easy monetary policy'. They argued that low interest will create excess liquidity which will penetrate into the commodity market and as such more people will switch from treasury funds to commodity contracts thereby increasing prices. Lower interest rates will therefore reduce the cost of holding inventories because it will no longer be profitable to invest.

2.5 Empirical review

It is an undisputable fact that lots of work have been done on the relationship between commodity prices and exchange rate. It is well known that changes in world prices of primary commodities are important determinants of changes in exchange rates of producing countries. Basic economic reasoning on currency demand suggests that the currencies of countries that exports depend heavily on a particular commodity should be strongly influenced by its price. Thus most

researchers have employed different methodologies to find out how change in the price of these commodities affects the exchange rates and vice versa.

Moslares et al, (2003) attempts to find the relationship between trade (imports and exports), relative prices and the volume of economic activity. They use monthly trade flows on United States exports to and imports from Spain over the period from January 1993 to December 2012. They also use the Autoregressive Distributed Lag (ARDL) approach to cointegration analysis as a method of bound testing. They found out that exports depend positively on the levels of foreign economic activity but negatively on relative prices. However, the exchange rate volatility tends to provide mixed effects. On the side of the imports the results shows that, imports depends positively on the levels of domestic economic activity but negatively on relative price. Again, the exchange rate volatility provides mixed effects. Their results however tends to conflict with the result obtained by other proponents who also worked in the area of exchange volatility and trade.

For instance, Onafowara and Owaye (2008), Chowdhury (1993), Pozo (1992), Arize et al, (2000) and Ltaifa (1992), found that the exchange rate volatility directly influence export through uncertainty and adjustment cost for risk-averse investors. On the other hand it influence export indirectly through its impact on the output structure policies set up by government and investment. Researchers like Doyle (2001), Chou, (2000), Mckenzie and Brooks (1997) and Peel (2001) also found out that volatility positively affected the volumes of export of some developed countries. This is because exchange rate volatility makes export more attractive to risk-tolerant exporting firms. The reason for the contradictory results by different studies may be attributed to a variety of factors, for instance, different methods used to measure exchange rate volatility, the use of different sample data, different time frames, different price deflators, the use of aggregate export data versus sectoral export data, to mention a few. Despite the numerous flaws Moslares et al's work tend to be the most significant.

The surge in commodity prices in the 2000's called out for the interest for the co-movement of commodity prices and their determinants. Mollick et al. (2008), for example, investigate the role of globalization in the terms of trade of relative prices and test whether US relative prices are affected by international prices. They do find a decreasing trend in relative prices, but argue that this trend is not related to globalization or international integration. On this evidence, they conclude that policies aiming at increasing or decreasing the degree of integration with the world economy would not be effective at modifying this long term trend.

Akram (2009), used the structural VAR model of quarterly data from 1990 to 2007 to examine separately the impact of real interest rates change on the real price of crude oil, raw materials from industries, food and metal. Vansteenkiste (2009) also extracts a dynamic principal component from a large set of monthly commodity prices for the recent period and tests its potential determinants using IV regressions. She finds that co-movement was highest in the 1970s and 1980s, declined in the 1990s and has recovered somewhat during the early years of this century. Also, she finds evidence that supply, global demand, exchange rate and real interest rate are important.

Manzur, (2002) explores the link between exchange rate instability and domestic inflation. Exchange rate, prices and trade play a very important role in the economy, however the analytical approach to deal with the most controversial issues in exchange rate economies is a sophisticated one. Manzur therefore provides a systematic treatment of the interaction between national price levels and exchange rates, the formation of expectations regarding exchange rates, and the effect

of real exchange rate changes on trade flows. He uses a new methodology for the listing of purchasing power parity and provides an original approach to the measurement of variation in the structure of relative prices and use of new measures in econometric work. In order to do so he presents a model which link the patterns of the world trade to variations in relative price and examines modern issues related to the characteristics of foreign exchange market.

Ahmet et al, (2015) used the dynamic conditional correlation (DCC)-GARCH model to analyze the dynamic co-movement of commodity futures returns using data from 1997 to 2013. Their findings from the dynamic equi-correlation GARCH model shows evidence of convergence for precious and industrial metal commodity futures since the mid 2000s. Their study further estimates that there is no sign of convergence across the agricultural commodity futures, with most of them moving in an unrelated manner. Again, a relatively high level of convergence was found for energy commodity futures but for natural gas futures which expectedly behave significantly different from the other energy commodity futures. In conclusion the findings of their study suggest some potential for diversification benefits within commodity-specific categories but at the same time the predominance of physical demand and supply balance as the main driving force of the commodity futures price dynamics rather than global financial conditions.

Groen et al (2009) used Partial Least Square (PLS) regressions to extract some relationship between exchange rate and commodity prices. Their study employs ten alternative indices and sub indices of spot prices for three different commodities classes across different periods. They found out that a positive relationship exist between exchange rate and commodity prices.

Mike Moffat in his article, “A Beginner’s Guide to Exchange Rate and the Foreign Exchange Market” considers the instabilities in the value of a country’s currency. In his work he examines how the Canadian dollar has been moving in an upward trend over the years, greatly appreciating relative to the dollar. Moffat associated the rise in the value of the Canadian dollar to three main factors and these are; rise in commodity prices, interest rate fluctuations and international factors and speculations. However to him the rise in the value of the Canadian Dollar is greatly associated with the rise in the price of commodities.

Canada exports commodities such as timber and natural gas to the United State. Increase in the demand for these ceteris paribus, causes the price of the commodities to go up. When this happens the Canadian Dollar appreciates relative to the U.S Dollar, through one of two mechanisms. One such ways is that Canadians producers sell to U.S buyers who pay in Canadian dollars. To make purchases in Canadian Dollars, American buyers must first sell American Dollars on the foreign exchange market in order to buy Canadian Dollars. This action causes the number of American Dollars on the market to rise and the number of Canadian Dollars to fall. To keep the market in equilibrium, the value of the American Dollar must fall and the value of the Canadian Dollar must rise. Another way is that Canadian producers sell to U.S buyers who pay in U.S dollars. Here Canadian producers sell products to Americans in exchange for American Dollars. As supply of the American dollar increases with a constant or fall in supply of the Canadian dollar, the value of the American dollar falls where as the Canadian dollar rises.

Salifu et al., (2007), introduced another aspect of the exchange rate commodity price relation. However their main concentration was on how the exchange rate can drastically affect the costs, profits and return on investments of firms and economies at large. This was what they referred to

as the exchange rate exposure. In their work they showed that there are two types of exposure, these are the transaction exposure and operational exposure. The former is related to those activities that trade internationally. For instance an EU company imports bicycle components from the United States with 2 months credit. Possible US dollar depreciation will be for the benefit of the EU organization since it will pay fewer Euros. On the contrary, if the US dollar appreciates, the company will pay more Euros. In short, the transaction exposure is the risk of adverse movement in the exchange rate. The latter however is the trade among individual firms rather international. Although a firm may not trade globally due to competitiveness, it may suffer the exchange rate risk.

Akbar and Chauveau (2009) using 3 different currencies, i.e, Euro, U.S dollar and Japanese yen established a relationship between the exchange rate and prices as well as Public Dept Portfolio of Pakistan (PDPP). Using the Value-at-risk (VAR) for the period 2001 to 2006 they came to the conclusion that the dollar was found to be less risky and Japanese yen to be high risky for PDPP. According to value at risk, no currencies found to have negative or positive beta and marginal. The lack of hedging policy was concluded by beta and component VAR analysis which called to be hedging analysis. This helps to expect more firms are exposed to foreign risk.

Olufem (2011) measured foreign exchange rate risk on 117 firms listed on Nigerian stock market using both financial and non financial sectors. The model elaborated the results on individual firms. The outcome of foreign exchange exposure in the research found that 77% firms have negative exposure towards US dollar, 73 % are exposed to UK pound and 63 % towards Euro. US dollar got highest number of firms significantly exposed as more trade dealing in US dollar. Later

researcher used different horizon to measure foreign exchange rate exposure. Scholars introduced short term and long term effect of exchange rate on firm's value.

Harper (2007) also used the Vector Error Correction Model (VECM) to show how Botswana economy benefited from its diamond refineries. He argued that since independence, Botswana has had the highest average economic growth rate in the world, averaging about 9% per year from 1966 to 1999. Growth in private sector employment has averaged about 10% per annum over the first 30 years of independence. Botswana is also commended for the site of Africa's longest and among the world's longest economic booms (which almost surpassed that in Asia's largest economies). The relatively high quality of the country's statistics means that these figures are likely to be quite accurate. The government has consistently maintained budget surpluses and has extensive foreign exchange reserves. His result showed that government setting up refineries in the country to sell diamond in its finished state attracted lots of revenue and this made their currency gain value. Botswana's impressive economic record has been built on a foundation of its diamond mining and the setting up of refineries to transform this mineral into priceless Jewelry.

Chow and Chen (1998) argue that short term and long term effect is transaction exposure and economic exposure respectively that makes stock return into 1 to 24 months. Dominguez et al., (2006), published a journal on exchange rate exposure. They believed that, changes in exchange rate have important implications for financial decision-making and for the profitability of firms. A sample of eight (non-US) industrialized and developing countries are used in their work and they considered a time period of 20 years, that is from 1980-1999.They found out that exchange rate movement do matter for a significant fraction of firms, although which firms are affected and

the direction of exposure depends on the specific exchange rate and varies over time. Five out of eight countries in the samples used revealed that over 20% of firms are exposed to weekly exchange rate movement and exposure at the industry level. Having established that there is a significantly significant relationship between profitability and the exchange rate they further explained why some firms are exposed and why some firms are not exposed to exchange rate movement. This is because at country level, the extent of exposure is robust, and that exchange movement may be linked to a number of firm and industry level characteristics.

In summary all these theories reviewed are relevant when looking at how commodity prices affect the exchange rate.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The purpose of this chapter is to discuss the appropriate methodology used in the study. This chapter also presents a discussion on the model specification, *a priori* expectations, discussion of the identification strategy adopted for the study, unit root in the data series as well as joint stationarity (cointegrating relationship) among the variables, types and sources of data and definition of variables.

3.2 Specification of the effects of commodity prices on exchange rate

Cassel (1996), stated that the nominal exchange rate should reflect the purchasing power of one currency against another. He used the purchasing power parity (PPP) to establish a relationship

between exchange rate and domestic prices. Thus adopting Cassel's absolute version of the PPP the exchange rate equation is specified as follows:

$$EX = f(CP, GP, X) \quad \ldots\ldots (3.1)$$

where EX denotes exchange rate, CP is the price of cocoa, GP is the price of gold and X is a vector of controlled variables. Interest rate and inflation are considered as the major determinants of exchange rates (Mussa, 1994).

In a more specific form, equation 3.1 can be written as:

$$\ln EX = \beta_0 + \beta_1 \ln CP + \beta_2 \ln GP + \beta_3 \ln INF + \beta_4 \ln INT + \varepsilon \quad \ldots\ldots (3.2)$$

The variables in consideration have been transformed into their natural logarithm so as to eliminate the possibility of outliers, reduce the presence of heteroskedasticity and also to be able to indicate percentage changes.

3.3 Specification of GARCH Model

The study analyzed the variables of interest using the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) methodology. The GARCH model is a generalized version of the Autoregressive Conditional Heteroskedasticity (ARCH) model. Modern developments in financial econometrics adopt the use of models and techniques that are able to model the attitude of investors not only towards expected returns but towards the unknown results as well (Martin, 1999). Thus, models that are capable of dealing with the volatility or variance of the series are required. The ARCH/GARCH models are the best techniques required to measure the volatility of a set of variables and hence they are employed in the study. A significance of the ARCH/GARCH model

is the recognition that volatility can be estimated based on past data and that a bad model can be detected directly using conventional econometric techniques.

Commodity price keeps on fluctuating day in day out. On the international market for instance, prices of commodities keeps on changing. Periods of high volatility alternate with periods of low volatility, which is usually described as volatility clustering (Sheperd, 2001). Thus the average value of the magnitude of the disturbance terms can be greater at certain periods compared with others. It is therefore preferable to examine patterns that allow the variance to depend upon its previous values. Volatility seems to follow autoregressive process, which means that it is dependent on its previous values and can be modeled.

3.2.1 Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model

The Autoregressive conditional heteroskedasticity (ARCH) model was introduced by Engle (1982) to provide a measure of volatility, which varies in time. An expanded version of the ARCH model is the GARCH model which has been generalized to be of more use (Bollerslev 1986). The GARCH model is used as an alternative to high-order ARCH models because it has less parameter to estimate and hence lose fewer degrees of freedoms.

The GARCH presentation can be specified as;

h_t □ □□ □ □□h_{t-1} □ $_1u^2_{t-1}$ ..... (3.3)

whereh_t is the variance and hence, equation 3.3 is the variance equation. The above equation simply means that when there is a big shock in the previous period, then the value of disturbance term (u_t) will be bigger as well. This model specification performs well and is easy to estimate

because it has only three unknown parameters;□□□□, 1 1, ,where□□represents long run average variance rate□1is a parameter that measures the sensitivity of the commodity price volatility and □1is coefficient of the lagged period. Following Bollerslev (1986), the study employs a basic GARCH (1,1) model including two variables; Cocoa price (CP) and Gold price (GP). GARCH (1,1) is chosen because it is the most commonly available and the most commonly used model. The variables in question (cocoa and gold) are first estimated to measure the level of volatility after which the effect it has on exchange rate is critically examined.

The results of equation (3.3) are then used to estimate the effect of volatility of commodity prices on the exchange rate. The equation is therefore modified and written as follows;

ln *EX* □ □□ □□□ ln*CP*□ □□2 ln*GP*□ □□……...(3.4)

where *EX* represents the exchange rate, *CP*□ the cocoa price with volatility, *GP*□ is the gold price with volatility and □ is the error term.

3.3 A Priori Expectation of the Variables

Based on economic theories and basic principles which are assumed to be true a positive relationship is expected to exist between commodity prices and exchange rate thus when cocoa and gold prices increases we expect the exchange rate to go up. This is because Ghana is a major exporter of cocoa and gold and as such when the price of these commodities increases Ghana reaps greater revenue from its export. The value of the Ghanaian cedi will therefore appreciate against other currencies.

A negative relationship is expected to exist between inflation and the exchange rate. Inflation in Ghana means that prices of commodities are persistently increasing and as such commodities have become less competitive. Demand for Ghanaian exports will fall and this fall implies a fall in the demand for the commodities by foreigners since they are relatively more expensive. With a fall in demand, revenue generation will also fall and the currency's value falls which is a depreciation of the currency. This is the wealth effect of the persistent increase in the general prices on exchange rate. The substitution effect occurs when consumers find it more attractive to buy imported goods from its foreign trade partners. This will result in an increase in supply of the cedi and with an increase in supply the value of the currency falls leading to depreciation of the cedi.

A positive relationship however is expected to exist between interest rate and exchange rate. This is because higher interest rate attracts foreign capital which increases the demand for the cedi and helps boost the value of the Ghanaian cedi against other major currencies.

3.4 Estimation Strategies

For consistency to exist among the parameters being estimated there is the need to examine the level of stationarity among the individual series in the regressions model in order to make sure that the estimated relationships are not spurious. To identify the effect the changes in commodity prices have on exchange rate, stationarity properties are very important (Haan, 1997). This is because when the stationarity of the variables is not known the regression is likely to produce spurious estimates. Also the study examines if in the long-run the variables of interest are related using the Johansen's multivariate cointegration technique.

3.4.1 Unit Root Testing

The first test required in estimating a time series data is the unit root test. This test is done in order to know the order of integration of each variable used. In cointegration process, it is very important to test the order of integration for econometric model specification. Again, most variables according to economic theories should be integrated or have a random walk. In such a situation, it is important to perform this test in other to find exact estimated values. For the purpose of this study this test is done with the help of the Augmented Dickey Fuller (ADF) and Philip-Perron test procedure. The objective of the unit root test is to ensure that the variables are stationary before proceeding to estimate the coefficients of the variables.

3.4.1.1 Augmented Dickey- Fuller (ADF) Test

In the traditional Dickey-Fuller test, the error terms are assumed to be uncorrelated and thus white noise. Dickey and Fuller further developed the "Augmented" version of the test for instances where the disturbance terms are likely to be correlated. Since the error terms of several macroeconomic variables are likely to be correlated mainly because the series are usually and more often trended as identified by Asteriou and Hall (2011), the ADF test is more useful in macroeconomic time series. The test adds extra lagged terms of the dependent variable to the equation (this is done to do away with autocorrelation). The ADF test may be expressed by the following equation:

$$\Delta Y_t = \alpha_0 + \beta t + \gamma Y_{t-1} + \sum_{i=1}^{P} \delta_i \Delta Y_{t-i} + \varepsilon_t \quad \text{..... (3.5)}$$

Where Y_t represents the time series variable, t is the time/trend variable, α_0 and α_0 are the estimated parameters, Δ is the first difference operator, $\alpha_0$denotes the various estimated parameters of the differenced values of the lagged variables andε_t is the white noise error term.

Based on equation 3.5, we test for the hypothesis that there exist a unit root or the time series is non-stationary; $\alpha 3 = 0$. If the null hypothesis is rejected, then the series is stationary. If, however, we are unable to reject the null hypothesis then, the series is non-stationary and as such possess unit root. A stationary series has temporary shock effects whiles non – stationary series have permanent shock effects. Thus the ADF test is mostly preferred to the Dickey-Fuller test.

3.4.1.2 Philips-Perron (PP) Test

Philips and Perron (1988) came up with an expanded version of the ADF test. They modified and generalized the ADF test procedure by correcting for serial autocorrelation and heteroskedasticity in the residuals non-parametrically. This version is an upgrade of the ADF because it is mostly viewed as DF test that cater for serial correlation by employing the NeweyWest (1987) heteroskedasticity and autocorrelation. The PP test therefore considers a less restrictive nature of the error process and it attempts finding a way of handling deviations in order not to achieve white noise in the estimated model.

The equation used to estimate the PP test is specified below;

$$\Delta y_{t-1} \quad \alpha_0 \quad y_{t-1} \quad \varepsilon_t \qquad (3.6)$$

Equation 3.5 postulates that when H0: $\gamma = 0$ then there is a unit root and when H0: $\gamma \neq 0$ then there is no unit root. Failure to reject the null hypothesis implies the variables in the series are not

stationary and hence there is a unit root. However when the null hypothesis is rejected, then the variable is stationary, hence integrated of order zero at the levels i.e. I(0).

The PP test is used in addition to the ADF test because it is non-parametric and hence does not require selecting the level of serial correlation as in ADF. Also it is more robust to deviations from set of properties thus serves as a back up to the ADF to ensure that results obtained are accurate.

3.4.2 Estimation of Long-Run Multipliers

To test for the long-run relationships between commodity prices and exchange rate, this study employs the Johansen cointegration test and the vector error-correction model (VECM).

3.4.2.1 Cointegration test

If after checking all the time series properties of the variables, they are found to be integrated of the same order, that is I~ (1), then the study will proceed to test Cointegration among the variables of interest. This is important because cointegration test will help to find out whether a class of non-stationary series is co-integrated or ensures stationarity. If two series are cointegrated, then these series are said to have some sort of relationship in the long run. When the variables in consideration are related, it is expected that they move together and hence their trends will be similar to each other. Thus when they are combined it is possible that the nonstationarity problem will be eliminated. It is for this reason that cointegration techniques are employed. Granger (1981) first introduced the concept however it was elaborated on further by Engle and Yoo (1987), Stock and Watson (1988) and Johansen (1995) among others. For the purpose of this study however the Johansen cointegration technique is employed.

3.4.2.2 Johansen Cointegration Technique

If there are more than two variables in a model, then the Johansen methodology appears to be the best technique due to the possibility of having more cointegrating vectors. In this situation, one cannot rely on the Engel-Granger approach to testing cointegration since more than one cointegration may exist. Johansen's cointegration technique, sequentially test cointegrated variables directly on maximum likelihood so as to know the total number of cointegration vectors. This is done by relying on the relationship between the rank of a matrix and its characteristic roots. One advantage of this test is that, it tests for all components in the residual process. This is because the critical values are determined conditionally on a normal distribution of the residual process. It is the best cointegration technique to use when we have very large sample size.

The equation for Johansen's methodology is given by:

$$y_t = u + A_1 y_{t-1} + \ldots\ldots + A_p y_{t-p} + \varepsilon_t \quad \ldots\ldots (3.7)$$

where y_t is an n x 1 vector of variables that are integrated of order one – I(1) and ε_t is an n x 1 vector of innovations.

Re-writing equation 3.8 we obtain:

$$\Delta y_t = u + y_{t-1} + \sum_{i=1}^{p-1} \Delta y_{t-1} + \varepsilon_t \quad \ldots\ldots (3.7)$$

Where $\Pi = \sum_{i=1}^{p} A_j - I$ and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$

If the coefficients matrix Π has reduced rank $r \prec n$, then there exist n x 1 matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. r is the number of cointegrating relationships, the elements of α are known as the adjustment parameters in the vector error correction model and each column of β defines the combination of y_{t-1} that yields the r largest canonical correlations of Δy_t with y_{t-1} after correcting for lagged differences and deterministic variables when present.

Johansen proposes two different likelihood ratio tests of significance of these correlations. These are the trace test and maximum eigenvalue test.

3.4.2.3 The Trace Test

The trace test is used to estimate the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors. In other words, it tests for the null hypothesis that, the number of cointegrating vector is less than or equal to r against the alternative hypothesis that there are more than r cointegrating vectors. The test statistic for the trace test is given as;

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i) \qquad \text{……………………………………………………………………… (3.8)}$$

where H0: represents the null hypothesis hence, only the first r eigenvalues are non-zero. The trace test has been found to be a better test since it is more robust to skewness and excess kurtosis (Sjo, 2008). Again, the trace test can be adjusted for degree of freedom which is important in small samples.

3.4.2.4 The Maximum Eigenvalue

The maximum eigenvalue on the other hand tests the null hypothesis of *r* cointegrating vectors present, against the alternative hypothesis of (*r+1*) cointegrating vectors. Each eigenvalue represents a stationary relationship. The test statistic is given by;

$$J \max = T \ln(1 - \lambda_{r+1}) \quad \text{.....(3.9)}$$

where *T* is the sample size, λ is the *ith* largest canonical correlation for $r = 0, 1, 2\ldots, p-2, p-1$. The null hypothesis *r* cointegrating vectors is tested against the alternative hypothesis of *r+1* vectors.

3.4.2.5 Vector Error Correction Model

The vector error correction (VEC) model is employed when the variables in the series are all stationary in the first difference i.e. I (1). It further takes into account any cointegration relationships among the variables. If the dependent and independent variable are stationary at the level the system can be estimated using the least squares applied to each equation, however if they are not stationary at the levels but stationary at first difference then we take the difference and estimate.

Given equation 3.2, the variables (cocoa, gold, inflation and interest rate) can be defined using the matrix notation below:

$$\ln EX = \alpha + \sum_{i=1}^{p} \beta_i \ln EX_{t-i} + \sum_{i=1}^{p} \gamma_i \ln CP_{t-i} + \sum_{i=1}^{p} \delta_i \ln GP_{t-i} + \sum_{i=1}^{p} \varphi_i \ln INF_{t-i} + \sum_{i=1}^{p} \omega_i \ln INT_{t-i} +$$

$$\sum_{i=1}^{p} \theta_i \ln EX_{t-i} + \sum_{i=1}^{p} \varphi_7 \ln CP_{t-i} + \sum_{i=1}^{p} \varphi_8 \ln GP_{t-i} + \sum_{i=1}^{p} \varphi_9 \ln INF_{t-i} + \sum_{i=1}^{p} \varphi_{10} \ln INT_{t-i} + \varepsilon_t \quad \text{.....(3.10)}$$

where X_t represent the matrix of the four variables used in the model. The above equation is reformulated in vector error correction model (VECM) as follows:

$$\Delta X_t = v + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \Gamma_3 \Delta X_{t-3} + \Gamma_4 \Delta X_{t-4} + \Pi X_{t-1} + u_t \text{ ……………………………….(3.11)}$$

$$\Gamma_i = -(I - A_1 - A_2 - A_3 - A_4) \; (i = 1,2,3,4) \; and \; \Pi = -(I - A_1 - A_2 - A_3 - A_4)$$

where X_t represents an $n \times 1$ vector of variables that are integrated of order one [I (1)]. Π is a 4×4 coefficient matrix which is called the impact matrix. It contains information regarding the long-run relationships between the variables and also determines the degree of cointegration in the system. u_t also represents $n \times 1$ vector of innovations and ΔX_t stationary, that is, I(0). Hence, all i=1,2,3,4 are also stationary; the residual is also assumed to be stationary. This also implies that, ΠX_{t-1} is also integrated of order zero; I(0).

3.4.2.6 Vector Autoregressive Model (VAR) and Impulse Response Function

Following Elder and Serletis (2010), the VAR is modified to accommodate a GARCH so as to know the effect of commodity price volatility on exchange rate. The VAR model estimated in the study is used to identify the effect of commodity price volatility on exchange rate. The estimation is done using the equation below;

$$y_t = A_0 + \sum_{(i=1)}^{P} A Y_{i \, t-1} + \varepsilon_t \text{ ……………………………………..…………………..(3.12)}$$

Equation 3.7 represents a VAR model of order P which includes k variables. P is the number of lags, $Y_t = [y_{1t}, y_{2t} \ldots\ldots\ldots y_{kt}]'$ is a column vector of all variables in the model. A_0 is a column vector of constant terms; A_i is a k x k matrix of unknown coefficients and ε_t is a column vector of errors.

In order to define commodity price volatility following previous studies such as Caporate et al (2015), the study considers a univariate GARCH (1,1) model estimated separately for each commodity.

In the case of cocoa the equation to be estimated is written as;

$$CP_t = CP_{t-1} + u_t \ldots\ldots\ldots\ldots (3.13)$$

where CP_t is the price of cocoa at time t, CP_{t-1} is the price of cocoa for the previous year and u_t is the commodity price change in each period.

In the case of gold the equation to be estimated is written as;

$$GP_t = GP_{t-1} + u_t \ldots\ldots\ldots\ldots (3.14)$$

where GP is the gold price at time t, GP_{t-1} is the price of gold for the previous year and u_t is the commodity price change in each period.

After estimating the VAR model for the commodity price volatilities the study further analyze the effect of the commodity price volatility on the exchange rate through the impulse response function. Though the VAR is a very reliable tool in econometric analysis, it is difficult to interpret the coefficients directly. Therefore, Stock and Watson (2001) proposed the impulse response functions and variance decomposition as more informative ways to understand the relationship among the variables than the coefficients and the R2 statistic from the VAR regression. The impulse response functions trace out the behavior of the dependent variables in response to shocks in the other variables in the VAR model.

3.5 Data Sources and Description

The study employs monthly data series from 1999 to 2014. The data set was obtained from the International Cocoa Organization (ICO) web site (http://www.icco.org), the Bank of Ghana (BoG), Ghana Statistical Service and the World Development Indicators (WDI). The study employs five variables of interest, namely, exchange rate, cocoa prices, gold prices, inflation and interest rate. The variables used in the study are described as follows.

3.6.1 Exchange rate

The term exchange rate can simply be defined as the value of one currency for the purpose of conversion to another. In a more simply explanation it is how much of one currency which can be exchanged for another. Like the price of an asset, the exchange rate is the price at which one can buy a currency. There are two types of exchange rate that is the real and the nominal exchange rate. The former is how much of one currency can be traded for a unit of another currency where as the latter describes how many of a good or service in one country can be traded for one of the

good or service in another country. For the purpose of this study however the nominal exchange rate is employed. In the foreign exchange market for instance, different currencies can be exchanged at a specific rate, making exchange rate a very important tool when it comes to imports and exports. The currency is measured by the Ghana cedi to the U.S dollar. The U.S dollar is used because it is the currency most used in international transactions and is the world's primary reserve currency. The exchange rate used in the study is interbank, that is, it is related to transaction or communications between banks. For the purpose of this study however appreciation of the cedi means the local currency gains value and hence less of it will be need in exchange for the dollar.

3.6.2 Commodities

A commodity is a basic good used in commerce that is interchangeable with other commodities of the same type. They are mostly used as inputs in the production of other goods and services. Thus any physical substance, such as food, grains and metals, which is interchangeable with another product of the same type, can be termed as a commodity. To an economist, a commodity should have two main properties; it is usually produced and/or sold by many different companies and it should be uniform in quality between companies that produce or sell it (Gushman, 1990). Price at which they sell the commodities is a subject to supply and demand. Price of a commodity is the value of a commodity and service expressed in terms of money. It is the amount of money expected, required or given in payment for the exchange of that commodity.

Commodities are composed of two main types, the hard and the soft commodities. The former refers to those types of commodities which are mined from the ground or taken from natural resources, for example gold, copper, aluminum, silver, natural gas, to mention a few whiles the

latter refers to those types of commodities which are usually grown, for example cocoa, corn, rice, rubber, cotton, to mention a few. Soft commodities are highly perishable and are therefore subject to spoilage where as hard commodities are less perishable and long lasting. For the purpose of this study however one hard commodity and one soft commodity that is gold and cocoa are employed.

There is however another type of commodity which in recent times has gained some popularity that is the energy commodity. These commodities may either be grown or mined from the ground and the most important characteristic is that it generates some sort of energy. A typical example is coal, timber, iron, hydro, etc. For the purpose of this work however hard and soft commodities will be considered. The study takes into account two major commodities; Cocoa and Gold .These are Ghana's major primary export commodities and as such changes in their prices greatly affect the exchange rate.

3.6.3 Inflation

Inflation is a persistent or substantial rise in the general level of prices. It is related to an increase in the volume of money resulting in the loss of value currency. The Consumer Price Index (CPI) is used as it is the measure mainly used by the Ghana Statistical Service as a measure of inflation and it is also able to capture nominal price change in the economy. The CPI is used with reference to the price levels in 2010 as the base. (CPI=2010=100) (Ghana Statistical Service, 2010).

3.6.4 Interest rate

An interest rate is simply how much extra money that is charged or paid for the use of money (Moessner, 2008). Thus when lender gives out money to a borrower and charges the borrower for

using that asset it is an interest rate. It is usually expressed as a percentage of the principal and they often change as a result of inflation and the Central Bank's policies. For the purpose of this study the 91-day treasury-bill rate is used as a proxy for interest rate. A treasury bill is a short-term investment product offered by the Bank of Ghana on behalf of the Government. Purchasing a treasury bill means lending money to the government and the government repays the amount it borrowed plus the determined interest rate given upon maturity. When demand for the t-bill goes up it goes a long way to affect the currency. When more individuals, firms and investors be it local or foreign purchase the t-bill because the interest they will gain is attractive the cedi gains value and the currency appreciates.

CHAPTER FOUR

EMPIRICAL RESULTS AND ANALYSIS

4.1 Introduction

This chapter presents the estimated results of the empirical models specified in Chapter Three with focus on the stated research problem, objectives and research questions outlined in Chapter One. The study first begins with the presentation and discussion of trend analysis and unit root tests. Then the study proceed to test and present the results of existence of cointegration or otherwise among the variables in our model. As a final step, the study present the results on estimated relationship between commodity prices and the exchange rate using the various models stated in the third chapter.

4.2 Trend Analysis of Variables

The graphical analysis of the variables helps to identify the behavior of the series over time. This is important to the study as it provides the trends in the variables and also an alternative way to check the level of the stationarity of the variables. The Figures 4.1-4.5 show the graphical analysis of the trends in the series from 1999 to 2014 in their levels.

4.2.1 Graph of Variables at the level

Figures 4.1-4.5 show the graphical representation of the exchange rate, cocoa, gold, inflation and interest rate at the level. The graphs explain the behaviour of these variables during the adopted time period.

Figure 4.1 Cocoa

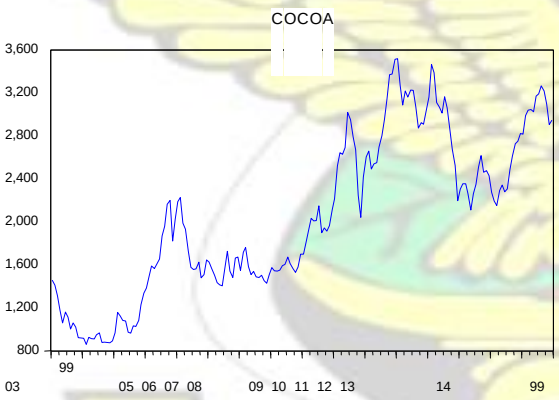


Figure 4.2 Exchange rate

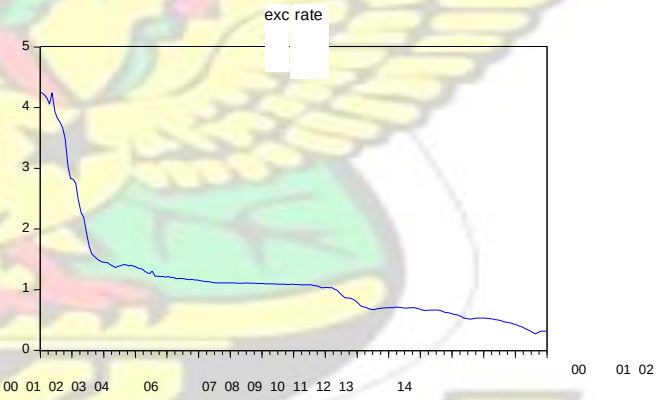


Figure 4.3 Gold

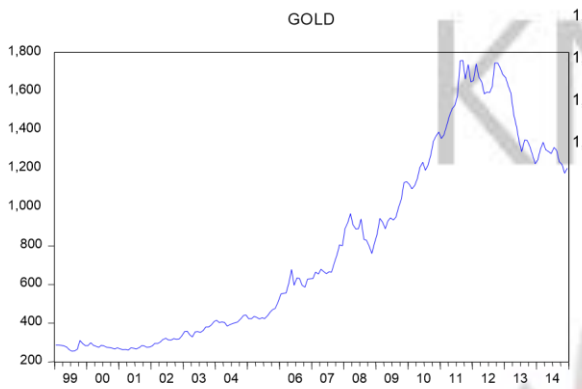


Figure 4.4 Inflation

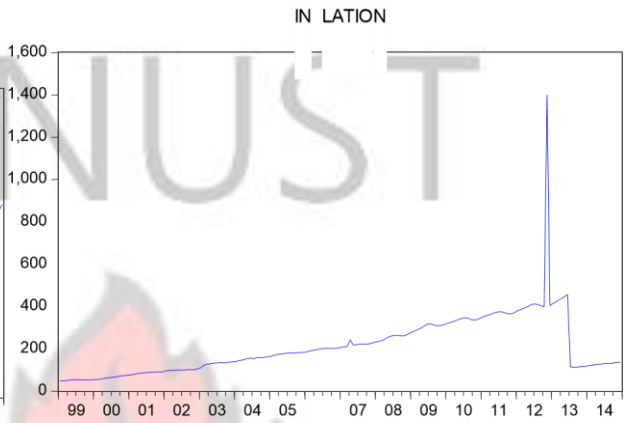


Figure 4.5 Interest rate

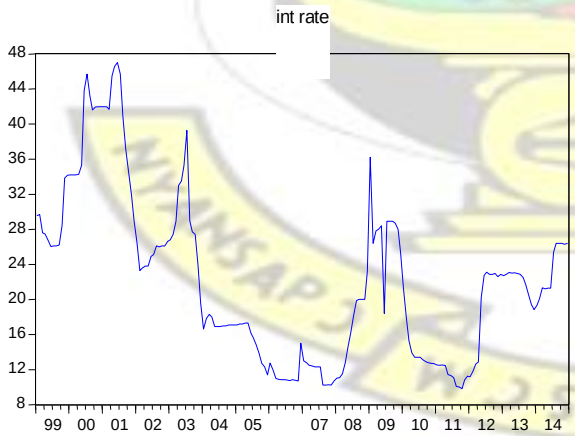


Figure 4.1 shows the decomposed trend analysis of cocoa during the adopted time period. The production and export of cocoa beans has been the most important source of income for Ghana since independence (Marcella, 2007). From Figure 4.1cocoa prices on the international market exhibits a fluctuating trend over the sample period. Cocoa production dwindled in the 90's because majority of the cocoa was obtained from small family-run farms which mostly rely on outmoded farming practices and had limited organizational leverage, falling prices, changing weather patterns as well as political factors. Between the year 2001 and 2003 Ghana's cocoa production doubled due to the intervention from the International Monetary Fund (IMF) (Bulir, 1998). Production fell for the subsequent years and begun to rise after 2007 due to the revaluation of the cedi and more importantly due to the fact that the Ghana Cocoa Board set up a more stringent quality control team, which ensures cocoa being exported are of standard and attract higher prices (Paulo et al, 2007). Cocoa prices fell sharply after 2008 but begun to rise in 2009 hitting its highest point in 2010 and then falling and rising again in the subsequent years. Proponents argue that the rise and fall pattern of cocoa prices after 2010 is due to political factors, lack of incentives and labor shortage.

Figure 4.2 shows that gold production is not a steady one however the general overview of the graph indicates an upward trend in gold production over the entire period except after the year 2012 where there sharp decline. The country is Africa's largest gold producer, producing 80.5% of the total gold which came from Africa in 2008 (Kluvi, 2010). Over 21% of the total gold production in early 1990s was obtained from the underground mines in Western and Ashanti regions of Ghana. During that same period the overall cocoa production declined from 80% to 60% because other operators entered the industry and were exploiting the Ghanaian gold (Mintah, 2010). This can be seen graph above, as production was on the low below 2005. New mines such

as Anglo Gold Ashanti limited of South Africa, Red Back Mining of Canada, Golden Star Resources of Canada, Wassa gold mines, Gold Fields limited of South Africa and Denverbased Newmont mining corporation were all commissioned to start operation in the early 90's (Appiah, 1993). After the year 2011 however illegal miners gradually overtook the industry as it can be seen from the graph that production has been falling since then.

The graph which shows the behavior of inflation is labeled as figure 4.3. This figure indicates a chart of inflation rate displaying monthly rates from 1999 to 2014. The CPI measures the overall price of goods and services in the economy and the rate of change of CPI gives the rate of inflation and hence rates of inflation are calculated using the current consumer price index (Ghana Statistical Service, 2010). Studies such as Kwakye (2012), ISSER (2001-2005) and several others have shown that increasing prices (inflation) has over the years been a hindrance to economic growth and development.

From Figure 4.3, CPI inflation exhibits an upward trend over the sample period. Inflation in the early 1990s was attributed mainly to excessive borrowing and persistent budget deficit which were financed by loans from the BoG. In the early 2000s, the Ghanaian economy was regarded as being in a very bad state, which was evident in lower per capita income, declining (and negative) growth rates, huge debt and higher inflationary trends. This period saw inflation attaining its highest record level of 41.49% in 2012; however in 2013 the government in power managed to bring the figures down to as low as 11.1%.

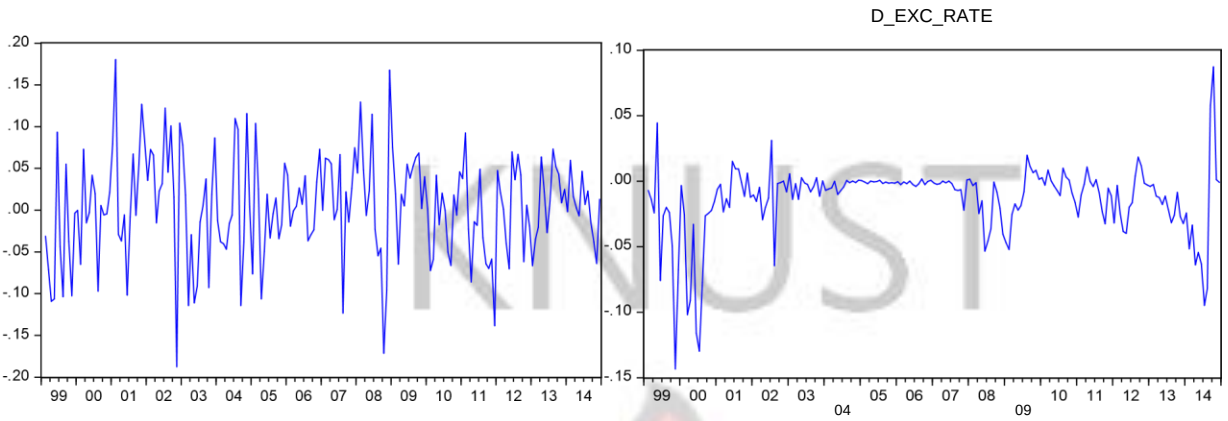
Figure 4.4 shows the interest rate for the sample period. The graph shows that interest rate has been inconsistent over the sample period. The fluctuations are largely associated with the interest

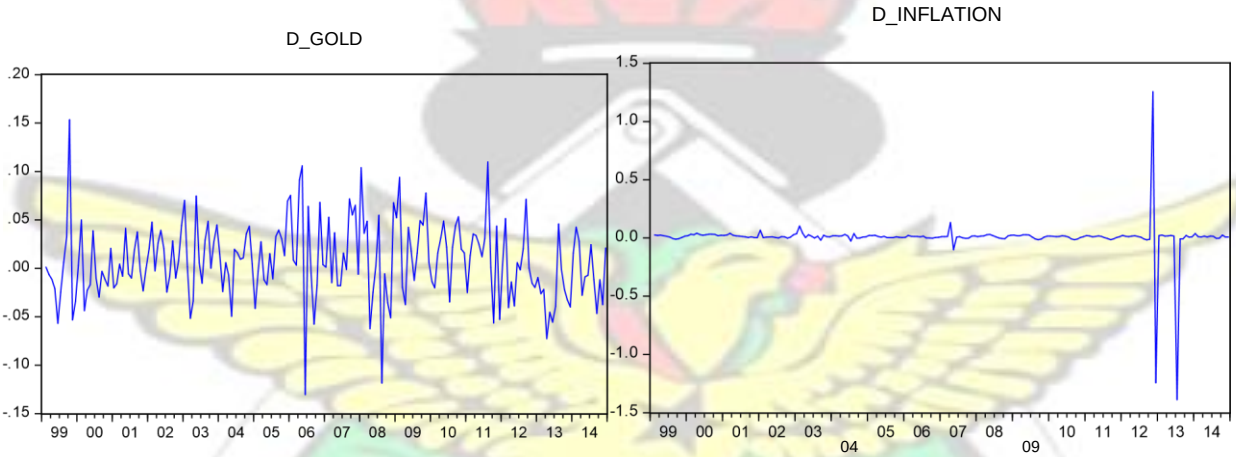
rates offered to clients. When the interest rates are high, it is attractive enough to motivate lots of individuals and corporate bodies to invest where as if the rates are low it will de motivate people to invest. From Figure 4.4 it can be seen that there was a rise in the purchase of treasury bills between the year 2000 and 2001. This could be attributed to higher interest rate within that period. After the year 2003 however it can be observed that the purchase of treasury bills dwindled because the cedi lost value until after 2007 where the cedi regained its value after the revaluation of the cedi. The initial stage of the revaluation of the cedi yielded positive results. It can be seen clearly from the graph that purchase of the Treasury bill increased however after the revaluation of the cedi the demand for t-bills kept on fluctuating as shown in the above graph.

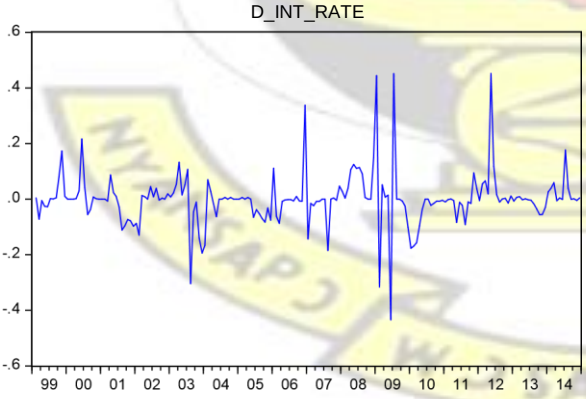
Last but not the least Figure 4.5 shows the path of the exchange rate from 1999 to 2014. The graph suggested that the exchange rate measured by the cedi against the US Dollar has been decreasing over the sample period. Historically, the Ghanaian cedi reached an all-time high in the year 2011 and a record low in 2007 which lead to an appreciation of the cedi. However, the appreciation of the cedi between 2007 and 2008 was attributed mainly to the initial stages of the redenomination of the Ghanaian cedi. On the average, the upswings and downswings could be attributed to the adjustment to the flexible exchange rate regime, as well as the adjustment to the
ERP and SAP as well as the redenomination of the cedi.

Figure 4.6 Graph of Variables in first difference

D_COCOA


D_EXC_RATE
.20
.15
.10
.05
.00
-.05
-.10
-.15
-.20
.10
.05
.00
-.05
-.10
-.15
99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14


D_GOLD
D_INFLATION
.20
.15
.10
.05
.00
-.05
-.10
-.15
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14


D_INT_RATE
.6
.4
.2
.0
-.2
-.4
-.6
99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14

The series tend to fluctuate around their mean after they were differenced once. This shows that the series became stationary in first difference form. Figure 4.6 show that the graphs of the first difference are stationary unlike the nature of the series shown in the previous figures. Thus, first difference graph shows that the nature of the variables employed in this study are mean reverting hence the series will achieve some form of stationarity after the first difference. Since this is an informal way of testing for unit root, the study proceeds to estimate the unit root using ADF and Philips-Perron test to confirm this assertion.

4.3 Results of stationarity test

In investigating the relationship between commodity prices and exchange rates it is important to test for the existence of unit root or otherwise in the series. To ensure that the presence of unit root in the individual series or otherwise is strong in the study two tests are employed in the study. The study thus tested the stationarity of the variables using the ADF and the Philip-Perron test. In both cases, the null hypothesis is the presence of unit root in the individual series (nonstationarity). This is tested against the alternative of stationarity. The Table 4.1 shows the unit root test results.

Table 4.1 Stationarity test results

VARIABLES	CONST	CONST + T	CONST	CONST + T	
			LEVELS		
LNEXR	-1.7777	-2.0065	-2.7005	-3.8776	?
LNCOCOA	-1.3581	-2.9574	-0.9796	-2.6560	?
LNGOLD	-0.6898	-1.0737	-0.7409	-1.3348	?
LNINF	-2.1890	-3.0710	-1.6955	-2.3768	?
LNINT	-1.7945	-1.7098	-2.0341	-2.0520	?
			FIRST DIFFERENCE		
LNEXR	-7.575***	-6.5682***	-9.8803***	-10.6733***	I(1)
LNCOCOA	-10.7740**	-10.7482**	-10.5837**	-10.5552**	I(1)
LNGOLD	-11.7063**	-11.6802**	-11.7084**	-11.6823**	I(1)
LNINF	-12.6835**	-12.6945**	-41.5036**	-45.3923**	I(1)

LNINT	-13.8437***	-13.8367***	-13.9157***	-13.9057***	I(1)

Note: **and *** denote rejection of the null hypothesis at 5% and 1% significance level respectively

From Table 4.1, it can be seen that the study failed to reject the null hypothesis of the presence of unit root when estimated in levels for both the ADF and the Philips-Perron tests. The study however rejected the null hypothesis when the series were first differenced for both tests. It can therefore be concluded that all the underlying series in the present study are integrated of order one [I (1)]. The presence of unit root in the data has both statistical and economic implications worth noting. Statistically, the presence of unit root in the data has the potential of producing spurious relationships when ordinary least squares methods are applied on the data. It is thus important to know the order of integration of each of the series in the model prior to estimation. The economic implication of unit root is that shock to any of the variables will have a lasting effect (lack of mean reversion). From the results however, all the variables were not stationary at the levels hence had unit root. Variables that are non-stationary have permanent shock effect. However, to correct a non-stationary series, the differencing approach is used. After differencing the series the first time, the variables were all stationary. This implies that the variables are all stationary at the first difference, hence integrated of order one. Stationary series have temporary shock effects and as such estimating a regression with stationary variables would help avoid spurious results. Based on the stationarity test, the study proceeded to test for the presence of cointegration using the Johansen Multivariate cointegration approach.

4.4 Lag Order Selection

The criteria for the selection of the optimal lag order of the variables included in the model is based on the four main frequently used measures according to literature and these are the Final Prediction

Error (FPE), the Akaike Information Criteria (AIC), Hannan-Quinn Criteria (HQ) and the Schwarz Criteria (SBIC). AIC, HQ and SBIC with lower values are selected whiles. The results show that all four measures supported a lag length of 4 thus the study opts for a lag length of 4. The result is presented in Appendix A.

4.5 Results and Analysis of the Cointegration

For the relationship between commodity prices and exchange rates to be examined the Johansen cointegration test is employed. The Johansen method indicates that, if the trace statistics is not greater than the critical value, then we do not reject the null hypothesis of no cointegration. If otherwise the test rejects the null hypothesis, then cointegration is said to be present. The cointegration result is presented in Table 4.2.

Table 4.2 shows the outcome of the cointegration test for the series. The study relies on the trace test to investigate the presence of cointegration amongst the series since it is widely accepted as the most appropriate test in determining the presence of cointegration. The trace statistics indicates that there is at least one cointegrating vector at 5% level of significance.

Table 4.2: Cointegration test for the Series

Sample (adjusted): 1999M06 2014M12 Included observations: 187 after adjustments

Series: LNEXC_RATE LNCOCOA LNGOLD LNINF LNINT_RATE

Lags interval (in first differences): 1 to 4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.	Max-Eigen Statistic	0.05 Critical Value	Prob.
None *	0.177981	74.6705*	69.81889	0.0194	36.65041*	33.87687	0.0227
At most 1	0.106285	38.02008	47.85613	0.3011	21.01288	27.58434	0.2755
At most 2	0.048077	17.00720	29.79707	0.6395	9.213680	21.13162	0.8148

At most 3	0.033386	7.793523	15.49471	0.4877	6.349852	14.26460	0.5687
At most 4	0.007690	1.443672	3.841466	0.2295	1.443672	3.841466	0.2295

Trace test indicates 1 Cointegrating eqn at the 0.05 level
Max-eigenvalue test indicates 1 Cointegrating sat the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Note: * indicate the level of integration

The decision rule is that if the test statistics is greater than the critical value, then the null hypothesis of no cointegration is rejected, hence a conclusion can be drawn that there is the presence of cointegration amongst the series. On the other hand, if the test statistics is lesser than the critical value, it leads to the non-rejection of the null hypothesis and a conclusion can be drawn that there is absence of cointegration amongst the series. From the results obtained from both the trace statistic and the max-eigenvalue however it can be concluded that there exit a long-run relationship among the variables. The study then proceeded further to examine the long run results of the model using the Vector Error Correction Model (VECM).

4.6 Results of effects of commodity prices on exchange rate

4.6.1 Long-run relationship

Upon establishing the presence of cointegration amongst the variables the next step is to proceed to estimate the long run estimates of the variables. Table 4.3 present the long-run results.

Table 4.3 Estimation of long-run results

Sample (adjusted): 1999M06 2014M12
Included observations: 189 after adjustments
Dependent variable: LNEXR

Variable	Coefficient	Standard errors	T – statistics
LNCOCOA(-1)	0.588356	0.46527	1.26456
LNGOLD(-1)	1.973960**	0.35530	5.55569
LNINF(-1)	-1.253272**	0.29717	-4.21736
LNINT(-1)	0.522798**	0.26423	1.97854

C	-0.008643	0.00200	-4.32150

Note: *, **, *** denotes rejection of the null hypothesis at 10%, 5% and 1% significance level respectively

The study finds that in the long-run commodity prices are positively related to exchange rate. In the case of cocoa, the study finds that a one percent change in the price of cocoa causes a 0.59 percent change in exchange rate in the long-run. Thus if cocoa prices increase by 1% exchange rate will also rise by about 0.59 % and when cocoa prices drop by 1% the exchange rate will fall by about 0.59 %. This is confirms a prior expectations. This is because Ghana depends largely on cocoa exportation for revenue generation thus when cocoa is sold at higher price on the international market Ghana generates lots of revenue. Ghana is a net cocoa exporter and as such when cocoa price is high Ghana tends to reap greater revenues from its cocoa export. With an increase in revenue generation the value of the national currency appreciates and hence the exchange rate appreciates as well. On the other hand when cocoa is being sold at a lower price on the international market the national currency depreciates. This is because when the price of cocoa drops Ghana generates less revenue from its cocoa export giving other currencies a boost over the Ghanaian cedi on the foreign exchange market. However it was not significant because over the years cocoa's contribution to economic growth and development has been declining.

In the case of gold a positive relationship was expected to exist between the exchange rate and the price of gold. The result confirms the prior expectation. The study finds that a 1 % change in the price of gold causes a 1.97 % change in the exchange rate in the long run. In that, if gold prices increase by 1 % the exchange rate will respond by increasing by 1.97 % and if gold price fall by 1 % the exchange rate will also fall by 1.97 %. Again Ghana is a country which depends largely on the mining and exportation of gold for its revenue generation. With an increase in the price of

gold, Ghana reaps greater revenue from its gold exportation giving the Ghanaian cedi a boost on the foreign exchange market.

The result further showed that, inflation rate is negatively related to the exchange rate in the long run. The study finds that a 1 % increase in inflation causes a 1.25 % decrease in the exchange rate in the long run. This confirms a prior expectation. This is not surprising since a persistent rise in domestic price levels will push Ghanaians to buy cheap imported foreign goods from their foreign trade partners. As more of the foreign goods are purchased the supply of the cedi increases and its value comes down hence the exchange rate depreciating. On the other hand when inflation reduces by 1% the exchange rate will in turn rise by about 1.25%. This is because when prices of commodities are lower domestically both local and foreign consumers are attracted to purchase Ghanaian commodities. Less of the cedi is therefore supplied and its value goes up leading to an appreciation of the currency.

Finally, the study finds that interest rate is positively related to the exchange rate in the long run as expected. Specifically, a unit change in interest rate causes a 0.52 % change in the exchange rate. Thus when interest rates increases by 1 % exchange rate will rise by about 0.52 % and when interest rate falls by one percent exchange rate will fall by 0.52 percent. This is not surprising because when interest rates are high investors are motivated to purchase the Treasury bills. As more Treasury bills are purchased more money is lent to the government and by so doing less of the currency is supplied and the currency gains value. Once the currency gains value it appreciate against other major currencies. Again as more people invest they tend to save and hence cut down on their consumption. Less of the cedi is therefore supplied into the system and the cedi gains value in the long run. Otherwise lower interest rates will demotivate both local and foreign

investors to purchase the Treasury bill and as people feel reluctant to invest they turn to spend more. As people spend more the supply of the currency increases and as more of the currency is supplied it loose value and it depreciates.

4.8 Results for the test of commodity price volatility

In other to know whether the commodity prices are volatile or not the GARCH Methodology was employed to test for the ARCH effect. Volatility here refers to the amount of uncertainty or risk about the size of changes in a commodity's value. A higher volatility means that a commodity's value can potentially be spread out over a larger range of values. This means that the price of the commodity can change dramatically over a short time period in either direction. A lower volatility means that a commodity's value does not fluctuate dramatically, but changes in value at a steady pace over a period of time. The results for cocoa and gold are presented in Table 4.4 and Table 4.5.

Regarding Table 4.4, it can be seen that at a 10 percent significant level cocoa has both ARCH effect and GARCH effect because their P values are 0.0615 and 0.000 respectively and both are less than 0.10. This means that cocoa prices are volatile on the international market thus affecting both demand and supply of cocoa. At a 5 percent significant level however there is

GARCH effect but no ARCH effect. Economically, this implies that cocoa prices can change dramatically over a short period of time. Cocoa prices therefore have a significant ARCH effect at a 10 percent significant level and this identifies a time varying conditional volatility hence indicates that cocoa prices are not stable on the international market. Thus ARCH test is a vital tool for examining the time dynamics of the conditional variance.

Table 4.4 Test for cocoa price volatility

Dependent Variable: D(LNCOCOA)
Method: ML-ARCH (Marquardt) – Normal distribution
Sample (adjusted):1999M03 2014M12
Convergence achieved after 24 iterations
Pre sample variance: backcast (Parameter = 0.7)
GARCH = c(3)+c(4)*RESID(-1)^2+c(5)*GARCH(-1)

Variable	Coefficient	Std Error	Z-statistics	Prob
C	0.003863	0.003992	0.967641	0.0332
D(LNCOCOA)	0.193157	0.079337	2.434633	0.0149

Variance Equation

C	0.000387	0.000421	0.917569	0.0358
RESID(-1)^2	0.105619	0.075434	1.400158	0.0615
GARCH(-1)	0.784853	0.161086	4.872248	0.0000

S.E. of regression	0.040062	Akaike info criterion	-3.610253
Sum squared resid	0.301738	Schwarz criterion	-3.524863
Log likelihood	347.9740	Durbin-Watson stat	2.067625

Source: Author's computation using data from ICO (1999-2014)

Similar results were obtained in the case of gold as shown in Table 4.5. At a 10 percent significant level gold has both ARCH effect and GARCH effect because their P values are 0.0987 and 0.0035 respectively and both are less than 0.10. Again this means that gold prices are volatile on the international market and hence affects both demand and supply of cocoa. At a 5 percent significant level however there is GARCH effect but no ARCH effect. This result further indicates that gold prices are not stable and it keeps changing dramatically over a short period of time.

Table 4.5: Test for gold price volatility

Dependent Variable: D(LNGOLD)
Method: ML-ARCH (Marquardt) – Normal distribution
Sample (adjusted):1999M03 2014M12 Convergence achieved after 21 iterations
Pre sample variance: backcast (Parameter = 0.7)
GARCH = c(3)+c(4)*RESID(-1)^2+c(5)*GARCH(-1)

Variable	Coefficient	Std Error	Z-statistics	Prob
C	0.006521	0.003182	2.048864	0.0405
D(LNCOCOA)	0.142044	0.090337	1.571692	0.1160
	Variance Equation			
C	0.000325	0.000267	1.217019	0.2236
RESID(-1)^2	0.143426	0.086851	1.651409	0.0987
GARCH(-1)	0.653390	0.223487	2.923620	0.0035
S.E. of regression	0.040062	Akaike info criterion		-3.610253
Sum squared resid	0.301738	Schwarz criterion		-3.524863
Log likelihood	347.9740	Durbin-Watson stat		2.067625

Source: Author's computation using data from World Bank's WDI (2014)

4.9 Results for the effect of commodity price volatility on exchange rate

The results obtained in section 4.8 shows that the commodity prices are volatile and hence the explicative effect of commodity price volatility on the exchange rate can be examined. To do this the VAR and the Impulse Response Function was employed. Following Elder and Serletis (2010) the VAR was modified to contain the GARCH in order to analyze the effect of commodity price on the exchange rate. The Impulse Response Function of the variables is done to provide an indication of how the exchange rate responds to fluctuations in the commodity prices.

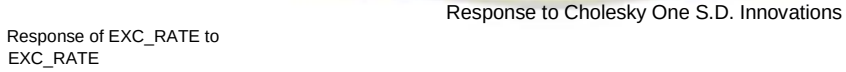
VAR is a reduced form model and as such its coefficients are difficult to interpret thus the Impulse Response Function (IRF) is used to examine how the variables develop and affect each other. The impulse response function is used to interpret the coefficients directly and provides a more informative way to understand the relationship among the selected variables of interest. The impulse response function generated from the base VAR model is presented in section 4.9.1 below.

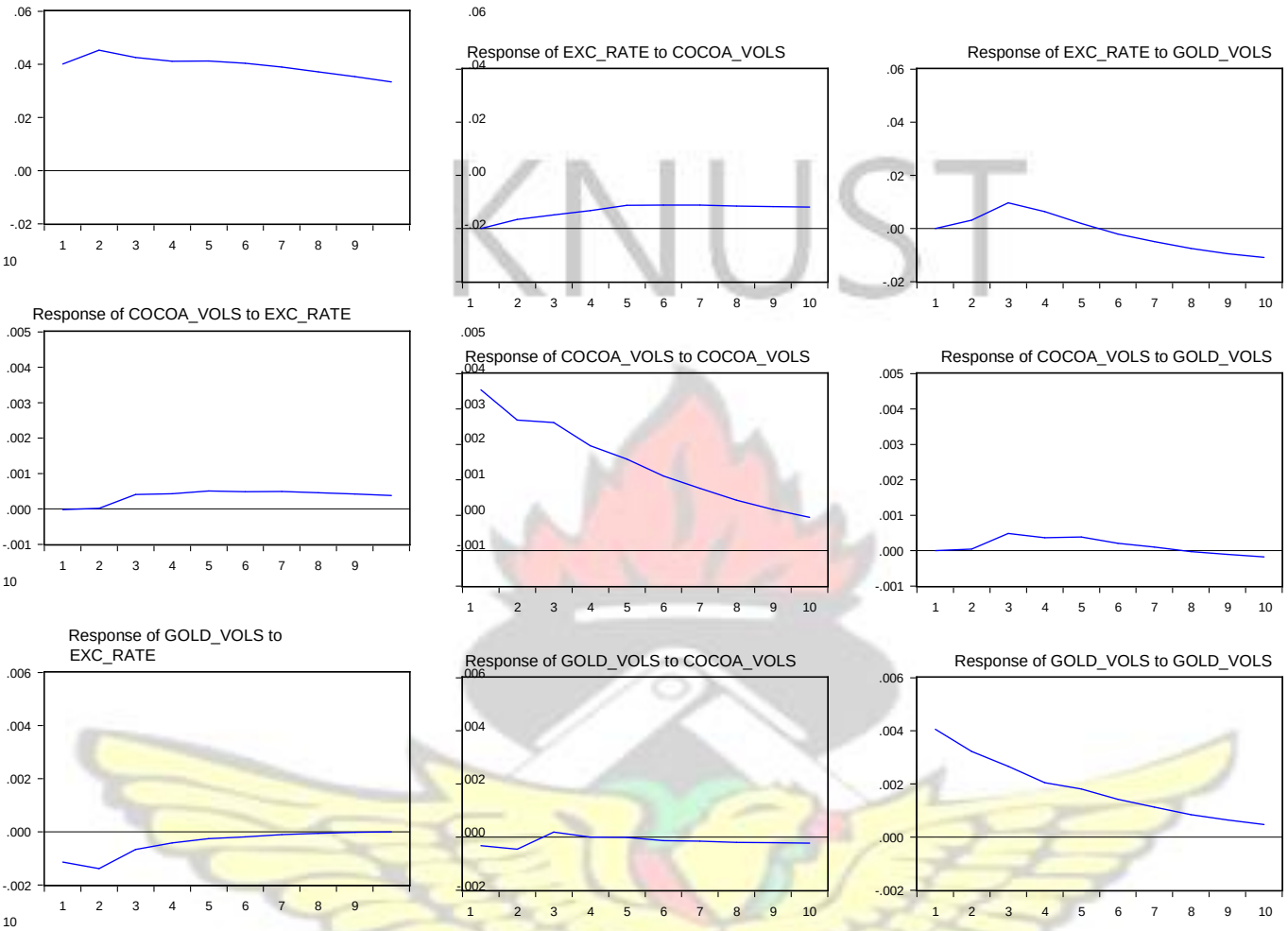
4.9.1 Impulse Response Function from the base model

The impulse response functions of the variables show how the exchange rate responds to the fluctuations in the prices of the commodity (Cocoa and Gold). The VAR model satisfied the stability condition such that all the eigenvalues are less than one and lie within the unit circle therefore making it possible to generate the Impulse Response Function. The stability test is presented in appendix G. The impulse response functions generated after the estimation of the VAR is presented to identify how the exchange rate responds to a one standard deviation of the various commodity prices. Figure 4.7 shows the various responses.

The First row shows how the exchange rate responds to fluctuations in the exchange rate itself, to cocoa price volatility and then to gold price volatility. The second row shows how cocoa prices volatility respond first to the exchange rate then to cocoa price volatility itself and then to gold price volatility. The third row shows how gold price volatility first responds to the exchange rate then to cocoa price volatility and then to gold price volatility itself. The focus here however is on the response of the exchange rate to cocoa price volatility and gold price volatility respectively.

Figure 4.7 Impulse Response Function Results





How the exchange rate respond to cocoa and gold price volatility can be seen in the last two graphs in the first rows in figure 4.7

In the case of cocoa the graph start from a zero value but begins to rise after the first period until after the fifth period where it stabilizes. The graph lies above the zero value indicating a positive response. Exchange rate therefore responds positively to cocoa price volatility. This means that when cocoa prices are not stable on the international market the exchange rate goes up and hence more of the cedi will be needed in exchange for the foreign currency. It can be observed that after the fifth period the exchange rate is stabilized for a while. This can be attributed to the redenomination of the cedi in the year 2007 and more importantly due to the fact that the Ghana

Cocoa Board set up a more stringent quality control team, which ensures cocoa being exported are of standard and attract higher prices (Paulo et al, 2007). The effect is minimal averaging between 0% and 1%.

In the case of gold similar results were obtained. It can be observed from the graph that exchange rate first responded positively to fluctuations in gold price but after the fifth period it responds negatively. It starts off at zero value and rises steadily up to the fifth period where it drops to negative. This shows that as gold prices keep on fluctuating the exchange rate goes up and as such more of the local currency will be needed to in exchange of the foreign currency. Again with the revaluation of the cedi in 2007 amidst exporting higher standard gold (which attract higher price) the exchange rate falls. In that case less of the local currency is needed in exchange for the foreign currency. This is represented by the declining part of the graph.

Thus when commodity prices keeps on fluctuating the exchange rate responds positively and hence more of the local currency will be needed in exchange for the for the foreign currency.

From figure 4.7 it can be observed that all the graphs in the diagonal are positive and are lying above the zero line. This is because the graphs in the diagonal depicts the responses of changes in the variables to shocks in the variables itself and hence the end result is a positive effect on the own variable.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Chapter five basically provides the summary and conclusion of the study. Policy implications and recommendations based on the findings obtained are also illustrated in this chapter.

5.2 Summary of Major Findings

This study sought to find out how commodity prices and exchange rates are related. To do so cocoa and gold which are Ghana's major primary export commodity were considered. Monthly time series data from 1999 to 2014 on the selected variables of interest was used to estimate the variables.

The study first employed the Johansen Cointegration technique and the Vector Error Correction Model (VECM) to accomplish the first objective. This model was used to establish a relationship between the dependent variable, which is exchange rate and the independent variables which are cocoa, gold, inflation and interest rate. Furthermore the Autoregressive Conditional Heteroskedasticity (ARCH) and the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) methodology were used to accomplish the second objective (that is, to test if the commodity prices are volatile). This model was used to examine the ARCH effect and test if volatility exists among commodity price. After testing if volatility exists among the commodity prices the study proceeded to use the VAR and the Impulse Response Functions to examine how the exchange rate responds to commodity price volatility.

The findings of the study are as follows:
The Johansen Cointegration method was employed to establish a relationship between the variables of interest and both the trace and maximum eigen statistics proved that the variables of

interest are cointegrated. Thus, there exist some sorts of long run relationship among the variables of interest.

The Vector Error Correction Model (VECM) was used to evaluate how the selected variables of interest are related. It was found out that commodity prices are positively related with exchange rate

Inflation responded negatively with exchange rate and as such when inflation increases by 1 % the exchange rate falls by 1.25%. Alternatively when inflation falls by 1 percent the exchange rate increases by 1.25%.

Also the study found out that interest rate is positively related with the exchange rate. From the results if interest rate increases by a unit the exchange rate will increase by 0.52% and when the interest rate falls by 1 percent the exchange rate drops by about 0.52%.

The GARCH methodology was used to test for the ARCH effect among the commodity prices and the results obtained revealed that there was ARCH effect. At a 10% significant level cocoa had both ARCH and GARCH effect but at a 5% significant level there was no ARCH effect. Similar results were obtained for gold price as well. At a 10% significant level gold had both ARCH and GARCH effect but only GARCH effect at a 5% confident level.

The VAR and the Impulse Response Function were used to examine the impact of commodity price volatility on the exchange rate. In both cases the results indicated that exchange rate

responded positively with fluctuations in the prices of the commodities. However in the case of gold the results changed after the fifth period.

5.3 Conclusion

The primary aim of the research work was to examine how commodity prices affect the exchange rate in Ghana using cocoa and gold which is the nation's major primary export commodity. The GARCH methodology and other methods were employed to undertake this study. Monthly time series data from 1999 to 2014 on the specific variables were employed as well. The study followed both empirical and theoretical foundations to make sure reasonable interpretations were achieved, the study however revealed some thought-provoking results.

The Johansen cointegration technique and the Vector Error Correction Model were used to establish the relationship between the variables of interest and it was seen that all the independent variables are positively related with the exchange rate except for inflation which exhibited a negative relationship. The commodity prices were proven to be volatile as the ARCH test results showed that there was ARCH effect. Finally the study employs the Impulse Response Functions based on the unrestricted VAR approach to examine how commodity price volatility affected the exchange rate. Responses of changes in the commodity prices to changes in the exchange rate were critically examined. These conclusions therefore called out for some recommendations which are outlined below.

5.4 Recommendation

The analysis of the study based on the Johansen, VECM and VAR proved that all the commodity prices were positively related with the exchange rate. This has an economic implication and hence

it is recommended that government set policies which will target increasing commodity prices on the international market.

For instance stringent measures can be used to ensure that finished products are exported and sold on the international market since finished products attract higher prices. Setting up refineries for the purification and refining of gold before exporting will attract higher prices. A typical example is in Botswana where the local mining companies partnered with some major international smelting companies. These companies fast tracked Botswana's metal discoveries and gave the local refineries financial support which helped the Bostwanian economy to sell refined diamond and other jewelries which attracts higher prices on the international market.

Ghana government can therefore adopt this strategy to help sell gold at a higher price.

Ghana depends so much on cocoa and gold for its revenue generation and hence shocks or instability in the prices of these commodities renders the economy highly vulnerable. The exchange rate responds consequentially to the commodity price volatility and as such when prices rises the exchanges rate rises and when it falls the exchange rate falls as well. Thus there is the need for government to put measures in place to reduce volatility and also try to stick to the forward volatility (when prices go up) as much as possible. For instance when ever the economy experience bumper harvest silos can be used to store the excess and sold at higher price in the near future when the commodity is in short. This will ensure that there is constant supply of the commodity on the market and price therefore its price will not be fluctuating.

Also government should set policies which will target reducing inflation in other for the currency to appreciate. The study found out that there was a negative relationship between inflation and the exchange rate and hence if inflation is brought down then the currency will appreciate. Persistent

increase in the general price level will make the currency lose value thus measures must be put in place to ensure that prices are stabilized.

In the light of the above results it can be concluded that the relationship between the exchange rate and commodity prices has been found to be relevant, however there is the need for further research on this topic. Also, this analysis could be extended to analyzing volatility of commodity prices and its effect on demand for the commodities.

REFERENCES

Akbar, F., & Chauveau, T. (2009). The exposure of Exchange Rate to Public Debt Portfolio of Pakistan: Using Value at Risk Approaches. *SBP Research Bulletin, Vol. 5, No. 2. , 5* (2).

Ales Bulir (1998). The Price Incentive to Smuggle and the Cocoa Supply in Ghana. International Monetary Fund Report.

Adjasi, F. (2007). The Role Price Plays in The Determination of the Exchange Rate: Using some selected developing countries. *NBER working papers #* 4562-67

Aguiar, M., & Gopinath, G., (2007). The Role of Interest Rates and Productivity Shocks in Emerging Market Fluctuation. *Journal of Economic Forecasting.* Vol 7

Anastopoulos, K.B., (2000) Monetary Policy Rate (MPR) and Its Impact on Emerging Economy. *Interest Rate Dynamics Report*, 214

Akomibi, N. (2010). How the Dimensions of A model is Estimated. *Journal of Statistics*. 573

Anang Tawiah, (2015). Ghana's cocoa imdustry. *Economy of Ghana,* Vol 2

Arezki, R., Dumitrescu, E., Freytag, A., and Quintyn, M. (2012). Commodity Prices and Exchange Rate volatility: Lessons from South Africa's Capital Account Liberation. International Monetary Fund Working Paper No. WP/12/168

Adam Vanghan., (2012). Agriculture in Ghana- Facts and Figures. *IISTE Journal*, Vol 3.

Akram, Q. F., 2008. Interest Raet, Comoditty Prices and the Dollar' Research Department of the Norges Bank Working Paper No. 2008/12, August.18

Ahmet, S., Erk, H., Duc, W.N., (2015). Dynamic Convergence of Commodity Futures. Research Department of Bora Instanbul,

Bartov, E., Bodnar, G., & Kaul, A. (1996). Exchange rate variability and the riskiness of US multinational firms: evidence from the breakdown of the Bretton Woods system. *Journal of Financial Economics* (42), 105–132.

Bryne, J.P., Farzio G., Fiess N., (2013). Primary Commodity Prices: Co-Movement, Common Factors and Fundamentals. *Journal of Development Economics.* Vol 101

Baffe, J. (2001). Evidence on LOOP: The Law of One Price Still Holds.*American Journal of Agricultural Economics 73(1991):1264–73.*

Bashar, K.M.R., and Sarkar H.K., (2013). Relationship between Commodity Prices and Exchange Rate in the Light of Global Financial Crisis: Evidence from Australia. *International Journal Of Trade, Economics and Finance.* Vol 4, No. 5.

Branson, W., (1993). Macroeconomic Determinants of Real Exchange Risk: Managimg Foreign Exchange Risk. Cambridge University Press.

Bollerslev Tim, (1986). Generalized Autoregrssive Conditional Heteroskedasticity with Application in Finance. *Journal of Applied Econometrics.* Duke University Press.

Bessler, D.A. and D.G Akleman. (1995) Farm Prices, RetailPrices and Directed Graphs: Results ForPork and Bee f." *American Journal of Agricultural Economics 80(1998):* 1144–1 149.

Bulir, A.Z (1998). Production in an Economy. Internatioanal Handbook on the Economics of Production

Cashin, P., Liang, H., McDermott, C.J., (2000). How Persistent are Shocks to World Commodity Prices. International Monetary Fund Staff Papers. Vol 47

Chow, E & Chen, H.L (1998). How to determine foreign exchange rate exposures: A case study on Japan firms. *Pacific-Basin Finance Journal, 6,153-74*

Caporale, G.M., Menla Ali, F., Spagnolo, N., (2015). Oil price uncertainty and sectoral stock returns in China: A time-varying approach. *China Econ. Rev.* 34, 311–321.

Cassel, G. (1996). Purchasing Power Parity Issues among developing countries. *International Journal of Economics, 5, 276-91*

Carloo, G., Leiderman, L., and Reinhart, C., (1996). Inflows of Capital to Developing Countries in the 1990's. *Journal of Economic Perspective.* 10(2) 123-139

Cecchetti, S.G & Moessner R. (2008). How commodity prices and Inflation interacts over time. *Bank for International Settlement Quaterly review*. 565-62

Chibuike, R.O., Jude, O., Chukwu, A., and Joseph, I.A., (2010). Purchasing Power Parity Puzzle: Evidnce from Ghana. *Journal of Developing Areas,* Vol. 44 No. 1.

Chikili, W., Hammoudeh, S., Nguyen, D.K., (2014). Volatility Forecasting and Risk Management for Commodity Market in the Presence of Asymmetry and Long Memory. *Journal of Energy Economics*. Vol 41.

Chen, Y., Rogo, K.,and Rossi, B., (2008). Can Exchange Rates Forecast CommodityPrices? National Bureau of Economic Research. Paper # 13901.

Clark, T. E., & West, K.D., (2006)." How to test for the Martingle Differnce using out of sample mean squared prediction errors", Economrteics Journal 135.pp 155-186.

Calvo, G., (2008). Exploding Commodity Prices. Lax Monetary Policy and Sovereign Wealth Funds. Vox UE.

Cheung, G., Lordine, F.K., and Demoti, A., (2007). Purchasing Power Parity issues in Emerging economies. *China Economics Rev* 156-432

Dominguez, K., and Tesar, L., (2006). Exchange rate exposure. *Journal of International Economics , 68*, 188-218.

Danshesku, O.P., (2007). Exchange Rate and Commodity Price volatility. International Monetary Fund Working Paper no. WP/14/150

Dixit, A., and Pindyck, R.S., (1994). Investment Under Uncertainty. Princeton University Press.*Journal of Development Economics.* Vol 69.

Haan, D. (1997). A guide to estimating Robust Covariance Matrix. *Hnadbook of ststistics* 24, pp 291-341

Dornbush, R. and Fisher, S., (1980). Exchange Rates and the Current Account. American Economic Review 70.

Daskalaki C., Skialopoulos H., (2011). Should Investors Include Commodities in their Portfolio after all? New Evidence, *Journal of Banking Finance*. Vol 35, 2606-2626.

Dontoh Ekow, (2013). Foreign Direct Investment and its impact on the economy: The Ghanaian case.

Deaton, A., (1999). Accerleration of commodity prices in Africa and Trade*Journal of Economic Perspective.* Vol 13

Engel, C. and West K. D., (2005). Exchange Rates and Fundamentals", *Journal ofPolitical Economy* 113, pp. 485-517.19.

Elder, J., Serletis, A., (2010). Oil price uncertainty. *J. Money Credit Bank*. 42, 1137–1159.

Edward, S., (1985). Commodity Export Prices and the Real Exchange Rate in Developing Countries: Case Study of Coffee in Columbia. National Bureau of Economic Research. Working Paper No. 1570

Frankel, J. (2008). How monetary Policy affects real Commodity prices. Unicersity of Chicago Press. Pp 291-334

Frederick, P. (2008). Causes of Fluctuations in the Canadian Dollar: Case study in Canada. *Journal of Financial Economics* 60-525

Groen, J. J. J. and G. Kapetanios, (2009). How Factor Augmented Models are selected. Federal Reserve Bank of NY State. Report # 363

Gorton, G. and K. G. Rouwenhorst, 2005. Facts and Fantasies About Commodity Futures. Yale ICF Working Paper No. 04-20.

Goodwin, R. (1992). Impact of Inflation on the value of local currencies in emerging economies. IMF Working Paper # 6538-567

Ghana Statistical Service The, (2010). Consumer Price Index, Accra, Ghana.

Gushman C.M (1990). Exchange Rate Dynamics in a Model of Pricing to Market. *Journal of international economics* 50, 215-44

Hamilton, J. (2009). Causes and the effect of Oil price Fluctuations during 2007-8, Brooking paper on economic Activity, Spring forthcoming.

Israd, M. (1997). The dynamic effects of aggregate demand and supply disturbances. *The American Economic Review*, Vol 79(4), ppt. 655-673.

Jacque, L. (1996). Management and Control of Foreign Exchange Risk. *Kluwer Academic Publishers*.

Jeret, D., Cuddington, J.T (2008). Expanding the Search for Metal Price Super Cycles to steel and other Realted metals. Resource Policy Vol 33

Jian Yang, David, A., Bessler, D., Leathan, J., (2000). The Law of One Price in developed and developing Countries *Journal of Agricultural and Applied Economic.* Vol 3.
John Harper (2007). Botswana Federal Trade Unions and Policy Positions. Jornal of Trade and Economics.

Joseph Opoku Gakpo, (2012). Why Ghana is cocoa and cocoa is Ghana, A handbook on the economy of Ghana, Vol. 5.

Jorion, P. (1990). The exchange-rate exposure of US multinationals. *Journal of Business , 63* (3), 331-45.

Jan-Groen, J.J. and Pesenti P.A., (2009). Commodity Prices, Commodity Currencies and Global Economic Developments. Federal Reserve Bank of New York, Staff Report.

Khoo, A. (1994). Estimation of foreign Exchange exposure: an application to mining companies in Australia. *Journal of International Money and Finance , 13* (3), 342-363.

Kofi Adu Domfeh, (2014). What will save Ghana's Agricultural Industry: Recent Evidence from Ghana. Graduate Institute of International and Development Studies, International Economics Department Working Paper Series. Working Paper No. IHEIDWP14-2015

Krugman, P., (2008). The Oil Non Bubble. The New York Times.

Michael, L.M., (1998). The Theory of Exchange Rate Determination. University of Chigaco Press. Vol 26. National Bureau of Economic Research.

Michael, P., Nobay, R.A., and Peel, D., (1994). Purchasing Power Parity Yet Again: Evidence From Spatially Separated Commodities Markets. *Journal of International Money and Finance* 3(1) 324-383.

Moslares, C., and Rafael, A.S., (2003). The Impact of Exchange Rate Volatility on Commodity Trade between the United States and Spain. *Journal of Financial Economics.* Vol 31

Marcella, V., (2007). Drivers of Cocoa Production Growth in Ghana. Overseas Development Institute Working Paper No. 35

Mike Moffatt (2000). Exchange Rate and Commodity Price Relation. *Journal of International Economics.* Vol 32.

Nancy Clark, (1994). Mining and petroleum Industries. *Library of Congress Federal Research Division.*

Opoku, E., Dzene, R., & Zeilin A., (2009). Improving Productivity through Group Lending. Center for the Study of Africa Economics, University of Oxford.

Onafowara, H.E, and Owaye L, (2008). Commodity Spot Prices: An Explanatory Assessment of Market-Structure and Forward-Trading E®ects," University of Warwick andUniversity of Guelph Working Paper, No 4803.

Olefum, A. (2011). Risk in Exchange Rate fluctuation in some selected firms. A Nigerian case study *Journal of International Business Research , 4* (2).

Pozo, P. K., (2008).The link between the oil and dollar" *The International Economy*, Spring,pp.46-50.

Pilbeam, S. D (1992). Responses of Exchange Rate to Changes In Prices. NBER Working Paper 298

Reinhart, C.M, (1988). The Real exchange rate and the prices of commodities in A neoclassical modle in Washington D.C., *International Monetary fundWorking* Paper No. WP/88/55

Ravallion, M., (1986). Testing Market Integration. *American Journal of Agricultural Economics*. Vol 73.

Rogoff, K., (1996). The Purchasing Power Parity Puzzle. *Journal of Economics Literature*. Vol 34(2).

Robert E., (2002). Dynamic Conditional Correlation: A Simple Class of Multivariate GARCH models. *Journal of Business and Economics Statistics.* Vol 2

Samuelson, T., (2000) Theory of Money and His Attack on the classical model. IAER, Vol. 7, NO.4, pp.409-418

Schwarz, G., (1978). Estimating the Dimension of a Model", *Annals of Statistics* 6, pp.461-464.

Shashi K. and Marcella V., (2009). Cocoa in Ghana: Shaping the Success of the Economy.

Salifu, Z., Osei, A., and Adjasi, C. (2007). "Does the Law of One Price Really Hold for Commodity Prices?" *Journalof Risk* Finance71 (1989 :661–669.)

Steven, J., Falolo J., (2012). Culture and Customs of Ghana. Ghana Mineral and Minning Sector Investment Business Guide.

Sheffrin, S. (2004). Basic Principles In Trade Economic. *International Economics Working Papers*. Paper # 308.

Stoll, H.R., and Rose, P., (1983). Spot and Futures Prices and The Law of One Price. *Journal of Finance.* Vol 38

Stock, J. H. and Watson, M.W., (2002).Forecasting Using Principal Components froma Large Number of Predictors", *Journal of the American Statistical Association* 97, pp.1167-1179.

Stigler, G.T., and Sherwin R.A., (1985). The Extent of The Market. *Journal of Law and Economics*. Vol 2

Simpson, J.L. (2002). How the Australian Dollar and Oil Price is related. EMFA Working paper # 202

Vansteenkiste, I., (2009). How Important are Common Factors in Driving Non-Fuel Commodity Prices? A Dynamic Factor Analysis. Working Paper 1072

Wu Shaowen, (1996). Mechanism of PPP Puzzle In China. *CASE Report* No. 52Walid, C., Khuong, N., and Duc K., (2014). Exchange Rate Movement and Stock Market Returns in A Regime-Switching Environment: Evidence From BRICS countries.

Wolf, M., (2008). Global Prospects of the Economy. IBRD Working paper # 634

Whelan, M. & Socrate, D. (2000). The Relationship between Production, Prices and Income. *Principles of Economics Rev 973*

Walid, K. (2014). The Effect of Fiscal Policy and Monetary Policy on economic Growth: Which Policy Is More Potent? *International Journal of Empirical Finance* Vol. 3, No. 2, pp. 61-75

APPENDICES

APPENDIX A: LAG LENGTH SELECTION

Lag selection criteria

VAR Lag Order Selection Criteria
Endogenous variables: LNEXC_RATE LNCOCOA LNGOLD LNINFLATION LNINT_RATE
Exogenous variables: C
Sample: 1999M01 2014M12
Included observations: 188

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-291.2361	NA	1.61 e-05	3.151448	3.237523	3.186322
1	1306.018	3092.556	8.76e-13	-13.57466	-13.05821*	-13.36541*

2	1342.035	67.81837*	7.79e-13*	-13.69186*	-12.74503	-13.30824
3	1359.921	32.72780	8.42e-13	-13.61618	-12.23897	-13.05819
4	1374.413	25.74661	9.44e-13	-13.50439	-11.69681	-12.77203

APPENDIX B: STABILITY TEST

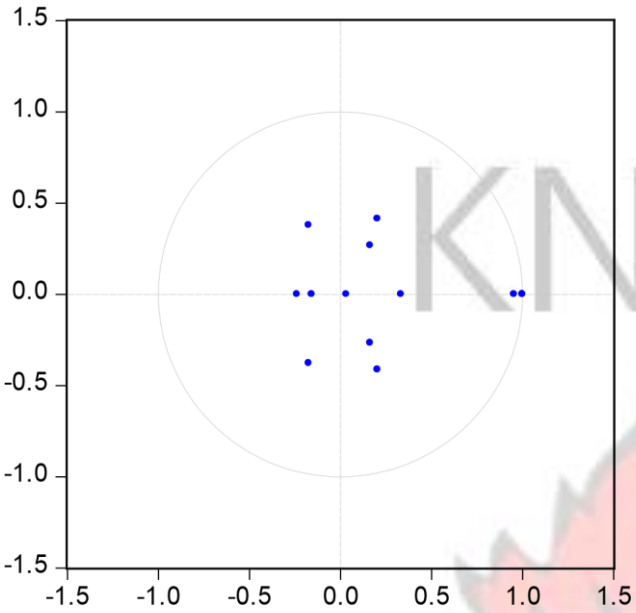
Roots of Characteristic Polynomial
Endogenous variables: LNEXC_RATE LNCOCOA LNGOLD LNINFLATION LNINT_RATE
Exogenous variables:
Lag specification: 1 2

Root	Modulus
1.000000 - 4.58e -16i	1.000000
1.000000 + 4.58e-16i	1.000000
1.000000	1.000000
1.000000	1.000000
0.953346	0.953346
0.204066 - 0.412595i	0.460302
0.204066 + 0.412595i	0.460302
-0.173732 - 0.378498i	0.416466
-0.173732 + 0.378498i	0.416466
0.333871	0.333871
0.164921 - 0.267260i	0.314049
0.164921 + 0.267260i	0.314049
-0.237784	0.237784
-0.156858	0.156858
0.033513	0.033513

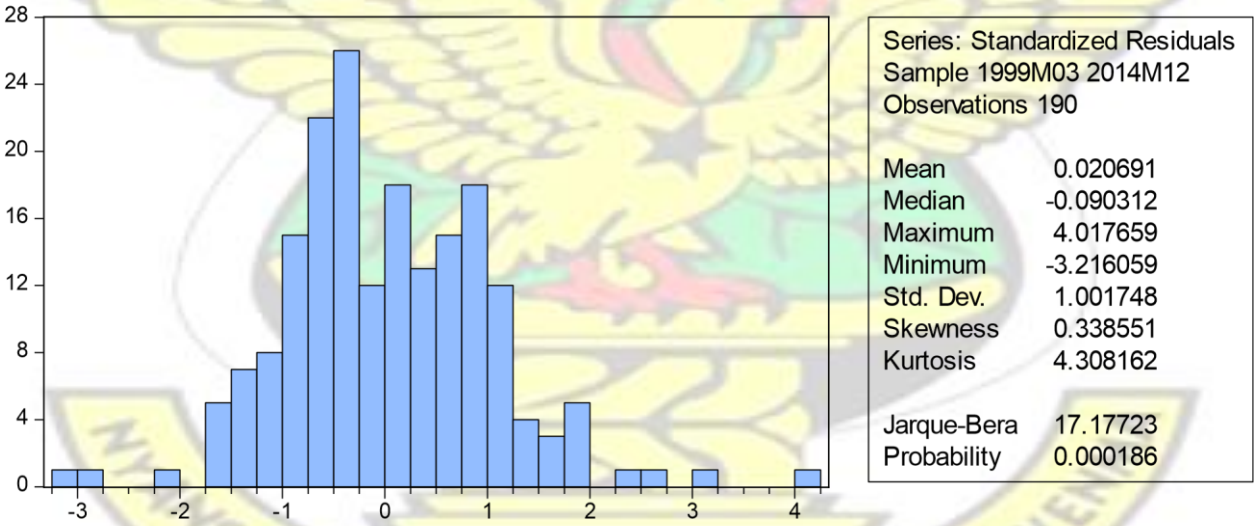
VEC specification imposes 4 unit root(s).

FIGURE 1: FIGURE SHOWING STABILITY

Inverse Roots of AR Characteristic Polynomial



TEST FOR NORMALITY



APPENDIX C: JOHANSEN COINTEGRATION TEST

Date: 06/28/16 Time: 04:42
Sample (adjusted): 1999M06 2014M12
Included observations: 187 after adjustments
Trend assumption: Linear deterministic trend

Series: LNEXC_RATE LNCOCOA LNGOLD LNINFLATION LNINT_RATE
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.177981	74.67049	69.81889	0.0194
At most 1	0.106285	38.02008	47.85613	0.3011
At most 2	0.048077	17.00720	29.79707	0.6395
At most 3	0.033386	7.793523	15.49471	0.4877
At most 4	0.007690	1.443672	3.841466	0.2295

Trace test indicates 1 cointegrating eq n(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.177981	36.65041	33.87687	0.0227
At most 1	0.106285	21.01288	27.58434	0.2755
At most 2	0.048077	9.213680	21.13162	0.8148
At most 3	0.033386	6.349852	14.26460	0.5687
At most 4	0.007690	1.443672	3.841466	0.2295

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

APPENDIX D: VECTOR ERROR CORRECTION ESTIMATE

Vector Error Correction Estimates
Date: 06/28/16 Time: 04:46
Sample (adjusted): 1999M04 2014M12
Included observations: 189 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LNEXC_RATE(-1)	1.000000
LNCOCOA(-1)	0.588356
	(0.46527)
	[1.26456]

LNGOLD(-1)	1.973960
	(0.35530)
	[5.55569]
LNINFLATION(-1)	-1.253272
	(0.29717)
	[-4.21736]
LNINT_RATE(-1)	0.522798
	(0.26423)
	[1.97854]
C	-3.390769

Error Correction:	D(LNEXC_RATE)	D(LNCOCOA)	D(LNGOLD)	D(LNINFLATION)
CointEq1	-0.015434	-0.002544	-0.010600	0.035326
	(0.00306)	(0.00860)	(0.00546)	(0.02196)
	[-5.04041]	[-0.29577]	[-1.94097]	[1.60892]
D(LNEXC_RATE(-1))	0.442951	0.018042	0.035567	0.406618
	(0.07526)	(0.21143)	(0.13424)	(0.53969)
	[5.88537]	[0.08533]	[0.26495]	[0.75343]
D(LNEXC_RATE(-2))	-0.107676	0.103613	0.057127	0.032250
	(0.07376)	(0.20719)	(0.13155)	(0.52888)
	[-1.45991]	[0.50008]	[0.43427]	[0.06098]
D(LNCOCOA(-1))	0.004975	0.222325	0.107663	-0.040500
	(0.02715)	(0.07628)	(0.04843)	(0.19471)
	[0.18321]	[2.91457]	[2.22303]	[-0.20800]
D(LNCOCOA(-2))	-0.012567	-0.153591	-0.132041	0.048008
	(0.02746)	(0.07715)	(0.04899)	(0.19694)
	[-0.45758]	[-1.99070]	[-2.69551]	[0.24377]
D(LNGOLD(-1))	-0.081948	-0.062891	0.075116	0.292937
	(0.04202)	(0.11805)	(0.07495)	(0.30134)
	[-1.95002]	[-0.53273]	[1.00218]	[0.97211]

D(LNGOLD(-2))	0.035891	0.094032	-0.047038	0.731845
	(0.04238)	(0.11905)	(0.07559)	(0.30389)
	[0.84691]	[0.78985]	[-0.62231]	[2.40830]
D(LNINFLATION(-1))	-0.010365	-0.020725	-0.026101	-0.330603
	(0.01049)	(0.02947)	(0.01871)	(0.07523)
	[-0.98794]	[-0.70320]	[-1.39489]	[-4.39461]
D(LNINFLATION(-2))	-0.008993	-0.028393	-0.004569	-0.097353
	(0.01031)	(0.02897)	(0.01839)	(0.07394)
	[-0.87222]	[-0.98022]	[-0.24843]	[-1.31672]
D(LNINT_RATE(-1))	-0.025788	0.016548	0.002743	0.030027
	(0.01683)	(0.04728)	(0.03002)	(0.12068)
	[-1.53232]	[0.35002]	[0.09139]	[0.24881]
D(LNINT_RATE(-2))	-0.000762	-0.002925	0.001261	0.037656
	(0.01690)	(0.04749)	(0.03015)	(0.12121)
	[-0.04510]	[-0.06160]	[0.04183]	[0.31067]
C	-0.008643	0.005745	0.008972	0.005946
	(0.00200)	(0.00563)	(0.00357)	(0.01437)
	[-4.31309]	[1.02056]	[2.51026]	[0.41382]
R-squared	0.411320	0.069752	0.113045	0.153763
Adj. R-squared	0.374736	0.011940	0.057924	0.101172
Sum sq. resids	0.084658	0.668087	0.269309	4.353004
S.E. equation	0.021870	0.061437	0.039007	0.156822
F-statistic	11.24298	1.206540	2.050839	2.923757
Log likelihood	460.4996	265.2810	351.1399	88.16885
Akaike AIC	-4.746027	-2.680222	-3.588782	-0.806020
Schwarz SC	-4.540202	-2.474397	-3.382956	-0.600194
Mean dependent	-0.013717	0.004274	0.007606	0.005357
S.D. dependent	0.027658	0.061807	0.040188	0.165413

Determinant resid covariance (dof adj.)	5.81 E-13
Determinant resid covariance	4.19E-13
Log likelihood	1352.488
Akaike information criterion	-13.62421
Schwarz criterion	-12.50932

APPENDIX E: ARCH/GARCH TEST ESTIMATE

COCOA

Dependent Variable: D(LNCOCOA)
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 08/10/16 Time: 12:20
Sample (adjusted): 1999M03 2014M12
Included observations: 190 after adjustments
Convergence achieved after 24 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.003863	0.003992	0.967641	0.3332
D(LNCOCOA(-1))	0.193157	0.079337	2.434633	0.0149
Variance Equation				
C	0.000387	0.000421	0.917569	0.3588
RESID(-1)^2	0.105619	0.075434	1.400158	0.0615
GARCH(-1)	0.784853	0.161086	4.872248	0.0000

R-squared 0.036263 Mean dependent var 0.003876 Adjusted R-squared 0.031137 S.D. dependent var 0.061887
S.E. of regression 0.060916 Akaike info criterion -2.755485
Sum squared resid 0.697629 Schwarz criterion -2.670037
Log likelihood 266.7711 Hannan-Quinn criter. -2.720872 Durbin-Watson stat 1.948565

Date: 08/10/16 Time: 12:21
Sample: 1999M03 2014M12
Included observations: 190

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	0.041	0.041	0.3175	0.573
*|. |	*|. |	2	-0.137	-0.139	3.9456	0.139
.|* |	.|* |	3	0.081	0.095	5.2217	0.156
.|. |	.|. |	4	-0.020	-0.050	5.3040	0.258
*|. |	*|. |	5	-0.113	-0.086	7.8014	0.168
.|. |	.|. |	6	0.040	0.035	8.1120	0.230
.|* |	.|* |	7	0.151	0.129	12.631	0.082
*|. |	*|. |	8	-0.088	-0.084	14.196	0.077
*|. |	*|. |	9	-0.104	-0.074	16.376	0.059
.|. |	.|. |	10	0.008	-0.033	16.387	0.089
.|. |	.|* |	11	0.066	0.081	17.270	0.100
.|. |	.|. |	12	-0.014	0.006	17.312	0.138
.|. |	.|. |	13	-0.008	-0.023	17.326	0.185
.|. |	.|. |	14	0.056	0.017	17.974	0.208
*|. |	.|. |	15	-0.079	-0.057	19.269	0.202
.|. |	.|. |	16	-0.015	0.037	19.313	0.253
.|* |	.|. |	17	0.092	0.057	21.087	0.222
.|. |	.|. |	18	0.027	0.003	21.243	0.267
.|. |	.|* |	19	0.054	0.084	21.873	0.291
*|. |	*|. |	20	-0.097	-0.122	23.888	0.247
*|. |	*|. |	21	-0.133	-0.115	27.695	0.149
.|. |	.|* |	22	0.055	0.075	28.361	0.164
.|. |	.|. |	23	-0.032	-0.059	28.578	0.195
.|. |	.|. |	24	-0.033	-0.017	28.818	0.227
.|. |	.|. |	25	0.054	0.008	29.456	0.245
.|. |	.|. |	26	-0.022	-0.038	29.562	0.286
*|. |	*|. |	27	-0.193	-0.133	37.915	0.079
*|. |	*|. |	28	-0.102	-0.108	40.260	0.063
.|. |	.|. |	29	0.052	-0.012	40.870	0.071
.|. |	.|. |	30	-0.015	-0.021	40.921	0.088
.|. |	.|. |	31	0.038	0.058	41.249	0.103
.|. |	*|. |	32	-0.039	-0.090	41.604	0.119
.|. |	.|. |	33	-0.018	-0.025	41.683	0.143
*|. |	*|. |	34	-0.107	-0.079	44.377	0.110
.|. |	.|* |	35	0.053	0.075	45.029	0.119
.|* |	.|. |	36	0.134	0.042	49.282	0.069

GOLD

Dependent Variable: D(LNGOLD)

Method: ML - ARCH (Marquardt) - Normal distribution
Date: 08/10/16 Time: 12:31

Sample (adjusted): 1999M03 2014M12
Included observations: 190 after adjustments
Convergence achieved after 21 iterations
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.006521	0.003182	2.048864	0.0405
D(LNGOLD(-1))	0.142044	0.090377	1.571692	0.1160

Variance Equation

C	0.000325	0.000267	1.217019	0.2236
RESID(-1)^2	0.143426	0.086851	1.651409	0.0987
GARCH(-1)	0.653390	0.223487	2.923620	0.0035

R-squared	0.006878	Mean dependent var	0.007533
Adjusted R-squared	0.001595	S.D. dependent var	0.040094
S.E. of regression	0.040062	Akaike info criterion	-3.610253
Sum squared resid	0.301738	Schwarz criterion	-3.524805
Log likelihood	347.9740	Hannan-Quinn criter.	-3.575639
Durbin-Watson stat	2.067625		

Date: 08/10/16 Time: 12:35
Sample: 1999M03 2014M12
Included observations: 190

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	-0.003	-0.003	0.0017	0.968
.|. |	.|. |	2	-0.002	-0.002	0.0024	0.999
.|. |	.|. |	3	-0.051	-0.051	0.5082	0.917
.|* |	.|* |	4	0.135	0.135	4.0999	0.393
.|. |	.|. |	5	-0.001	-0.002	4.1002	0.535
.|. |	.|. |	6	-0.023	-0.026	4.2055	0.649
.|. |	.|. |	7	0.050	0.065	4.6972	0.697
.|. |	*|. |	8	-0.058	-0.079	5.3763	0.717
.|. |	.|. |	9	-0.022	-0.024	5.4737	0.791
.|. |	.|. |	10	-0.029	-0.016	5.6454	0.844
.|. |	.|. |	11	0.015	-0.009	5.6925	0.893

*|. |	*|. |	12	-0.105	-0.092	7.9630	0.788
.|. |	.|. |	13	0.006	0.015	7.9716	0.845
.|. |	.|. |	14	-0.053	-0.056	8.5605	0.858
.|. |	.|. |	15	0.037	0.033	8.8427	0.886
.|. |	.|. |	16	-0.044	-0.020	9.2522	0.903
.|. |	.|. |	17	0.001	-0.008	9.2525	0.932
.|. |	.|. |	18	-0.053	-0.045	9.8492	0.937
.|. |	.|. |	19	0.034	0.035	10.090	0.951
.|. |	.|. |	20	0.024	0.014	10.211	0.964
.|. |	.|. |	21	0.021	0.022	10.305	0.975
.|. |	.|. |	22	-0.021	-0.021	10.403	0.982
.|. |	.|. |	23	-0.007	-0.007	10.413	0.988
.|. |	.|. |	24	-0.018	-0.040	10.487	0.992
.|. |	.|. |	25	0.008	0.011	10.502	0.995
.|. |	.|. |	26	0.032	0.016	10.734	0.996
.|. |	.|. |	27	-0.024	-0.019	10.861	0.998
.|. |	.|. |	28	0.061	0.063	11.697	0.997
*|. |	*|. |	29	-0.097	-0.093	13.843	0.992
.|. |	.|. |	30	-0.007	-0.030	13.856	0.995
.|. |	.|. |	31	-0.021	0.003	13.953	0.996
.|. |	.|. |	32	0.057	0.025	14.709	0.996
.|. |	.|. |	33	-0.024	0.002	14.841	0.997
.|. |	.|. |	34	-0.055	-0.050	15.548	0.997
.|. |	.|. |	35	-0.034	-0.041	15.819	0.998
.|* |	.|* |	36	0.118	0.122	19.113	0.991

APPENDIX F VECTOR AUTOREGRESSION ESTIMATE

Vector Autoregression Estimates
Date: 09/03/16 Time: 18:17
Sample (adjusted): 1999M06 2014M12
Included observations: 187 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	EXC_RATE	COCOA_VOLS	GOLD_VOLS
EXC_RATE(-1)	1.153119	0.001100	-0.012101
	(0.06327)	(0.00717)	(0.00667)
	[18.2253]	[0.15351]	[-1.81397]
EXC_RATE(-2)	-0.190669	0.011957	0.025688
	(0.09688)	(0.01098)	(0.01022)
	[-1.96803]	[1.08943]	[2.51470]
EXC_RATE(-3)	-0.013713	-0.011776	-0.012884
	(0.06070)	(0.00688)	(0.00640)

	[-0.22590]	[-1.71240]	[-2.01303]
COCOA_VOLS(-1)	0.805185	0.813239	-0.043171
	(0.65232)	(0.07390)	(0.06878)
	[1.23434]	[11.0047]	[-0.62766]
COCOA_VOLS(-2)	-0.261497	0.143598	0.168313
	(0.83812)	(0.09495)	(0.08837)
	[-0.31200]	[1.51238]	[1.90463]
COCOA_VOLS(-3)	-0.197631	-0.119911	-0.140765
	(0.65577)	(0.07429)	(0.06914)
	[-0.30137]	[-1.61409]	[-2.03583]
GOLD_VOLS(-1)	0.761143	0.010216	0.795545
	(0.71752)	(0.08128)	(0.07565)
	[1.06080]	[0.12569]	[10.5156]
GOLD_VOLS(-2)	0.900661	0.102518	0.033375
	(0.91562)	(0.10373)	(0.09654)
	[0.98367]	[0.98834]	[0.34570]
GOLD_VOLS(-3)	-2.359615	-0.109648	-0.030984
	(0.70029)	(0.07933)	(0.07384)
	[-3.36951]	[-1.38213]	[-0.41963]
C	0.045834	0.008359	0.008176
	(0.02777)	(0.00315)	(0.00293)
	[1.65032]	[2.65669]	[2.79200]
			0.665349
R-squared	0.996318	0.787335	
Adj. R-squared	0.996130	0.776522	0.648333
Sum sq. resids	0.284246	0.003648	0.003160
S.E. equation	0.040074	0.004540	0.004225
F-statistic	5321.152	72.81067	39.10109
Log likelihood	341.3822	748.6372	762.0622
Akaike AIC	-3.544195	-7.899863	-8.043446
Schwarz SC	-3.371408	-7.727076	-7.870660
Mean dependent	1.064796	0.059765	0.039378
S.D. dependent	0.644213	0.009603	0.007125

Determinant resid covariance (dof adj.)	5.44 E-13
Determinant resid covariance	4.62E-13

Log likelihood	1859.770
Akaike information criterion	-19.56974
Schwarz criterion	-19.05138

APPENDIX G: VAR STABILITY CONDITION

Roots of Characteristic Polynomial
Endogenous variables: EXC_RATE COCOA_VOLS GOLD_VOLS
Exogenous variables: C
Lag specification: 1 3
Date: 09/04/16 Time: 00:12

Root	Modulus
0.928638	0.928638
0.854828	0.854828
0.716407 - 0.126954i	0.727569
0.716407 + 0.126954i	0.727569
-0.558936	0.558936
0.076368 - 0.399142i	0.406382
0.076368 + 0.399142i	0.406382
-0.024088 - 0.086428i	0.089722
-0.024088 + 0.086428i	0.089722

No root lies outside the unit circle.
VAR satisfies the stability condition.