Prices Dynamics and Volatility: Empirical Evidence from Time Series Analysis

Abstract

This study was carried out to achieve two objectives: firstly, the study examined the dynamic relationship between commodity prices (gold and crude oil prices) and financial variables (share price index, interest and exchange rates) and the volatility of each of the variables. In order to achieve the objectives, daily time series data was collected from the reserve bank of England data bank from 1990 to 2015. The study used ADF and PP to examine the stochastic properties and Johnson co-integration for the long run relationship. The study found that most of the variables are differenced stationary and the co-integrating evidence shows the presence of one co-integrating vector. To see the dynamic impact of the variables, VECM model was estimated and it was found that crude oil and gold prices are the only variables that are related, this evidence is consistent for both full, pre and post crisis samples. In order to achieve the second objective, three sets of volatility models were estimated; that is, GARCH, TGARCH and EGARCH for each of the five series. The result reveals that crude oil price and exchange rate are the most volatile variables and the parsimonious of the volatility model depends on the variable and the sample period. Hence, the study concludes that commodity prices response to financial variables was insignificant.

CHAPTER 1: INTRODUCTION

1.1: General Background

The relationship between real and nominal variables has well been documented at both theoretical and empirical literature in finance and economics. The early effort at the theoretical level has to do with the work of classical economist which assumed that all variables are real. This came from the fact that, in classical economist, the assumption is that economic agents are relational who will always make an optimal decision given the available information at any point in time. Hence, the decision of economic agents with regards to macroeconomic variables will take into consideration the effect of inflation; hence price changes will have no effect on macroeconomic variables.

Keynesian macroeconomics came into been as a result of the inability of the classical doctrine to pool the world economy out of the great depression which happened in 1930s. Keynes challenged most of the assumptions and conclusions within which classical model was built up on. But what is of interest to our research is the ability of the Keynes to differentiate between real and nominal variables. To him, economic agents are not always rational, because at times, they suffered from money illusion, that's they will mistake a nominal to real increase in wage. To understand this better, let use the labour – leisure decision problem of households. Households, have a total of 24 hours a day, in which they will divide this between labour supply and leisure. When wages is higher, household will supply more time for productive activities and less time for labour and vice versa. Given the exogenity assumption of nominal wage in Keynesian model, when firms when to increase output, the can do two things at a time; that is, to increase both nominal wage and prices of their product. The action of the firm will keep real wage constant. But because works has limited information of the firms decision, the will suffer the problem of money illusion by mistaken the nominal wage increase to a real wage increase hence they will increase their labour supply. When households go to the market to buy goods, they will realize that the prices of goods have also increased. Therefore, the purchasing power of their money has decreased. This will make them to ask for wage increase and the process continues.

The second debate at theoretical level is on the assumption on the nature of the nominal variables. While classical economist believes that all nominal variables are flexible, as such, when there is any disequilibrium situation in the economy, the flexibility of the nominal variables will automatically restore the economy back to full employment equilibrium hence there is no need for any government intervention. However, the Keynesians rejected the classical preposition on nominal variables by arguing that, they are sticky. An example of nominal rigidities can be found in Taylor (1979), Calvo (1983), Roberts(1995) and Rotemberg (1982) among others. Here, the assumption is that nominal variables are rigid for a given period in time, hence fiscal and monetary policies will have impact real variables in the short run. This is the idea of non neutrality of money in the short run.

The above views, presents to dichotomous view on the theoretical relationship between eal and nominal variables. At empirical levels, various empirical evidences exist, evaluating the relationship between real and normal variables. But what is of interest to the present research is the relationship between the nominal variables themselves. McCandless and Weber (1995) examined the short and long run relationship between nominal variables using static and dynamic correlation analysis for a period of 30 years, the result he found which is consistent with the empirical regularities is that: in long run, the result reveals the presence of positive and almost one to one relationship between money growth and prices (inflation) which the correlation coefficient varying from 0.92 to 0.96. This finding is consistent with both theoretical and empirical relationship between the two variables. For example, the quantity theory of money states that, given that the economy is at full employment and a constant velocity, an increase in nominal money supply will lead to a proportionate increase in price level and vice serve. At empirical level, the finding is consistent with those of Lucas(1980b), Beretsen, Menzio and Wright(2008) and Fischer and Seater (1993) among others.

The second finding of McCandless and Weber (1995) is that there is no relationship between inflation and money growth and output and money growth. They found the existence of positive relationship between money growth and output but not between inflation and output, this evidence is for the OECD countries. Although the correlation coefficient is was found to be low. This finding was also reported by Kormendi and Meguire (1984), Geweke (1986), Barro (1995, 1996), Boschen and Mills (1995b), King and Watson (1997) and Bullard (1999) among others. Another finding has to do with the relationship between interest rate, inflation and money. This relationship was derived theoretically from Fisher (1936) equation that says nominal interest equals real interest rate plus expected inflation. If real return is independent of inflation, nominal return will be positively related to inflation. Monnet and Weber (2001) examined the relationship between interest and money growth which they found the presence of positive and significant correlation between interest rate and money growth with a correction coefficient between 0.66 to 0.84. This finding is consistent with what the fisher's equation predicts.

On the empirical relationship between commodity price; crude oil and gold prices with interest rate and exchange rates. A lot of empirical works exist trying to evaluate either the static or dynamic relationship between some variables. For example, Abubakar and Umar (2001), Fratzscher, Schneider and Robays (2014) and Hidhayathulla and Rafee (2014) among others. These papers study the relationship between exchange rate and crude oil price for different economies. In most of the works, the finding is in favor of the existence of the relationship between exchange rate and crude oil price. However, the sign of the magnitude of the relationship depend on whether the country is a net oil importer or exporter. It was found that, an increase in crude oil price will lead to appreciation of exchange rate for oil exporting economy and depreciation of exchange rate for oil importing economies and vice verse.

Some of the research examined the relationship between oil, exchange rate and commodity prices. For example, Harri, Nalley and Hudson (2009) found that commodity price is linked to exchange rate. Other studies include Dawson (2014), Ghosh (2016), Al-mulali (2010) and Shaaria et-al (2013) among others. From all the forgone research, we found no evidence of any research that attempts to study the relationship between commodity prices (crude oil and gold prices) and financialization (represented by interest rate and exchange rate). Also, there is no empirical evidence on how commodity prices and financial variables affect output in UK economy. This research intends to cover this empirical gap by developing a systematic study that will address all the issued raised.

Objectives:

The general objective of this study is to examine the volatility as well as the dynamic relationship between commodity prices, exchange and interest rates for full, pre and post 2008 global financial crisis periods. The specific objectives are:

i) To examine the stochastic and time series properties of the variables under consideration

ii) To assess the dynamic impact of commodity prices, exchange rate and interest rate for the full, pre and post 2008 global financial crisis periods

iii) As investigate the short run as well as long run relationship between the variables

iv) To determine the direction of causation between commodity prices, exchange rate and interest rate

v) To examine the volatility for each variable using different classes of volatility model.

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Outline of the work

The work is designed to contain six chapters. Chapter one will provide a general background of the study which includes a general introduction of the dynamic relationship between the variables, the objectives the study seeks to achieve and outline of the work. In chapter two, relevant literature will be reviewed which include theoretical and empirical literature review and also the gap of the study will be presented in the section. Chapter three will be dedicated to the methodology of the research. In chapter four and five, the empirical evidences with regard to the dynamic relationship and volatility evidences will be presented and finally, chapter six will present conclusion(s), summary of findings and recommendations.

CHAPTER 2: LITERATURE REVIEW

: Introduction

This section provides compressive reviews of the theoretical relationship between real and nominal variables; which includes: fisher's (1936) hypothesis, Modified Purchasing power parity relationship (PPP), Interest rate parity relationship (IRP) and modified Solow growth model for output gap. Also, the section contains an empirical literature on the relationship between commodity prices and exchange and interest rates as well as their relationship with output. Finally, a gap from both theoretical and empirical evidences is presented in the section.

: Theoretical Literature Review

In order to understand the theoretical relationship that connects our variables, we consider the following long run relationships as described by various economic theories.

$$\left(\pi_t - \pi_t^*\right) - \left(\pi_t^* - \pi_t^0\right) - FXR_t = \delta_1 + \delta_2 t + \delta_3 \left(\pi_t^* - \pi_t^0\right) + e_{1t} \quad \ldots (2.1)$$

$$i_t - i_t = \alpha_1 + e_{2t} \ldots\ldots (2.2)$$

$$y_t - y^*_t = \varpi_1 + e_{3,t} \ldots\ldots (2.3)$$

$$i_t = R_t + \pi^e + e_{4,t} \ldots\ldots (2.4)$$

Where π_t and π_t^* is the log of domestic and foreign prices of goods, FXR_t is the real effective exchange rate.

Equation 2.1 presents the modified purchasing power parity theory, which is based on international market arbitrage, but the relationship was adjusted in order to include the effect of crude oil price. By purchasing power parity relationship, it means that in the long run, it will make no difference to exchange one country currency for another country currency and use the same to buy goods and services as if you are using the original currency. For example, if GBP is exchanged for a dollar, the dollar should be able to purchase the same quantity of goods and services the GBP can purchase. If this relationship holds in the long run, it means there is no arbitrage opportunity that exist between the two currencies; that is GBP and dollar. But on the other hand, when you have GBP and use it to buy dollar, and the dollar purchase more or less quantity of goods and services than the GBP then there is the existence of arbitrage opportunity. If the dollar buy more goods, it means, the arbitrage opportunity run from US to UK and vice versa. In the relationship we described in 2.1, the effect of oil price and exchange rate has been removed from the domestic price.

In equation 2.2, the interest rate parity relationship is presented. The relationship takes the difference between domestic and foreign interest rate. For the relationship to hold, there must be two things in place: that is, capital mobility ad perfect subtutability. The theory assumed that, in the long run, investors will be indifferent to deposit their money in either country A or B banks, because the expected return from the deposit will be the same. This means that the arbitrage opportunity will not exist if the interest rate parity relationship holds. There are two types of this relationship; that is covered and uncovered. By covered, it means that a forward or futures exchange rate between the two countries is taking into account, such that the foreign exchange movement will not affect the return. Risk averse investors normal use this relationship for evaluating their investment opportunity. For the uncovered interest rate parity relation, it means that only the spot exchange rate between the two countries is taken into account hence exchange rate fluctuation is important in affecting the relationship. The relationship is said to be invalid if it is profitable to deposit money in bank of country A than in country B. Here, there the arbitrage opportunity exist because it will be profitable for an investor to borrow in a country will lower interest rate and invest in a country with higher interest for a given period of time and make profit. However, it is important to note that arbitrage opportunity does not last for a longer period for two reasons: firstly, investors will rush for it hence the market will adjust and the regulator agency of the country will adjust its interest rate to reflect its actual value hence in the long run the relationship must hold.

The output relation was derived from Solow – Swan (1956) exogenous long run growth model. The model explains the long run economic growth with the help of cobb-doglass type production function that assumes aggregate demand to be a function of capital accumulation, population growth rate and technological advancement. The model came from the independent works of Solow (1956) and Swan (1956); hence Solow-Swan growth model, which serves as an advancement of the Harrod-Domar growth model which was been popularized by post Keynesians. The output gap relation presented in equation 2.3 was derived from the model and it explains the deviation of output from its long run trend.

Finally, equation 2.4 presents the fisher's equation, which shows the relationship between nominal and real interest rate. According to this equation, at any given point in time, nominal interest rate will be equals to the real interest rate plus future expected inflation. In the long run, the inflation is expected to be zero, hence a one to one relationship between real and nominal rates. However, in the short run, nominal interest rate is said to be correlated with expected inflation. The fisher's equation was derived from the Siduraski's money in the utility function which is a variant of neo-classical dynamic stochastic general equilibrium model (DSGE). It is an equation use in describing the relationship between interest rate and inflation in economics literature.

: Empirical Literature Review

In this section, the study reviewed various empirical works that study the following: the relationship between crude oil price and exchange rate, interest rate and inflation, inflation and exchange rate and those works that study the impact of commodity prices and financial variables on output.

: Empirical evidences on the relationship between nominal interest rate and inflation

This section concentrates on the works that tries to examine the existence of fisher's hypothesis for different economies. One of the early effort in modern time follows the work of Mishkin and Simon (2005) who examined the existence of fisher's hypothesis for Australia economy. Based on the modern time series analysis, they found that, both inflation and nominal interest rate contains unit root; that is, the series are none level stationary. In order to correct the unit root problem, they obtained the correct sample size distribution of the test statistic using Monte Carlo simulations. They found the presence of fisher's hypothesis implying that nominal interest rate and inflations one to one relationship in the long run.

However, the works of Obi et-al(2009), Lee (1998) and Abubakar and Sivaganaman (2016), while the former two tests use johansen co-integration test and error correction mechanism to examine the existence of fisher's hypothesis for Nigeria and Singapore respectively, the latter use Gregory and Hensen (1996) and Peasaran, Smith and Shin (2001) test co-integration for Indian economy. The studies found the rejection of fisher's hypothesis in all the three countries.

: Empirical evidences on the relationship between crude oil price and exchange rate

On the relationship between crude oil price and exchange rates, a lot of empirical works exist trying to evaluate either the static or dynamic relationship between some variables. For example, Abubakar and Umar (2001), Fratzscher, Schneider and Robays (2014) and Hidhayathulla and Rafee (2014) among others. These papers study the relationship between exchange rate and crude oil price for different economies. In most of the works, the finding is in favor of the existence of the relationship between exchange rate and crude oil price. However, the sign of the magnitude of the relationship depend on whether the country is a net oil importer or exporter. It was found that, an increase in crude oil price will lead to appreciation of exchange rate for oil exporting economy and depreciation of exchange rate for oil importing economies and vice verse.

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: Empirical evidences on the relationship between interest rate and exchange rate

The relationship between interest rate and change rate has received great attention from empirical point of view and the findings are consistent with the fact that, there exist a relationship between the two variables. Engle (1986) use a simple monetary model to explain that the relationship between foreign exchange and nominal interest rate is not a necessary condition for movement in real interest rate. Sanchez (2005) studied the relationship between foreign change and interest rate by using a model that incorporate the role of exchange rate pass – through domestic prices. The result shows correction evidence between foreign exchange and interest. Dash (2014) also examined the relationship between exchange rate and interest using time series analysis. He found an evidence of long run relationship between exchange rate and interest rate. However, Wilson and Sheefeni (2014) investigated the relation for the Namibian economy using time series analysis of co-integration and error correction model. Their result was contracting all the above findings, because they reject the existence of relation between foreign exchange rate and interest rate.

CHAPTER 3: RESEARCH METHODOLOGY

: Introduction

In this section, the methodological procedure used in achieving the stated objectives is described. The section contains data and definition of variables, outline of the work, techniques of data analysis; which includes the dynamic impact model, where the stochastic properties of the series were examined using Augmented Dickey Fuller (ADF) test and Phillips and perron (PP) test, the co-integrating properties of the series using Johansen multivariate test and the impact model using vector error correction model. In the second part of the chapter, the univariate volatility models which includes, GARCH, TGARCH and EGARCH were discussed.

: Data and Definition of the variables

In order to carry out the empirical examination, a daily time series data for commodity price represented by crude oil price and gold price and financial variables represented by GBP / USD exchange rate and USA interest rate were collected from 1990:M1 to 2016M2 from the databank of the reserve Bank of England.

For crude oil price, we use the price of Brent – Dollars per barrel. For gold, the data for golf fixing price 10:30 am (London time) in London Bullion market was used which also based on US dollar. The GBP/Dollar exchange rate; which represents the pound price of dollar was used and for interest rate, 3- month London inter-bank offered rate (LIBOR) based on US dollar was used. Because there is the need to calculate volatility of the series, we have to convert them into return series. To do that, the following formula was used:

$$r_t = \left(\log\left(R_t\right) - \log\left(R_{t-1}\right)\right) \times 100 \quad \text{(3.1)}$$

Where r_t is the return series, R_t is the present value of the series and R_{t-1} is the last year's value of the series. All the series are converted into return for the volatility analysis.

: outline of the work

The study followed the following strategy. Three sets of models were estimated, each for the full sample (1990:M1) to 2016M2, pre 2008 financial crisis (1990:M1 to 1999:M12) and post financial crisis periods. The essence is to compare the evidences and see whether financial crisis has significantly affected the dynamic relationship as well as the volatility of the variables and for the univariate volatility models, each variable is estimated using autoregressive (AR) or moving average (MA) or both autoregressive and moving average (ARMA) as the explanatory variables of the mean equation and the resultant volatility model was estimated.

: Techniques of data analysis

To achieve the objectives, two set of models will be used. Firstly, a time series analysis for the dynamic relationship which contains; a stochastic property examination using Augmented Dickey Fuller and Philips and Perron (ADF and PP) tests. If integration exist, then we will examine the co-integrating relationship between the variables using Johansen Multivariate co-integration test and if the co-integration exist, the impact model will be estimated using vector error correction model (VECM) otherwise a differenced vector autoregressive model will be used. However, if the variables are level stationary, the impact model will be estimated using level VAR model. Also, a Granger causality test will also be used in order to assess the direction of the causality between the variables.

For the volatility analysis, two different classes of univariate volatility model will be estimated; that is, symmetric volatility model (GARCH model) and asymmetric volatility models (TGARCH and EGARCH models). The essence is to see which among the classes of volatility model fit the data most

: Dynamic Modeling approach.

Unit Root Test

As stated in section 3.4.1, in order to choose the model for the impact analysis, the stochastic as well as the co-integrating properties of the series need to be examined. For the stochastic properties; this is the test for the presence of unit root. Initially, the stationarity of a series is examine through the use of graphical analysis, correlogram and random walk models mong others. The first formal effort for assessing the stochastic properties of the series came from separate works of Dickey (1976) and Fuller (1989), who assumes three set of random walk models; that is, driftless and trendless model, a trendless model and trend and drift model. The models are presented in equations 3.2-3.4 below:

$$z_t = \theta_1 z_{t-1} + u_{1t} \quad (3.2)$$

$$z_t = \theta_2 + \theta_3 z_{t-1} + u_{2t} \quad (3.3)$$

$$z_t = \theta_4 + \delta t + \theta_5 z_{t-1} + u_{3t} \quad (3.4)$$

Equation 3.2, is the trendless and driftless model, equation 3.3 is the trendless model while question 3.4 is a random walk model with drift and trend. Here, depending model favored by data generating process. For example, if the DGP favors model 3.2, the test statistic of the autoregressive component is compared against the ADF generated critical value at a given level of significance. The null hypothesis of unit root is tested against an alternative of stationary and the decision is to accept the null if the ADF critical value is greater than the calculated test statistic at a given level of significant other. However, if the test statistic is greater than the critical value, the alternative hypothesis of stationarity is accepted.

In the same vein, if the DGP favors the model in equation 3.3, that is the is the existence of drift in the model, the test statistic of the coefficient of the lagged value of the dependent variable is considered, the hypothesis and decision rule stance as in the model in 3.2. If the data favors the model in equation 3.4, there are two possibilities: the series can be stationary around trend or around level. If we are interested of testing trend stationarity, we check the test statistic of the trend coefficient and the hypothesis and decision rule in 3.2 stands. Otherwise, if we are interested in level stationarity, we look at the test statistic of the autoregressive component of the model we make an appropriate statistical decision regarding the hypothesis.

There are two problems associated with the equation 3.2 – 3.4: Firstly, determination of the data generating process the model favors. In the case of the above three equations, it will be base on trial and error. The second problem has to do with error terms. It was found in most empirical research that the errors are serially correlated hence the estimates are both inconsistence and inefficient. In order to overcome the identified problem, Dickey (1976) and Fuller (1979) augmented the three models to produce what is known as Augmented Dickey Fuller (ADF) test. The resultant model for the ADF test is given as follows:

$$z_t = \theta_1 + \theta_2 z_{t-1} + \delta t + \sum_{i=1}^{p} \theta_3 \Delta z_{t-i} + u_t \quad (3.5)$$

Where z_t is the time series under examination, for a trend stationary, the test statistic of the coefficient of the autoregressive component is compared with the corresponding level of significance and for tend stationary, the test statistic of the coefficient of the trend is used. The last term of the expression was included in order to take care of serial correlation; that is, sufficient lagged values of the dependent variable that will make the model free from serial correlations should be included. One of the limitations of the ADF test statistic is that the correction of the serial correction is done by assuming that the sample size should be large and that the series must assume distribution; that is, the test introduced parametric way of correcting the serial correlation problem as identified in the rondom walk model specifications.

Phillip and Perron defers from ADF test by coming with a test statistic that assumed the use of non parametric way of correcting the serial correction problem. To understand the Phillips and perron test, consider the following relationship:

$$z_t = \theta_1 + \delta t + \theta_2 z_{t-1} + u_t \quad \text{(3.6)}$$

Here, the error term is assumed to have zero mean but the variance can be hetroscadestic. For the sake of this research, equations 3.5 and 3.6 were used to examine the stochastic properties of the series.

Co-integration Test

The idea of testing co-integration between two or more variables came into been when most macroeconomic variables appeared to be integrated at level. When a series contains unit root at level, it can't be use for long run impact analysis. The idea of co-integration is to see whether the combination of two or more series will have a common stochastic component in the long run, hence the co-integration between the series. The early effort in econometrics literature to model the co-integrating relationship comes from the work of Engle and

Granger (1987). They developed a residual test to co-integration. The procedure is to estimate a model with the integrated variables, then unit root test using either ADF or PP should be perform on the residual. If the residual is found to be stationary then the series are said to be co-integrated.

However, there are three problems associated with the test: firstly, it is residual based test; that is, even if there are more than two variables, the test can only give an evidence of one co-integrating vector. Secondly, since the test is a theoretic, then the problem of which variable is to be use as dependent variable or explanatory also exist as change in the position of the variables may alter the conclusion. Finally, the test assumes that all the variables of be integrated of order one. In order to solve the first and second problems associated Engle and Granger (1987) test, Johasen(1991) developed multivariate test to co-integration using vector error correction framework. This test has the capacity to contain N number of variables and it can give up to N-1 co-integrating vectors. Also, since the test is base on VAR framework, all the variables are treated as endogenous variables and their lagged values are used as the explanatory variables hence the problem of dependent versus explanatory variable in Engle and Granger disappeared. However, this test also requires that the variables must be integrated of order one. But in some case, some variables do appeared to have different order of integration; that is, some variables will be of order one while others will be of order zero. If this happens, the Johasen(1991) can't be used. In order to solve for this problem, Peasaran, Shin and Smith (2001) proposes bond test to co-integration. The test assumes that the variables can be of different order; that is, order zero and one and it can produce maximum co-integrating. For the sake of this study, Johasen(1991). For this test, lets assumes that the data generating process is given as:

$$\Delta z_t = \theta_1 + \delta t + \alpha\beta z_{t-1} + \sum_{i=1}^{p} \theta_2 \Delta z_{t-i} + u_t \quad (3.7)$$

Where z_t is Nx1 vector of macroeconomic variables, t represent trend of the relationship; which can either be stochastic or deterministic. θ_1 is NxN matrix of the drift parameters, α and βz_{t-1} are the NxK and KxN matrices of coefficient of the speed of adjustment and long run co-integrating vectors. θ_2 Is NxN matrix of the short run coefficients of the VAR component to make decision regarding the number of co-integrating vectors, two tests statistics were developed; that is, the maximum eigen value and trace test.

The Dynamic Impact Model

For the dynamic impact model, the choice is between three set of models which the stochastic and co-integrating properties of the variables determines. Thus, the choice is as follows: if the series are level or trend stationary, a level VAR model is appropriate for the impact analysis. However, if all or some of the series contains unit root at level, co-integrating properties of the series has to be examined and if they are found to have common stochastic trend, the vector error correction model is used for the impact analysis. But if there is no common stochastic trend between the series, difference VAR is used for the impact model.

Base on the stochastic and co-integrating properties of our series, which appeared to be level non stationary but after differencing, they became stationary. The co-integrating analysis also reveals the presence of common stochastic trend hence vector error correction model (VECM) becomes the appropriate model to use for the impact analysis. To understand the model considers the relationship below:

$$\begin{pmatrix}\Delta OP_t\\ \Delta GP_t\\ \Delta FXR_t\\ \Delta INT_t\end{pmatrix} = \begin{pmatrix}\theta_1\\ \theta_2\\ \cdot\\ \cdot\\ \theta_t\end{pmatrix} + \begin{pmatrix}\alpha_{11}&\alpha_{12}&\alpha_{13}\\ \alpha_{21}&\alpha_{22}&\alpha_{23}\\ \alpha_{31}&\alpha_{32}&\alpha_{33}\\ \alpha_{41}&\alpha_{42}&\alpha_{43}\end{pmatrix}\begin{pmatrix}\beta_{11}&\beta_{12}&\beta_{13}&\beta_{14}\\ \beta_{21}&\beta_{22}&\beta_{23}&\beta_{24}\\ \beta_{31}&\beta_{32}&\beta_{33}&\beta_{34}\end{pmatrix}\begin{pmatrix}OP_{t-1}\\ GP_{t-1}\\ FXR_{t-1}\\ INT_{t-1}\end{pmatrix} + \sum_{i=1}\theta_i\begin{pmatrix}\Delta OP_t\\ \Delta GP_t\\ \Delta FXR_t\\ \Delta INT_t\end{pmatrix} + U_t \qquad \ldots\ldots(3.8)$$

Where OP and GP represents the oil and gold price, FXR and INT stances for exchange rate and interest rate, θ_i is 4x4 matrix of short run VAR parameter of the model, θ is Nx1 vector of drift parameter, α is the loading factor and β is the long run parameter matrix. To analyze the dynamic impact of the variables, impulse response and variance decomposition generated from equation 3.8 is used.

: Volatility models

In order to assess whether the variables under consideration are volatile over the sample horizon or not, univariate volatility models were employed. The assumption with regards to the error term in equation 3.6 is that it should have zero mean and constant variance, once this is achieved, OLS will provide consistent estimates. However, if this assumption is violated, that is the variance is hetroscedestic rather than homoskedestic then the model in equation 3.6 will provide inconsistent and inefficient estimators of the true population parameters. Various tests statistics have been developed in order to test the nature of variance of the error term of a regression model. For example, Breusch-Pagan test, Glesser test, Harvey-Goldfrey test, Park test, Goldfeld-Quandt test and White test. These test made different assumption on how the auxiliary regression should be and they are based on Lagrange multiplier (LM) test. However, Engle came up with a test known as ARCH test or effect which assumes that instead of the moving average (MA) of residual as assumed by all the other tests, the Engle ARCH test assumes that the residual depends on the autoregressive of variance. Consider a mean equation represented by ARMA (1, 1). The Engle ARCH test is presented below:

$$r_t = \alpha_1 + \alpha_2 r_{t-1} + e_t + e_{t-1} \qquad (3.9)$$

$$e_t / \Omega_{t-1} \sim iid(0, h_t) \qquad (3.10)$$

$$h_t = \alpha_1 + \alpha_2 \sum_{i=1}^{q} e_{t-i}^2 \qquad (3.11)$$

Where equation (3.9) presents the distributional assumption o the error and equation (3.11) represent the ARCH model. Here, a null hypothesis which assumes that the sum of the coefficients of the lagged values of the variance is zero or statistically insignificant is tested against an alternative hypothesis that they are not equals to zero. LM statistic is compared with tabulated chi-square value and if the tabulated value is greater than the calculated LM statistic the evidence is in favor of null hypothesis. Otherwise if the calculated LM statistic is greater than the tabulated chi-square value the evidence is in favor of alternative hypothesis. The null hypothesis implies that the variance of the residual is constant or homoscedestic, whereas, the alternative hypothesis implies that the variance is time varying or hetroscdestic.

However, Bollerslev(1986) criticized the specification of the ARCH model on ground that it only represent moving average (MA) of the relation instead, he generalized the model to include both the autoregressive (AR) and moving average (MA) this is give birth to a model called GARCH. Consider the specification of GARCH model of order (p, q) as follows:

$$r_t = \alpha_1 + \alpha_2 r_{t-1} + e_t + e_{t-1} \qquad (3.12)$$

$$e_t / \Omega_{t-1} \sim iid(0, h_t) \qquad (3.13)$$

$$h_t = \alpha_1 + \alpha_2 \sum_{i=1}^{q} e_{t-i}^2 + \alpha_3 \sum_{j=1}^{p} h_{t-j} \qquad (3.14)$$

Where equation (3.12) represent the mean of the equation, equation (3.13) is the distributional assumption of the error term and equation (3.14) is the GARCH (p,q) model. α_2 Represent the ARCH term and α_3 is the GARCH term. The sum of α_2 and α_3 represent the volatility of the model. The problems that have to do with the Bollerslev (1986) GARCH (p, q) includes the following: firstly, the assumption of positive definite is not imposed in the model as either the ARCH and GARCH parameter can be negative. The second issue has to do with symmetric assumption of the GARCH model, the model assumes that the model response to both positive and negative news are same. Due to this problem, Glosten, Jaganathan and Runkle (1993) came up with a model known as GJR-GARCH or TGARCH model. This model resolve the problem of symmetric of GARCH, as an asymmetric parameter was included to measure the role of information. The TGARCH model is specified below:

$$h_t = \alpha_1 + \sum_{i=1}^{q}(\alpha_t + \beta_i d_{t-1})e^2_{t-j} + \sum_{j=1}\alpha_2 h_{t-j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.15)$$

Where the dummy variable d will represent the role of information, if β is positive it implies the impact of positive news, whereas, if it is negative, it represent the role of negative news. But the model does not address the issue of positive definite. In order to address this problem, Nelson (1993) introduced an exponential GARCH model; that is exponential GARCH model. The model takes care of all the problems identified with Bollerslev (1986) GARCH model.

$$\log(h_t) = \alpha_1 + \sum_{j=1}^{q}\alpha_2\left[\frac{e_{t-1}}{h_{t-1}}\right] + \sum_{j=1}^{q}\alpha_3 \frac{e_{t-1}}{h_{t-1}} + \sum_{i=1}^{p}\alpha_4 \log h_{t-i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.16)$$

In order to assess the volatility of the commodity price (crude oil and gold price) and financial variables (exchange rate and interest rate), the study estimated equation 3.9 as the mean equation with equations 3.14, 3.14 and 3.15 for GARCH, TGARCH and EGARCH models respectively.

CHAPTER 4: RESULT OF DYNAMIC IMPACT MODEL

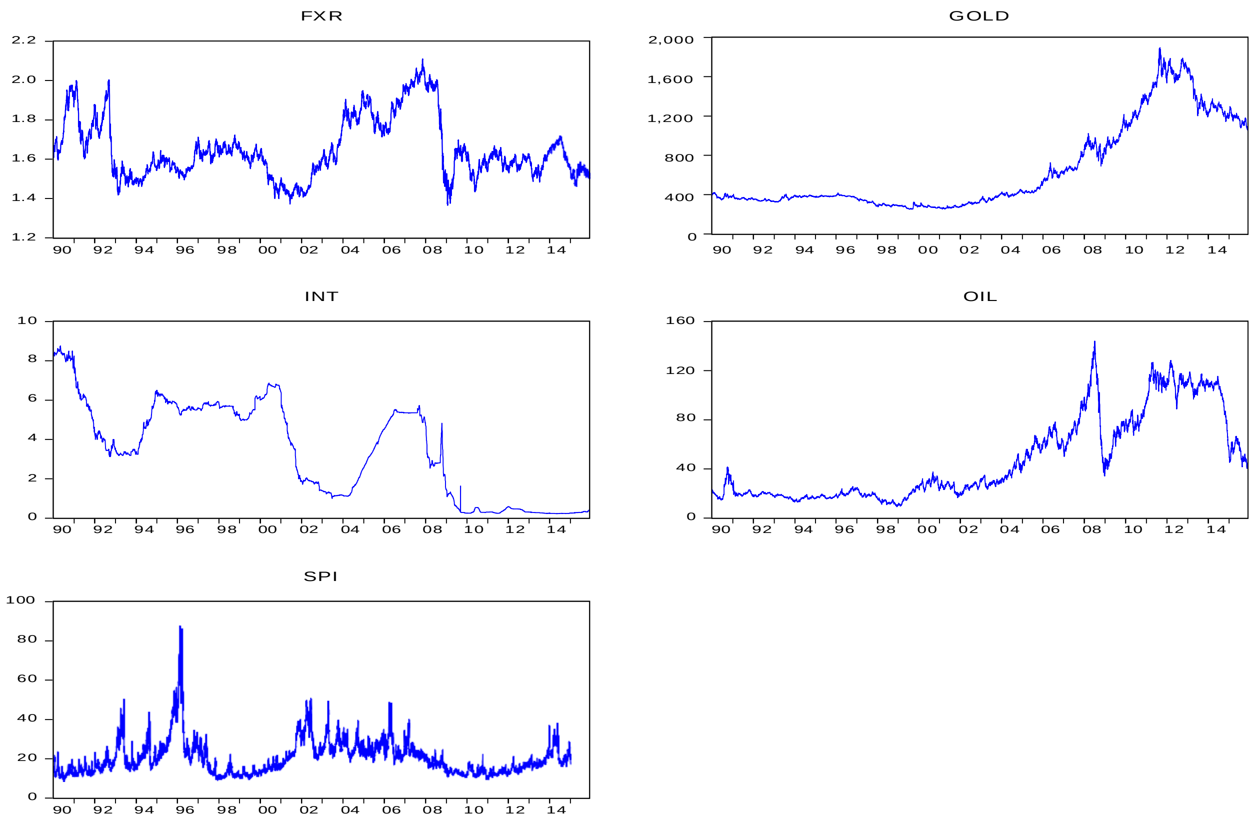
This chapter presents the empirical result on the dynamic relationship between commodity prices and financial variables. Here, we start with trend analysis, descriptive statistic and correlation coefficients. The study proceeds by presenting the stochastic and co-integrating properties and finally, the impulse response and variance decomposition extracted from vector error correction model were presented.

Figure 4.1 presents the trend of the commodity prices and financial variables. The first graph in the top panel shows the trend of the exchange rate. It shows that the variable was volatile over the entire sample horizon. It can be seen from the graph that the GBP/pound exchange rate has some important breaks. The first one happens in 1992 and it continues until in 1994 from where the series continue to fluctuate until the next shift at 2001. The date shows a point of pound rise in 2002 and fall in 2008. The evidence of 2008 financial is also visible on the data. The second graph in the upper panel shows the trend of the gold price. Unlike the foreign exchange, the gold price is stable around $400 until in 2004 when the price start rising. It went up to $1800 in 2008 to 2011 before it start declining. The clear evidence of 2008 global financial crisis is also visible on the series.

The trend of the interest rate was shown in graph one of the middle panel. The 3- month London inter-bank offered rate (LIBOR) based on US dollar shows a little fluctuation unlike exchange rate. It shows three important points, the 1992, 2003 and 2010 declines which a corresponding values of 4%, 2% and less than 1%. The interest rate was stable between 1994 to 2000 and another one between 2001 to 2004 and 2010 to 2015. The trend of the series shows clearly how the federal reserve bank of England raised interest in order to check the effect of 2008 global financial crisis. Also, the series shows the recent reserve bank effort of maintaining interest rate close to zero so as to stimulate investors.

The second graph of the middle pane shows the trend oil price. Just like the goal price, the oil price was stable from 1990 to 2003 at around $40. The series show an increasing trend from 2004 to 2008 before the series declined to its trend in 2008. The series went up again to about $120 and was stable until 2013 before it declined to less than $40. Finally, the trend of share price index shows that the value has been volatile throughout the sample period. However, there was an element of spikes in 1995 when the stock price index raised to $80 and an upward trend from 2002. But in all, the series was on a constant trend until the end of the sample.

Figure 4.1: Trend of the series



Now, having examined the trend of the series, the next step is to present the descriptive statistics; that is, the mean, median and standard deviation and it covers the full, pre and post 2008 global financial crisis.

Table 4.1: Summary statistic

Variables	Full Sample			Pre 2008 Financial Crisis			Post 2008 Financial Crisis		
	Mean	Median	Std. Dev	Mean	Median	Std. Dev	Mean	Median	Std. Dev
FXR	1.65	1.61	0.15	1.67	1.63	0.16	1.57	1.58	0.06

Gold	653.95	390.47	445.74	408.59	370.75	153.29	1327.97	1288.50	245.37
INT	3.42	3.50	2.43	4.54	5.06	1.85	0.37	0.29	0.22
OIL	47.78	29.77	34.85	32.50	22.73	23.85	89.74	99.53	128.14
SPI	20.41	8.24	8.79	22.01	21.17	9.51	16.92	16.07	4.74

The mean and median for GBP/USD exchange rate was 1.65 and 1.61 for the full sample with a standard deviation of 0.15. The mean, Median and standard deviation parameter for pre 2008 financial crisis sub-sample is higher than that of the full sample and post 2008 crisis sample. Therefore, the conclusion is that the post 2008 parameters are lower than the full and pre 2008 financial crisis sub-samples. The gold price has mean and median values of $653 and $390.47 with a standard deviation of $445.74 for the full sample. The standard deviation shows that the gold price was volatile. When the full sample horizon was divided to pre and post 2008 financial crisis, the evidence shows that the series has been affected by the financial crisis as shown in the graph above. The post crisis mean and median are higher than the full and pre crisis sample only that the standard deviation of the full sample period is higher than that of the pre and post crisis period. This shows that the gold price is among those commodities that were affected by the financial crisis.

The interest rate for the full sample shows mean of 3.42 with a standard deviation of 2.43 and a median of 3.50. The pre crisis evidence show higher values of mean and median while the full sample have the highest standard deviation. The descriptive statistic of the interest series shows that it has not been affected by the 2008 crisis unlike the gold price. For the oil price, its average price from 1990 to 2015 is $47.78 with a standard deviation of $34.85. This is event because of the number of oil glut that happened in the global oil market within the review period, with pre crisis period having the least mean and standard deviation values of $32.50 and 23.85

respectively. The post crisis mean and standard deviation were higher; the average price of crude oil per barrel was around \$89.74 with a standard deviation of \$128.14, this happens even with the presence glut because oil price was sold above \$140 around 2010 to 2013, this is an important reason that made the average price to be high. Finally, the average return of S&P share index shows an average value of \$20.41 with a standard deviation of \$8.79 for the full sample, when you look at the pre crisis period, the descriptive statistic estimates were higher than the full and post crisis estimates and the post crisis parameters are lower than those of the full sample. From the descriptive statistics, it is evident that commodity prices suffered from the 2008 financial crisis than the financial variables, this is because in most of the series, the values of the commodity prices used to be higher for post crisis period than in the full and pre crisis samples. This trend has two side effects: firstly, for oil and gold exporting economies, the rise of these commodities prices is to their advantage because it will raise their foreign exchange earnings and vice versa. The second side of the effect is a negative one which is affect oil importing economies, when there is an increase in the price of oil, this rise energy and input cost and the multiplier effect will extends to domestic prices. This has an effect of worsen balance of payment problem, exchange rate and reserve crisis.

Having examined the descriptive statistics, the study also estimated the short run static correlation coefficients of the commodity prices and financial variables. The essence is to have a clue on what the relationship will be. However, it is important to note that the correlation only states the degree of the relationship, but it will neither explain the impact nor the causation.

Table 4.2: Static correlation coefficients

Correlation	FXR	GOLD	INT	OIL	SPI
FXR	1.000000				
GOLD	-0.064945	1.000000			
INT	0.236265	-0.716096	1.000000		
OIL	0.193977	0.897250	-0.627906	1.000000	
SPI	-0.052571	-0.220231	-0.020308	-0.159863	1.000000

Table 4.2 presents the parameter of the static correlation coefficient between the variables. The result shows that the correlation between GBP/dollar exchange rate, S&P index and gold price is negative and very close to zero. The correlation coefficients are -0.06 and -0.05 for foreign exchange and gold, foreign exchange and stock price respectively. However, the correlation between exchange rate and interest rate and exchange rate and oil price is positive but still remain low. These estimates mean that foreign exchange is negatively correlated with gold price and share price index and positively correlated with interest rate and only price. But it is important to note that the correlation coefficients between the exchange rate and the other variables are statistically insignificant.

The gold price is negatively related with interest rate and stock market index but positively related with oil price. The correlation coefficient is insignificant between gold price and share price index but statistically significant between gold price and crude oil prices. This implies that the commodity prices are highly correlated within them but less correlated with other financial variables. The correlation coefficients between interest rate and oil price is negative and statistically insignificant while the coefficient of the correlation coefficient between interest rate and stock price though negative but statistically significant, hence we expect interest rate to have negative and significant impact on crude oil price and vice versa. Finally, the oil price is negatively and insignificant relationship on stock price. In conclusion, the commodity prices are higherly correlated while the financial variables are not. We also found the evidence of negative and significant correlation between oil price and interest rate.

All the above are the preliminary evidence on the nature of the dynamic relationship between commodity prices and financial variables. Our next task is to examine them in detailed and more formal way. But before then, the study presents the ex anti diagnostic checks of the variables. This has to do with the stochastic and co-integrating properties of the series. This is evidence is also for the full, pre crisis and post crisis periods.

Table 4.3: Unit Root Test: ADF and PP for the full sample

Variables	ADF		PP	
	Level	Difference	Level	Difference
FXR	-2.48 (0.11)	-79.55 (0.00)	-2.60 (0.09)	-79.56 (0.00)
Gold	-0.64 (0.85)	-87.47 (0.00)	-0.64 (0.85)	-87.48 (0.00)
INT	-1.18 (0.68)	-27.97 (0.00)	-1.66 (0.44)	-88.95 (0.00)
Oil	-1.40 (0.58)	-79.48 (0.00)	-1.46 (0.54)	-79.52 (0.00)
SPI	-4.71 (0.00)	-27.55 (0.00)	-6.07 (0.00)	-100.3 (0.00)

Table 4.3 above presents the unit root test based on ADF and PP. The test represents the evidence for full sample and it was estimated for both level and first difference, the t-statistic together with the probability values in parenthesis are presented above. The level evidence based on ADF

shows that all the variables except share price index that is stationary at 1% and GBP/USD at 11%, all the rest are non stationary. The ADF level evidence is the same with that of PP only that the GBP/USD is now stationary at 9% which is a better acceptable limit. After taking the first difference, all the series appeared stationary. This evidence is consistent for the two tests used by the study. Now, since we know the stochastic properties of the series, and since some variables are level while others are differenced stationary, the next task is to assess the co-integrating evidence, this will enable us to know whether the series have a common stochastic trend that will pool the series at equilibrium in the long run.

Table 4.4.A: Johansen Co-integration

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.006257	72.88720	69.81889	0.0279
At most 1	0.002487	30.48400	47.85613	0.6940
At most 2	0.001419	13.66114	29.79707	0.8591
At most 3	0.000478	4.068724	15.49471	0.8979
At most 4	0.000124	0.838809	3.841466	0.3597

Table 4.4.B: Johansen Co-integration

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.006257	42.40320	33.87687	0.0038
At most 1	0.002487	16.82287	27.58434	0.5952
At most 2	0.001419	9.592414	21.13162	0.7820

At most 3	0.000478	3.229915	14.26460	0.9302
At most 4	0.000124	0.838809	3.841466	0.3597

Table 4.4 A and B presents the co-integrating evidence based on the Johansen multivariate Co-integrating test. As described in the methodology section, this test allowed us to retrieve up to N-1 co-integrating vectors unlike Engle and Grander test that can only show the presence of one co-integrating vectors even if there is N variables. Two sets of test statistic were presented. Tale 4.4.A presents the estimates of the co-integrating relationship which was extracted using trace statistic while Table 4.4.B was based on maximum eigen value. The evidences from the two test statistics are consistent because they both present the presence of one co-integrating vector at 5% level of significance. We tried to increase the acceptance limit to 10% but the evidence is still similar, therefore we report the 5%. Now, the conclusion from the above tests is, there exists a long run relationship between the variables. The next task is to present the estimates of the impact model. Since we found the presence of integration in the series and we further found an evidence of long run relationship between the variables, the best model to use for the impact analysis is vector error correlation model (VECM). We estimate the model by assuming one co-integrating vector, with 2 lags; which are the lags that send the model free from serial correlation. After estimating the reduce form parameter, because one of the main aim of this study is to see the dynamic relationship between the variables, an impulse response and variance decomposition were estimated from the VECM model and the results are presented in figure 4.2.

Figure 4.2: Impulse Response Function

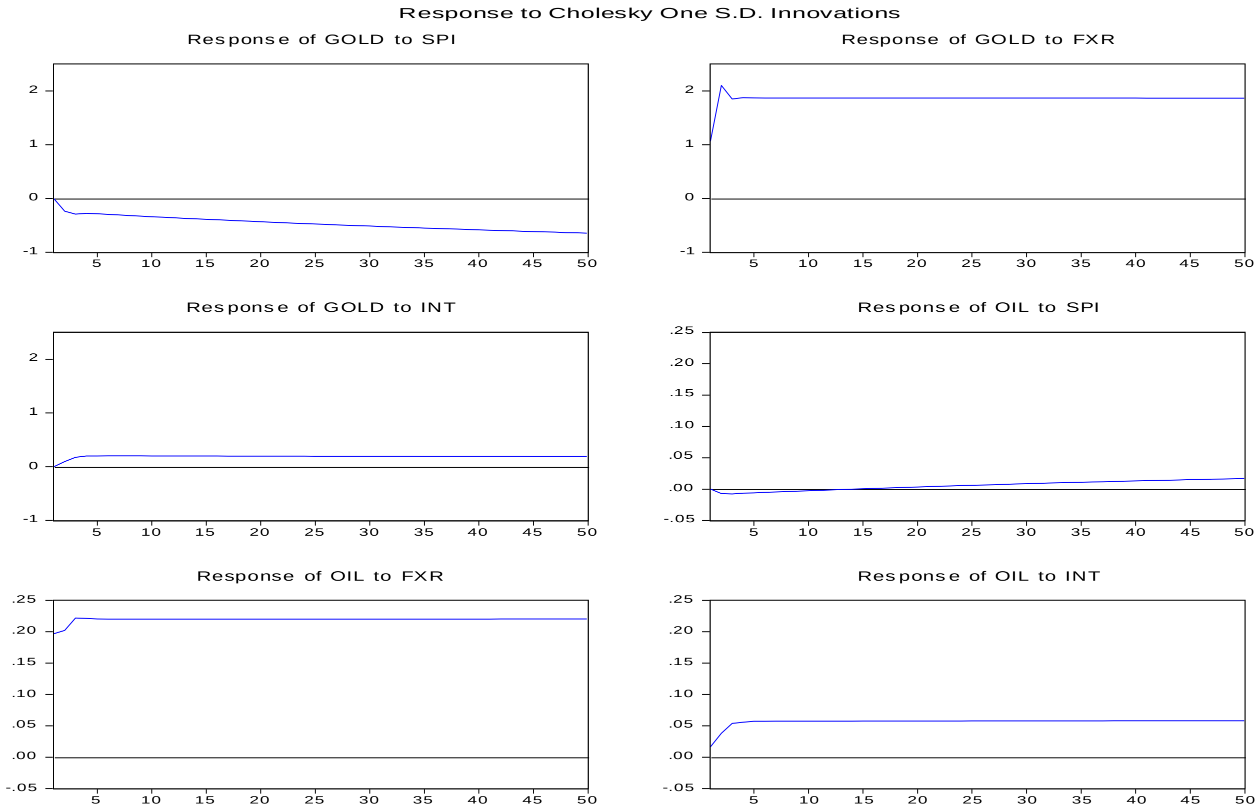


Figure 4.2 presents the of commodity prices to financial variable shocks. We deliberately extracted the response like this, given the fact that we so from the informal correlation test that the financial variables have very weak relationship between themselves. What we want to see is, how do commodity prices respond to shocks in interest and exchange rates and stock market price. The first graph in the above panel shows the response of gold price to stock market index. The response was estimated for the period of 50 months. The response shows that when there is a shock from stock market, it will have negative and significant impact on gold price. This can be seen from the trend of the response, it shows that as a result of the shock, the value declined from

its original value and it continue to shrink until the end of the 50 month horizon used by the study.

However, gold price response positively to exchange rate shock, the trend of the impulse shows that when exchange rate shock hitting the gold price, the gold price will raise and the increase continue until the end of the sample. The first graph of the middle panel shows the response of gold to interest rate shock, the trend shows that interest rate shock will have positive impact on gold price until the end of the 50 months horizon. The second graph of the middle panel shows the response of oil price to share price index shock, the graph shows a positive but insignificant impact because the magnitude of the impact is not statistically different from zero. The two graphs of the lower panel show the response of oil price to exchange and interest rates shocks. The trend shows that oil price respond positively to both exchange and interest rate shocks until the end of the sample horizon. In conclusion, the impulse response shows that the commodity prices response positively to shocks from financial variables except gold that response negatively to stock price shocks.

Figure 4.3: Variance Decomposition

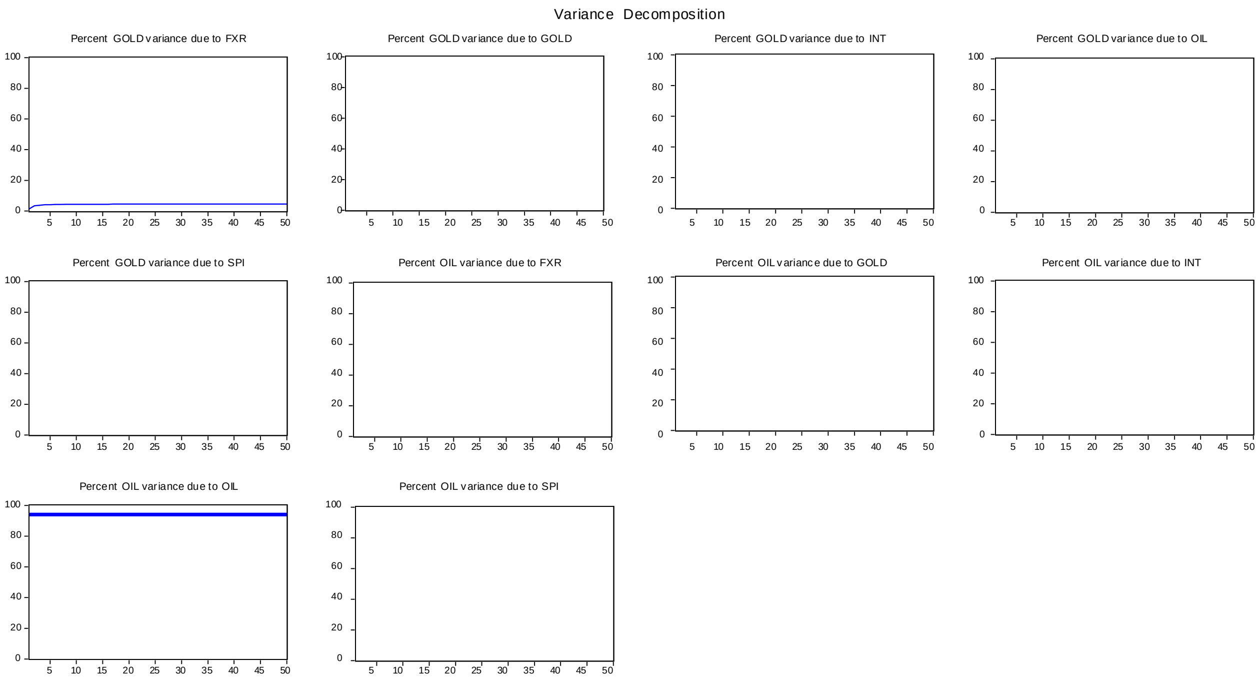


Figure 4.3 presents the forecast error variance of the relationship between commodity prices and financial variables. Graphs 1 to 5 of figure 4.3 shows the decomposition of error due to the forecast of gold price or the contribution of financial variables in the forecast of gold price. The result shows that only foreign exchange contribute in forecasting the error of gold price, although the contribution is very minimal, not more than 2% throughout the 50 months horizon. The gold price account for 98% of its forecast error. This implies that gold price has no relationship with interest rate, oil price and share price, but a little although insignificant relationship was found between gold price and exchange rate. Figure 5 to 10 shows the forecast error variance of crude oil price in relation to gold price, interest rate, exchange rate and stock price. The essence is to see the level of synchronization or otherwise of the variables. The trend of the forecast error variance shows that exchange rate and gold price are the only variables that contribute in the forecast error of crude oil, even though, the contribution is insignificant because the two

variables accounted for less than 10%. Whereas, about 90% of the forecast error crude oil is accounted by itself. Hence it the evidence shows a little synchronization of the variables.

Pre 2008 financial crisis evidence

The above analysis represents the full sample evidence. The next task is to assess whether the 2008 financial crisis has significantly affect the dynamic relationship of the variables. We first present the pre-2008 financial crisis evidence and this is followed by the post crisis evidence.

Table 4.5: Static correlation coefficients

Correlation	GOLD	INT	OIL	SPI	FXR
GOLD	1.000000				
INT	0.050259	1.000000			
OIL	0.832746	-0.091171	1.000000		
SPI	0.226970	-0.381463	0.181004	1.000000	
FXR	0.689618	0.098219	0.641478	-0.142239	1.000000

Table 4.5 presents the static correlation coefficient between the variables. The result shows that gold price is positively related with interest rate, share price, crude oil price and exchange rate. This evidence contradicts what was found in the full sample. In terms of the sign, the gold price and exchange rate have a positive relationship unlike in the full sample that shows a negative relationship. In terms of the significance of the relationship, gold and exchange rate show evidence of higher correlation with a coefficient of 0.68% unlike in the full sample that shows only 0.06%. The correlation coefficients between interest rate and gold price, gold price and oil price and gold price and share price have magnitudes of 0.05, 0.83 and 0.22 respectively. Interest

rate has negative relationship with oil and share prices and is positively related with foreign exchange. The oil price was found to be positively related with share price and exchange rate while share price index and exchange rate are negatively related. The evidence shows that gold price is positive and significantly related with oil price and exchange rate and oil price is also positively related with exchange rate. Under the pre crisis sample, there is evidence of relationship between commodity prices and financial variables (gold and exchange rate and oil price and exchange rate), this evidence is in variant with the full sample results.

The next task is to present the stochastic properties of the pre crisis period. The essence is to see whether there is different in terms of the stochastic properties between full and pre crisis samples.

Table 4.6: Unit Root: ADF and PP

Variables	ADF		PP	
	Level	Difference	Level	Difference
FXR	-1.36 (0.59)	-65.18 (0.00)	-1.46 (0.55)	-65.32 (0.00)
Gold	2.11 (0.99)	-72.26 (0.00)	1.94 (0.99)	-72.15 (0.00)
INT	-2.07 (0.25)	-61.45 (0.00)	-2.04 (0.26)	-61.84 (0.00)
Oil	0.66 (0.99)	-68.12 (0.00)	0.62 (0.99)	-68.13 (0.00)
SPI	-4.29 (0.00)	-24.21 (0.00)	-5.84 (0.00)	-91.76 (0.00)

Table 4.6 presents the unit root evidence for pre 2008 crisis period. The result reveals that only share price is level stationary while the other variables are none stationary. This evidence is consistent for both Augmented Dickey Fuller (ADF) and Phillips and Perron (PP) tests. After taking the first of the variables they all appeared stationary. This evidence is different from what

we found in the full sample, because both share price index and foreign exchange are found to be stationary in full sample using both ADF and PP but during the pre crisis period only share price is level stationary. Since four of the five variables are found to be integrated at level, there is the need to check whether the combination of the variables will have common stochastic trend. The evidence is presented in table 4.7 A and B below.

Table 4.7.A: Johansen Co-integration

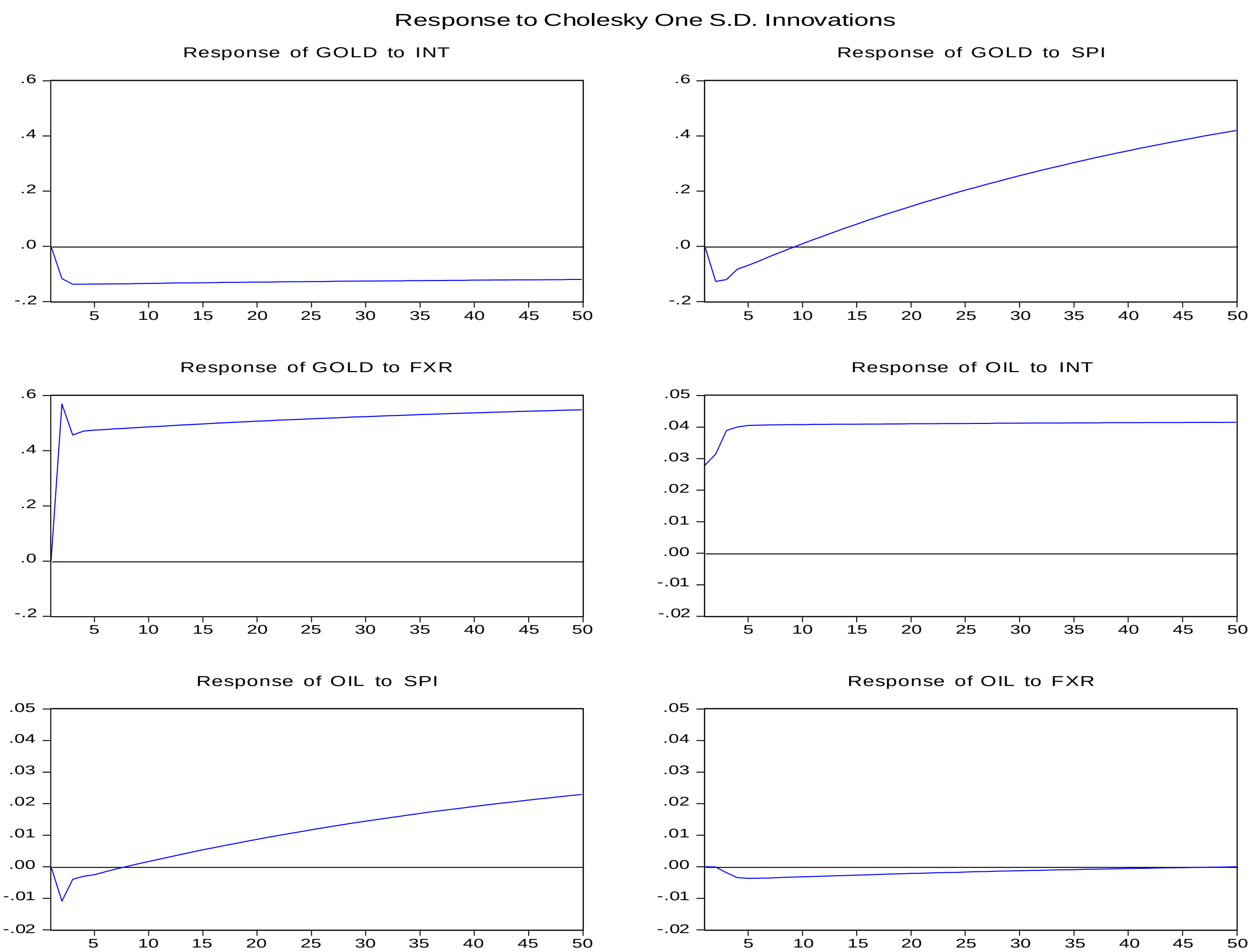
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.008431	80.58885	69.81889	0.0054
At most 1	0.004646	41.05621	47.85613	0.1869
At most 2	0.002347	19.31450	29.79707	0.4705
At most 3	0.001761	8.342448	15.49471	0.4295
At most 4	2.40E-05	0.111887	3.841466	0.7380

Table 4.7.B: Johansen Co-integration

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.008431	39.53264	33.87687	0.0095
At most 1	0.004646	21.74171	27.58434	0.2339
At most 2	0.002347	10.97205	21.13162	0.6501
At most 3	0.001761	8.230561	14.26460	0.3557
At most 4	2.40E-05	0.111887	3.841466	0.7380

The table 4.7 A and B presents the Johansen co-integration test based on pre crisis sample period. The both the trace statistic and maximum eignen values, there is the presence of one co-integrating vector, just as we found under the full sample. We tried to re-estimate the model by using 10% level of significance but the evidence remains the same. Hence the conclusion is that, for both full and pre crisis sample, there an evidence of one long run relationship between the variables. Based on the integrating and co-integrating evidences, the best model to use for the dynamic impact analysis is a VECM. Hence, just like for the full sample, also for the pre crisis sample, we estimated VECM model at lag two and by assuming the presence of one c0-integrating relationship. The extracted impulse response function and the forecast error variance of the impulses are presented in figures 4.4 and 4.5 below.

Figure 4.4: Impulse Response Function



The upper panel of figure 4.4 shows the response of gold price to one standard deviation shocks of interest rate and stock index shock. The evidence shows that a shock from interest rate lead to the reduction in gold price and the impact of the shock lasted throughout the entire 50 years sampling horizon. This implies the presence of inverse relationship between gold price and interest rate shock. Whereas, the share price index shock shows a positive relationship with gold price. The shock starts with negative impact for about 3 month before the impact became positive and continue to increase until the end the of 50 month sample period. The first graph in the middle panel shows the response of gold price to exchange rate shock, the evidence shows the presence of positive and significant response with an initial spike at first two lags before the impact sustain the momentum and continue at the sample positive and significant path until the end of the sample period.

The second graph of the middle panel shows the response of oil price to interest rate shock, the trend shows a positive response throughout the 50 month horizon. This implies a positive and a significant relationship between oil price and interest rate shock. The down panel of figure 4.4 presents the response of oil price to stock price and exchange rate shocks. The first graph show mixed evidence, first a negative response up to lag 2 then a positive response until the end of the sample period. This means that when there is a stock index shock hitting oil price, it will have a negative impact that will last for two month from where it will be positive and significance until the end of the sample. The second graph of the panel shows the response of oil price to exchange rate shock. The response was negative though insignificant throughout the sample period. The overall pre crisis evidence is that commodity prices; gold price and crude oil price, responds positively to interest rate and share index shocks and negatively to exchange rate shock. Based on the above, we present the decomposition of the error between the variables in forecasting the impulse response, this is presented in figure 4.5 below.

Figure 4.5: Variance Decomposition

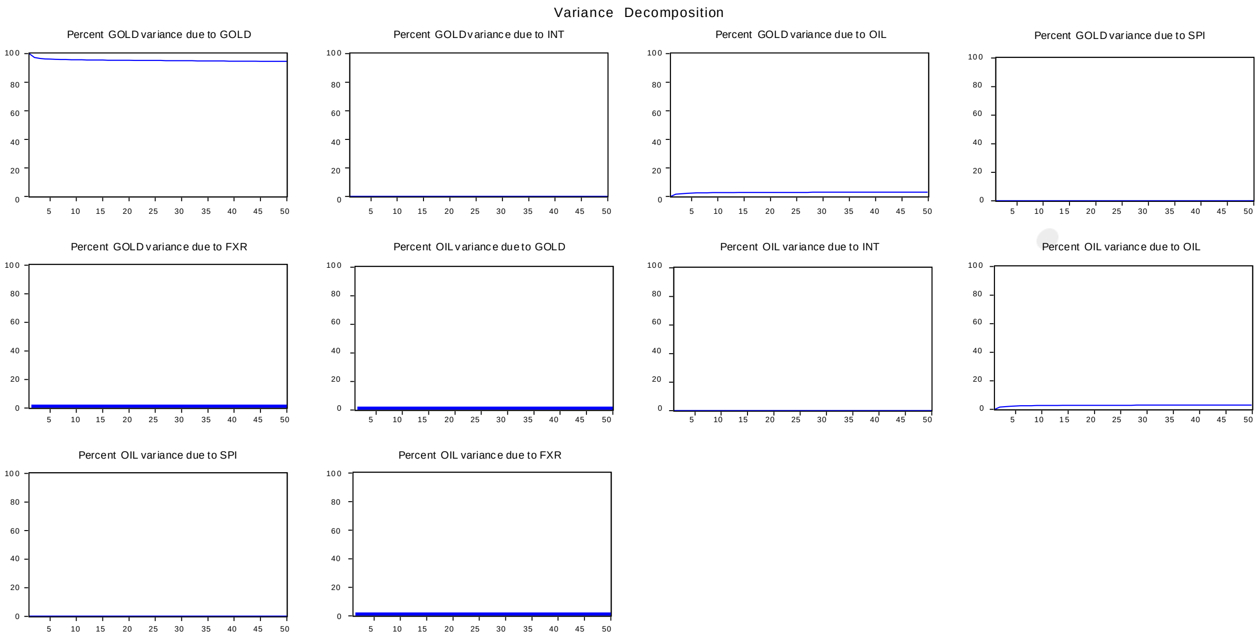


Figure 4.5 shows the forecast error decomposition of the variables, the first five graphs presents the decomposition of gold price forecast error between the variables. The evidence shows that only oil price contributes about 2% in the error committed in forecasting the values of the gold price and the gold price accounted for 98% of the errors. This signifies the divergence of the variables. This evidence is consistent with what we found in the full sample estimates. The last five graphs present the contribution of exchange rate, interest rate, gold price and share index in the forecast error of oil price. The evidence is consistent with full sampling evidence, where only gold price accounted for less than 2% of the error, but the oil price accounted for about 98% of the shock. The evidence here is that there is no synchronization between commodity prices and financial variables. Next we present the post crisis evidence.

Post crisis Evidence

This section presents the post 2008 evidence of the dynamic relationship between commodity and financial variables. The aim is to compare it with full and pre sample estimates with the view to ascertain the similarities and differences of the findings.

Table 4.8: Static correlation coefficient

Correlation	FXR	GOLD	INT	OIL	SPI
FXR	1.000000				
GOLD	-0.280733	1.000000			
INT	0.674533	-0.568090	1.000000		
OIL	0.469492	0.564138	0.030481	1.000000	
SPI	0.131778	-0.115836	-0.010968	-0.046601	1.000000

Table 4.8 presents the static correlation coefficients between the variables. The result shows that exchange rate is positively related with interest rate, oil price and share price index but negatively related with gold price. The magnitude of the relationship was high between interest rate and exchange rate (0.67%), moderate for exchange rate and oil price (0.46%) and low for exchange rate – gold price and exchange rate share price index. The correlations coefficients between gold price and oil price is positive and significant while the evidence shows that gold price is having negative relationship with interest rate and share price index. Although, the magnitude of the relationship between gold price and interest rate is higher. The evidence reveals the presence of negative and insignificant relationship between interest rate and share price and

positive but insignificant between interest rate and oil price and finally, a negative and insignificant relationship was found between oil price and share price index. Next we present the stochastic properties evidence of the post crisis sample. This is shown in table 4.9 below.

Table 4.9: Unit root test: ADF and PP

Variables	ADF		PP	
	Level	Difference	Level	Difference
FXR	-2.93 (0.04)	-45.23 (0.00)	2.94 (0.04)	-45.23 (0.00)
Gold	-1.61 (0.47)	-48.39 (0.00)	-1.62 (0.47)	-48.41 (0.00)
INT	-4.34 (0.00)	-11.41 (0.00)	-4.70 (0.00)	-55.40 (0.00)
Oil	-0.90 (0.78)	-43.43 (0.00)	-0.99 (0.75)	-43.42 (0.00)
SPI	-2.36 (0.15)	-11.42 (0.00)	-5.51 (0.00)	-89.86 (0.00)

Table 4.9 presents the ADF and PP unit root evidence for the post crisis period. The evidence shows that all the variables except exchange and interest are level non stationary using ADF. This evidence contradicted what we found in full and pre crisis samples, because interest rate and share price index were found to be level stationary in full sample and only share price appeared to be the only level stationary variable in the pre crisis period. But the post crisis sample shows that exchange rate and interest rate are the only level stationary variables with share price becoming stationary only at 15%, when the first difference of the series was taken, all the variables appeared stationary and all these evidences are for ADF. When we looked at PP, we found that exchange rate, interest rate and share price index are level stationary and after taking first difference, all the other variables became stationary. Here, if we accept the 15% stationary evidence for share price index using ADF and conclude that three out of the five variables are

level stationary, there is the need to check the possibility of co-integration if not among the five variables, at least between the two integrated variables. We checked for the long run relationship evidence using Johansen multivariate co-integration method as explained in the methodology section. The result is presented in table 4.9 A and B below.

Table 4.9.A: Johansen Co-integration

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.022729	93.43157	69.81889	0.0002
At most 1	0.011887	45.93234	47.85613	0.0750
At most 2	0.006851	21.22748	29.79707	0.3436
At most 3	0.002108	7.025206	15.49471	0.5747
At most 4	0.001290	2.666192	3.841466	0.1025

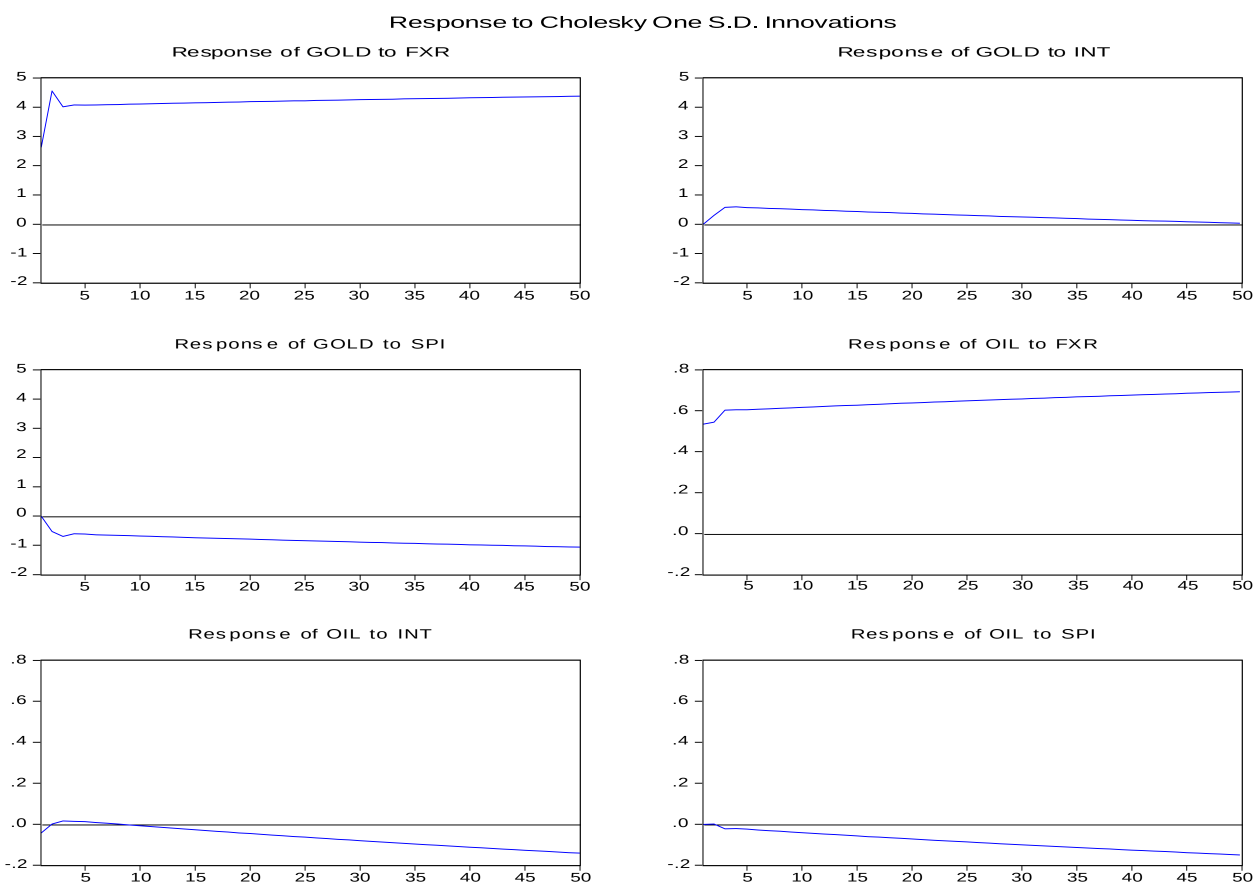
Table 4.9.A: Johansen Co-integration

Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.022729	47.49924	33.87687	0.0007
At most 1	0.011887	24.70486	27.58434	0.1119
At most 2	0.006851	14.20227	21.13162	0.3487
At most 3	0.002108	4.359014	14.26460	0.8197
At most 4	0.001290	2.666192	3.841466	0.1025

Table 4.9 A and B presents the c-integrating evidence based on Johansen multivariate test. The trace test and maximum eignen value evidences are presented in table 4.9.A and 4.9.B

respectively. The result shows that the two statistics are consistent in terms of the evidence they presented. The result reveals the presence of one co-integrating vector. This finding is consistent with full and pre crisis samples. Now we estimated the VECM and extracted he impulse response functions in order to see how commodity prices response to financial variables and also the forecast error decomposition to see the variables synchronization. The results are presented in figure 4.6 and 4.7 below.

Figure 4.6: Impulse Response Function



The upper panel of figure 4.6 presents the response of gold price to one standard deviation shocks of exchange rate and interest rate. The evidence shows that a shock from exchange rate lead to an increase in gold price and the impact of the shock lasted throughout the entire 50 years sampling horizon. This implies the presence of direct relationship between gold price and interest rate shock. Whereas, the interest rate shock shows a positive but insignificant relationship with gold price. The shock starts with positive impact for about 3 month before the impact became constant and continue to decrease until the end the of 50 month sample period where it ended at zero. The first graph in the middle panel shows the response of gold price to share price index shock, the evidence shows the presence of negative and significant response with an initial spike at first two lags before the impact sustain the momentum and continue on the same path until the end of the sample period.

The second graph of the middle panel shows the response of oil price to exchange rate shock, the trend shows a positive response throughout the 50 month horizon. This implies a positive and a significant relationship between oil price and exchange rate shock. The down panel of figure 4.4 presents the response of oil price to interest rate and share price index shocks. The first graph show mixed evidence, first absence of impact up to lag 15 then a negative response until the end of the sample period. This means that when there is interest rate shock hitting oil price, it will have a no impact for the first fifteen month from where it will be negative and significance until the end of the sample. The second graph of the panel shows the response of oil price to share price index shock. The response was negative though insignificant throughout the sample period. The overall pre crisis evidence is that commodity prices; gold price and crude oil price, responds positively to interest rate and share index shocks and negatively to exchange rate shock. Based on the above, we present the decomposition of the error between the variables in forecasting the impulse response, the evidence is presented below.

Figure 4.7: Variance Decomposition

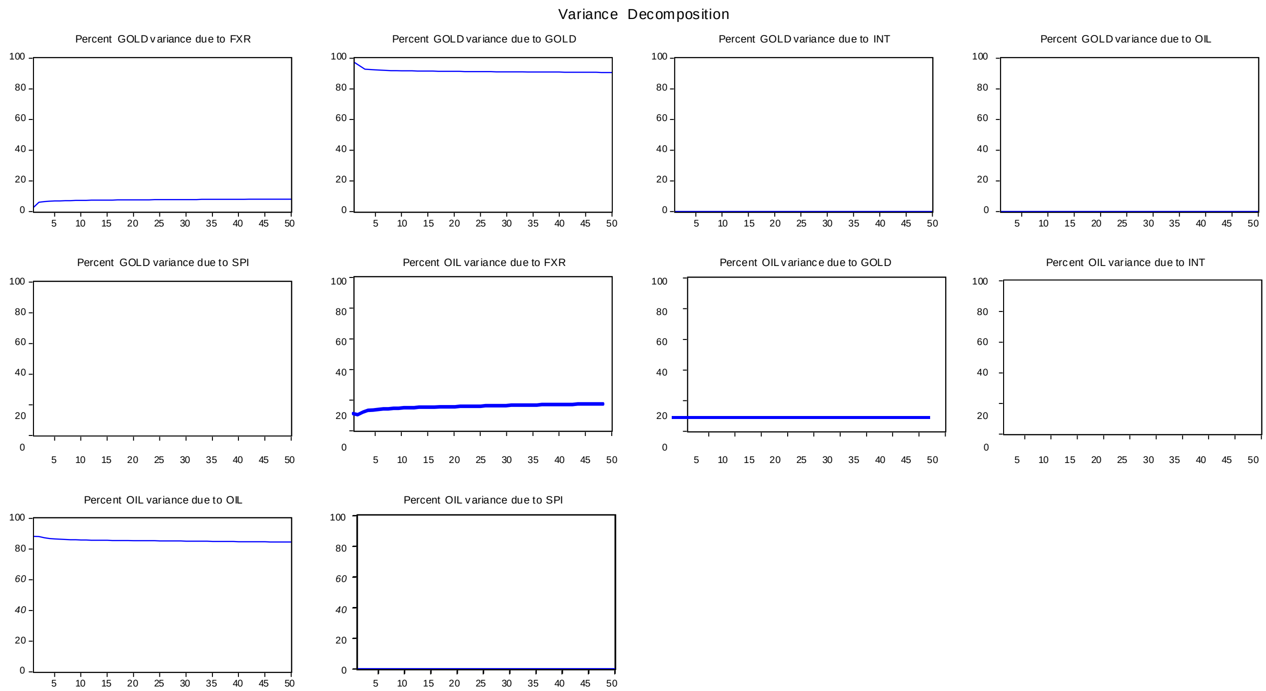


Figure 4.7 presents the forecast error variance of the relationship between commodity prices and financial variables. Graphs 1 to 5 of figure 4.7 shows the decomposition of error due to the forecast of gold price or the contribution of financial variables in the forecast of gold price. The result shows that only foreign exchange contribute in forecasting the error of gold price, although the contribution is very minimal, not more than 2% throughout the 50 months horizon. The gold price account for 98% of its forecast error, this response was consistent with what we found under the full sampling evidence. This implies that gold price has no relationship with interest rate, oil price and share price, but a little although insignificant relationship was found between gold price and exchange rate. Figure 5 to 10 shows the forecast error variance of crude oil price in relation to gold price, interest rate, exchange rate and stock price. The essence is to see the

level of synchronization or otherwise of the variables. The trend of the forecast error variance shows that exchange rate and gold price are the only variables that contribute in the forecast error of crude oil, even though, the exchange rate contributed about 20% before the end of the 50 years horizon, gold price contributes less than 5%. Whereas, about 85% of the forecast error crude oil is accounted by itself. Hence it the evidence shows a little synchronization of the variables.

CHAPTER FIVE: VOLATILITY MODELS

5.0: This chapter presents empirical evidence with regards to the volatility of commodity prices and financial variables. A univariate GARCH, TGARCH and EGARCH models were estimated for each variable, this is done for the full, pre and post 2008 financial crisis periods.

Table 5.10: Estimates of the Univariate Volatility, Exchange rate model

	Full Sample			Pre 2008 Financial Crisis			Post 2008 Fin. crisis		
Parameter	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH
ARCH	0.03	0.41	0.09	-0.06	0.04	0.08	0.30	0.30	0.06
GARCH	0.95	-0.17	0.99	-0.88	0.95	0.99	-0.44	-0.44	0.99
Asymmetry	-	-0.36	0.003	-	-0.01	0.01	-	-0.43	-0.03
C	1.72	0.0003	-0.14	0.0004	5.68	-0.14	0.001	0.001	-0.08

The table above shows the univariate volatility models for exchange rate, the sample is divided into three, full sample, pre 2008 financial crises and post 2008 financial crises, in each sample three set of models (GARCH, TGARCH, and EGARCH) were computed, that is three mean equations and three variance equations, this is in order to arrive at the most robust model, the mean equations follows an ARMA model. The GARCH model has two parameters, ARCH and GARCH otherwise known as the surprise and historical volatility, the ARCH parameter has a coefficient of 0.03 while the GARCH has a coefficient of 0.95, the constant of the GRACH model is 1.72, the volatility is arrived at by summing up the ARCH and GARCH parameters, as such the volatility is 0.98 which has a persistent effect and thereby having a long memory. The Threshold GARCH (TGARCH) unlike the GARCH model has three components the ARCH, GARCH and the Asymmetry parameter, the ARCH coefficient is 0.41 while the GARCH coefficient is -0.17, the volatility is 0.24, the asymmetry parameter is in conformity with the a priori expectation with a negative value of -0.36, meaning that negative news result to higher volatility than positive news, the mean value is 0.0003. The exponential GARCH model (EGARCH) has an ARCH parameter of 0.09 and a GARCH parameter of 0.99, the volatility coefficient is 1.08 which signifies explosion, the asymmetry parameter is 0.003 which signifies that positive volatility heightened volatility than negative volatility which is against the conventional wisdom. From the three models we can conclude that TGARCH outperformed GARCH and EGARCH because the volatility coefficient in EGARCH signifies explosion and the asymmetry coefficient is contrary to the a priori expectation.

In the pre-2008 financial crises three set of models GARCH, TGARCH and EGARCH were used in order to arrive at the most robust model, likewise the mean equations follows an ARMA representation. The GARCH model have two parameters ARCH and GARCH, the ARCH coefficient is 0.06 while the GARCH coefficient is -0.88, the mean value of the GARCH model is 0.001, the volatility magnitude is -0.94, which signifies negative volatility. The TGARCH model has three components ARCH, GARCH and an asymmetry component that captures the role of information, the ARCH parameter in the model is 0.04 while the GARCH parameter is 0.95, the volatility coefficient which is the summation of the ARCH and GARCH coefficient is 0.99 which signifies persistence effect in the volatility thereby having a long term memory, the asymmetry component have a coefficient of -0.01 which signifies that negative news heightened volatility than positive news and is in conformity with the a priori expectation. The EGARCH model also have three components that is the ARCH, GARCH and an asymmetry components, the ARCH coefficient is 0.08 while the GARCH coefficient is 0.99, the volatility magnitude which is derived by summing the ARCH and GARCH coefficient is 1.07 which is signifies an explosion, the asymmetry coefficient is 0.01 which means positive news increases volatility than negative news, which is against the conventional wisdom. The most robust model among the three is TGARCH because the volatility coefficient is greater than one and the asymmetry parameter is contrary to the empirical evidences.

The post 2008 financial crises also utilize the three different models, that is GARCH, TGARCH and EGARCH, with each having a mean equation that follows ARMA representation. The GARCH model has an ARCH coefficient of 0.30 and a GARCH coefficient of -0.44 with a constant value of 0.001, the volatility coefficient which is arrived at by summing the ARCH and GARCH coefficient is -0.14 which signifies a negative volatility. The TGARCH model has an ARCH coefficient of 0.30 and a GARCH coefficient -0.44, an asymmetry parameter of -0.43 and a constant value of 0.001, the volatility coefficient is -0.14 which is a negative volatility, the asymmetry coefficient is in conformity with the a priori expectation that negative news increases volatility than positive news. The EGARCH model has an ARCH coefficient of 0.06, GARCH coefficient of 0.99, an asymmetry coefficient of -0.03 and a constant of -0.08. The volatility coefficient which is arrive at by summing the ARCH and GARCH parameter is 1.05 which signifies an explosion, the asymmetry coefficient is in conformity with the a priori expectation that negative news heightened volatility than positive news. The most robust model in the post 2008 financial crises is the GARCH and TGARCH model because the EGARCH has a volatility greater than one.

Table 5.11: Estimates of the Univariate Volatility, Gold price model

	Full Sample			Pre 2008 Financial Crisis			Post 2008 Fin. Crisis		
Parameter	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH
ARCH	0.36	0.31	0.14	-0.18	-1.19	0.12	-1.90	-0.93	0.16
GARCH	-0.22	-0.22	0.99	-0.99	-0.98	0.99	-0.99	-0.98	0.99
Asymmetry	-	0.04	0.04	-	-2.03	0.07	-	-0.89	0.164
C	129103	129103	-0.09	7079	7129	-0.07	65411	65421	-0.07

The table above shows the univariate volatility models for gold price, the sample is divided into three, full sample, pre 2008 financial crises and post 2008 financial crises, in each sample three set of models (GARCH, TGARCH, and EGARCH) were computed, that is three mean equations and three variance equations, this is in order to arrive at the most robust model, the mean equations follows an ARMA model. The GARCH model has two parameters, ARCH and GARCH otherwise known as the surprise and historical volatility, the ARCH parameter has a coefficient of 0.36 while the GARCH has a coefficient of -0.22, the constant of the GRACH model is 129103, the volatility is arrived at by summing up the ARCH and GARCH parameters, as such the volatility is 0.14. The Threshold GARCH (TGARCH) unlike the GARCH model has three components the ARCH, GARCH and the Asymmetry parameter, the ARCH coefficient is while the GARCH coefficient is -0.22, the volatility is 0.09, the asymmetry parameter is notin conformity with the a priori expectation with a value of 0.04 meaning that positive news result to higher volatility than negative news, the mean value is 129103. The exponential GARCH model (EGARCH) has an ARCH parameter of -0.18 and a GARCH parameter of -0.99, the volatility coefficient is -1.17, the asymmetry parameter is 0.04 which signifies that positive volatility heightened volatility than negative volatility which is against the conventional wisdom.From the three models we can conclude that GARCH outperformed TGARCH and EGARCH because the asymmetry coefficient is contrary to the a priori expectation in TGARCH and EGARCH

In the pre-2008 financial crises three set of models GARCH, TGARCH and EGARCH were used in order to arrive at the most robust model, likewise the mean equations follows an ARMA representation. The GARCH model have two parameters ARCH and GARCH, the ARCH coefficient is -0.18 while the GARCH coefficient is -0.99, the mean value of the GARCH model is 7079, the volatility magnitude is -1.17, which signifies negative volatility. The TGARCH model has three components ARCH, GARCH and an asymmetry component that captures the role of information, the ARCH parameter in the model is -1.19 while the GARCH parameter is -0.98, the volatility coefficient which is the summation of the ARCH and GARCH coefficient is -2.17, the asymmetry component have a coefficient of -2.03 which signifies that negative news heightened volatility than positive news and is in conformity with the a priori expectation and the mean of the model is 7129. The EGARCH model also have three components that is the ARCH, GARCH and an asymmetry components, the ARCH coefficient is 0.12 while the GARCH coefficient is 0.99, the volatility magnitude which is derived by summing the ARCH and GARCH coefficient is 1.11 which is signifies an explosion, the asymmetry coefficient is 0.07 which means positive news increases volatility than negative news, which is against the conventional wisdom. The most robust model among the three is TGARCH because asymmetry parameter is contrary to the empirical evidences in EGARCH and the volatility is greater than one in both GARCH and EGARCH.

The post 2008 financial crises also utilize the three different models that is GARCH, TGARCH and EGARCH, with each having a mean equation that follows ARMA representation. The GARCH model has an ARCH coefficient of -1.90 and a GARCH coefficient of -0.99 with a constant value of 65411, the volatility coefficient which is arrived at by summing the ARCH and GARCH coefficient is -2.89 which signifies a negative volatility. The TGARCH model has an ARCH coefficient of -0.93 and a GARCH coefficient -0.98, an asymmetry parameter of -0.89 and a constant value of 65421, the volatility coefficient is -1.91 which is a negative volatility, the asymmetry coefficient is in conformity with the a priori expectation that negative news increases volatility than positive news. The EGARCH model has an ARCH coefficient of 0.16, GARCH coefficient of 0.99, an asymmetry coefficient of -0.03 and a constant of -0.08. The volatility coefficient which is arrive at by summing the ARCH and GARCH parameter is 1.15 which signifies an explosion, the asymmetry coefficient is not in conformity with the a priori expectation that negative news heightened volatility than negative news. The most robust model in the post 2008 financial crises is the TGARCH model because the EGARCH has a postive asymmetry coefficient

Table 5.12: Estimates of the Univariate Volatility, Interest rate model

	Full Sample			Pre 2008 Financial Crisis			Post 2008 Fin. Crisis		
Parameter	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH
ARCH	1.39	0.15	0.54	0.19	0.12	0.15	8.66	0.15	1.81
GARCH	0.67	0.89	0.97	0.80	0.82	0.96	0.07	0.42	0.95
Asymmetry	-	0.95	-0.28	-	0.08	-0.04	-	-1.19	-1.04
C	-4.33	-8.19	-0.42	6.42	5.82	-0.31	6.73	0.98	-1.16

The table above shows the univariate volatility models for interest rate, the sample is divided into three, full sample, pre 2008 financial crises and post 2008 financial crises, in each sample three set of models (GARCH, TGARCH, and EGARCH) were computed, that is three mean equations and three variance equations, this is in order to arrive at the most robust model, the mean equations follows an ARMA model. The GARCH model has two parameters, ARCH and GARCH otherwise known as the surprise and historical volatility, the ARCH parameter has a coefficient of 1.39 while the GARCH has a coefficient of 0.67, the constant of the GRACH model is -4.33, the volatility is arrived at by summing up the ARCH and GARCH parameters, as such the volatility is 2.06 which has an explosive effect. The Threshold GARCH (TGARCH) unlike the GARCH model has three components the ARCH, GARCH and the Asymmetry parameter, the ARCH coefficient is 0.15while the GARCH coefficient is 0.89, the volatility is 1.04, which signifies explosion, the asymmetry parameter is not in conformity with the a priori expectation with a positive value of 0.95, meaning that positive news result to higher volatility than negative news, the mean value is -8.19. The exponential GARCH model (EGARCH) has an

ARCH parameter of 0.54 and a GARCH parameter of 0.89, the volatility coefficient is 1.08 which signifies explosion, the asymmetry parameter is 0.95 which signifies that positive volatility heightened volatility than negative volatility which is against the conventional wisdom. From the three models we can conclude that TGARCH outperformed GARCH and EGARCH because the volatility coefficient in EGARCH signifies explosion and the asymmetry coefficient is contrary to the a priori expectation.

In the pre-2008 financial crises three set of models GARCH, TGARCH and EGARCH were used in order to arrive at the most robust model, likewise the mean equations follows an ARMA representation. The GARCH model have two parameters ARCH and GARCH, the ARCH coefficient is 1.19 while the GARCH coefficient is 0.80, the mean value of the GARCH model is 6.42, the volatility magnitude is 0.99, which signifies persistence effect in the volatiltity. The TGARCH model has three components ARCH, GARCH and an asymmetry component that captures the role of information, the ARCH parameter in the model is 0.12 while the GARCH parameter is 0.82, the volatility coefficient which is the summation of the ARCH and GARCH coefficient is 0.94 which signifies persistence effect in the volatility, the asymmetry component have a coefficient of 0.08 which signifies that positive news heightened volatility than negative news and is not in conformity with the a priori expectation. The EGARCH model also have three components that is the ARCH, GARCH and an asymmetry components, the ARCH coefficient is

while the GARCH coefficient is 0.96, the volatility magnitude which is derived by summing the ARCH and GARCH coefficient is 1.11 which is signifies an explosion, the asymmetry coefficient is -0.31 which means negative news increases volatility than positive news, which is in line with the conventional wisdom. The most robust model among the three is

GARCH because the volatility coefficient is greater than one and the asymmetry parameter is contrary to the empirical evidences in TGARCH and EGARCH respectively.

The post 2008 financial crises also utilize the three different models that is GARCH, TGARCH and EGARCH, with each having a mean equation that follows ARMA representation. The GARCH model has an ARCH coefficient of 8.66 and a GARCH coefficient of

0.07 with a constant value of 6.73, the volatility coefficient which is arrived at by summing the ARCH and GARCH coefficient is 8.73 which signifies an explosive effect in the volatility. The TGARCH model has an ARCH coefficient of 0.15 and a GARCH coefficient 0.07, an asymmetry parameter of -1.19 and a constant value of 0.98, the volatility coefficient is 0.57 which is a negative volatility, the asymmetry coefficient is in conformity with the a priori expectation that negative news increases volatility than positive news. The EGARCH model has an ARCH coefficient of 1.81, GARCH coefficient of 0.95, an asymmetry coefficient of -1.04 and a constant of -1.16. The volatility coefficient which is arrive at by summing the ARCH and GARCH parameter is 2.76 which signifies an explosion, the asymmetry coefficient is in conformity with the a priori expectation that negative news heightened volatility than positive news. The most robust model in the post 2008 financial crises is TGARCH model because GARCH and EGARCH has a volatility greater than one.

Table 5.13: Estimates of the Univariate Volatility, Oil Price model

	Full Sample			Pre 2008 Financial Crisis			Post 2008 Fin. Crisis		
Parameter	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH
ARCH	0.51	-0.93	0.13	0.08	0.15	0.15	-0.005	-0.001	-0.02

GARCH	-0.34	-0.93	0.99	0.91	-0.17	0.99	-0.99	-0.99	-0.90

Asymmetry	-	-0.72	0.01	-	-0.90	0.03	-	0.003	-0.02
C	749.45	334.29	-0.10	0.001	92.13	-0.12	5.14	5.14	1.80

The table above shows the univariate volatility models for oil price, the sample is divided into three, full sample, pre 2008 financial crises and post 2008 financial crises, in each sample three set of models (GARCH, TGARCH, and EGARCH) were computed, that is three mean equations and three variance equations, this is in order to arrive at the most robust model, the mean equations follows an ARMA model. The GARCH model has two parameters, ARCH and GARCH otherwise known as the surprise and historical volatility, the ARCH parameter has a coefficient of 0.51 while the GARCH has a coefficient of -0.34, the constant of the GRACH model is 749.45, the volatility is arrived at by summing up the ARCH and GARCH parameters, as such the volatility is 0.17 which has a very low volatilityand thereby having a short memory. The Threshold GARCH (TGARCH) unlike the GARCH model has three components the ARCH, GARCH and the Asymmetry parameter, the ARCH coefficient is -0.93 while the GARCH coefficient is -0.93, the volatility is -1.86, the asymmetry parameter is in conformity with the a priori expectation with a negative value of -0.72, meaning that negative news result to higher volatility than positive news, the mean value is 0.0003. The exponential GARCH model (EGARCH) has an ARCH parameter of 0.13 and a GARCH parameter of 0.99, the volatility coefficient is 1.12 which signifies explosion, the asymmetry parameter is -0.01 which signifies that negative volatility heightened volatility than positive volatility which is in line with the conventional wisdom. From the three models we can conclude that GARCH outperform the other volatility models because the volatility coefficient in TGARCH and EGARCH signifies explosion.

In the pre-2008 financial crises three set of models GARCH, TGARCH and EGARCH were used in order to arrive at the most robust model, likewise the mean equations follows an ARMA representation. The GARCH model have two parameters ARCH and GARCH, the ARCH coefficient is 0.08 while the GARCH coefficient is 0.91, the mean value of the GARCH model is 0.001, the volatility magnitude is 0.99, which signifies persistency in the volatility. The TGARCH model has three components ARCH, GARCH and an asymmetry component that captures the role of information, the ARCH parameter in the model is 0.15 while the GARCH parameter is -0.17, the volatility coefficient which is the summation of the ARCH and GARCH coefficient is- 0.02 which signifies negative volatility, the asymmetry component have a coefficient of -0.90 which signifies that negative news heightened volatility than positive news and is in conformity with the a priori expectation. The EGARCH model also have three components that is the ARCH, GARCH and an asymmetry components, the ARCH coefficient is 0.15 while the GARCH coefficient is 0.99, the volatility magnitude which is derived by summing the ARCH and GARCH coefficient is 1.14 which signifies an explosion, the asymmetry coefficient is 0.03 which means positive news increases volatility than negative news, which is against the conventional wisdom. The most robust model among the three is GARCH because the volatility coefficient is greater than one in TGARCH and EGARCH and the asymmetry parameter is contrary to the empirical evidences in EGARCH.

The post 2008 financial crises also utilize the three different models, that is GARCH, TGARCH and EGARCH, with each having a mean equation that follows ARMA representation. The GARCH model has an ARCH coefficient of -0.02 and a GARCH coefficient of -0.90 with a constant value of 5.14, the volatility coefficient which is arrived at by summing the ARCH and GARCH coefficient is -0.995 which signifies a negative volatility. The TGARCH model has an ARCH coefficient of -0.001 and a GARCH coefficient -0.99, an asymmetry parameter of 0.003 and a constant value of 5.14, the volatility coefficient is -0.991 which is a negative volatility, the asymmetry coefficient is not in conformity with the a priori expectation that positive news increases volatility than negative news. The EGARCH model has an ARCH coefficient of -0.02, GARCH coefficient of -0.90, an asymmetry coefficient of -0.02 and a constant of 1.80. The volatility coefficient which is arrive at by summing the ARCH and GARCH parameter is 0.92 which signifies persistence volatility, the asymmetry coefficient is in conformity with the a priori expectation that negative news heightened volatility than positive news. The most robust model in the post 2008 financial crises is the GARCH model because TGARCH and EGARCH has a volatility greater than one.

Table 5.13: Estimates of the Univariate Volatility, Share price Model

	Full Sample			Pre 2008 Financial Crisis			Post 2008 Fin. Crisis		
Parameter	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH	GARCH	TGARCH	EGARCH
ARCH	0.16	0.17	0.06	0.19	0.18	0.09	0.01	0.15	0.05
GARCH	0.84	0.35	0.99	0.79	0.32	0.98	0.89	0.15	1.00
Asymmetry	-	-0.57	0.23	-	-0.60	0.25	-	-0.41	0.19
C	0.03	20.40	-0.05	0.79	28.37	-0.06	0.01	9.06	-0.04

The table above shows the univariate volatility models for share price, the sample is divided into three, full sample, pre 2008 financial crises and post 2008 financial crises, in each sample three set of models (GARCH, TGARCH, and EGARCH) were computed, that is three mean equations and three variance equations, this is in order to arrive at the most robust model, the mean equations follows an ARMA model. The GARCH model has two parameters, ARCH and GARCH otherwise known as the surprise and historical volatility, the ARCH parameter has a coefficient of 0.16 while the GARCH has a coefficient of 0.84, the constant of the GRACH model is 0.03, the volatility is arrived at by summing up the ARCH and GARCH parameters, as such the volatility is 1 which has a persistent effect and thereby having a long memory. The Threshold GARCH (TGARCH) unlike the GARCH model has three components the ARCH, GARCH and the Asymmetry parameter, the ARCH coefficient is 0.17while the GARCH coefficient is 0.35, the volatility is 0.52, the asymmetry parameter is in conformity with the a priori expectation with a negative value of -0.57, meaning that negative news result to higher volatility than positive news, the mean value is 20.40. The exponential GARCH model (EGARCH) has an ARCH parameter of 0.06 and a GARCH parameter of 0.99, the volatility coefficient is 1.05 which signifies explosion, the asymmetry parameter is -0.05 which signifies that negative volatility heightened volatility than positive volatility which is against the conventional wisdom. From the three models we can conclude that GARCH and TGARCH outperformed EGARCH because the volatility coefficient in GARCH signifies explosion and the asymmetry coefficient is contrary to the a priori expectation.

In the pre-2008 financial crises three set of models GARCH, TGARCH and EGARCH were used in order to arrive at the most robust model, likewise the mean equations follows an ARMA representation. The GARCH model have two parameters ARCH and GARCH, the ARCH coefficient is 0.19 while the GARCH coefficient is 0.79, the mean value of the GARCH model is 0.79, the volatility magnitude is 0.98, which signifies persistence in volatility. The TGARCH model has three components ARCH, GARCH and an asymmetry component that captures the role of information, the ARCH parameter in the model is 0.09 while the GARCH parameter is 0.98, the volatility coefficient which is the summation of the ARCH and GARCH coefficient is 1.16 which signifies explosion effect in the volatility, the asymmetry component have a coefficient of -0.60 which signifies that negative news heightened volatility than positive news and is in conformity with the a priori expectation. The EGARCH model also have three components that is the ARCH, GARCH and an asymmetry components, the ARCH coefficient is 0.09 while the GARCH coefficient is 0.98, the volatility magnitude which is derived by summing the ARCH and GARCH coefficient is 1.07 which is signifies an explosion, the asymmetry coefficient is 0.25 which means positive news increases volatility than negative news, which is against the conventional wisdom. The most robust model among the three is GARCH because the volatility coefficient is greater than one in TGARCH and EGARCH and the asymmetry parameter is contrary to the empirical evidences in EGARCH.

The post 2008 financial crises also utilize the three different models, that is GARCH, TGARCH and EGARCH, with each having a mean equation that follows ARMA representation. The GARCH model has an ARCH coefficient of 0.01 and a GARCH coefficient of 0.89 with a constant value of 0.01, the volatility coefficient which is arrived at by summing the ARCH and GARCH coefficient is 0.9 which signifies a high volatility. The TGARCH model has an ARCH coefficient of 0.15 and a GARCH coefficient 0.15, an asymmetry parameter of --0.41 and a constant value of 9.06, the volatility coefficient is 0.3 which is a positive volatility, the asymmetry coefficient is in conformity with the a priori expectation that negative news increases volatility than positive news. The EGARCH model has an ARCH coefficient of 0.05, GARCH coefficient of 1.00, an asymmetry coefficient of 0.19 and a constant of -0.04. The volatility coefficient which is arrive at by summing the ARCH and GARCH parameter is 1.05 which signifies an explosion, the asymmetry coefficient is not in conformity with the a priori expectation that negative news heightened volatility than positive news. The most robust model in the post 2008 financial crises is the GARCH and TGARCH model because the EGARCH has a volatility greater than one.

CHAPTER 6: SUMMARY CONCLUSIONS AND RECOMMENDATION

: introduction

This chapter presents the summary of the entire research work, the summary of the findings, the conclusion made by the study and recommendations; which includes both policy and recommendations for further research.

: Summary of the work

This research was developed in six chapters, chapter one presents the general background of the study, the objectives the study sets to achieve and the plan of the work. Chapter two was developed to contain both theoretical and empirical evidences. In chapter three, the methodological procedure was developed, this includes the time series procedure such as Unit root (ADF and PP), Co-integration and VECM. Then the techniques for univariate volatility analysis were presented in the section. Chapter four presents the empirical evidences of time series, whereas chapter five was devoted for the volatility analysis and finally the summary of the work, conclusion and recommendations were presented in this chapter.

: Summary of the findings

Based on the empirical examinations, the study made the following findings:

- For the stochastic properties of the series, the ADF and PP evidences were found to be consistent hence the difference in using parametric or non parametric method of correcting serial correlation doesn't arise in our case. Therefore, it makes no difference to use either of the tests. In terms of the empirical evidences, share price and exchange rate were found to be stationary except in post crisis period. Exchange rate was found to be level stationary in post crisis period. The implication of this finding is that the variables that are not level stationary can't be used for long impact analysis.
- For the co-integrating evidence, we found the presence of one co-integrating vector for both full, pre and post financial crisis periods. This implies the presence of at least one long run relationship between the variables.
- The impulse response for the full sample shows that the commodity prices response positively to shocks from financial variables except gold that response negatively to stock price shocks, the variance decomposition shows a little evidence of synchronization between the variables.
- The overall pre crisis impulse response evidence is that commodity prices; gold price and crude oil price, responds positively to interest rate and share index shocks and negatively to exchange rate shock. The evidence here is that there is no synchronization between commodity prices and financial variables.
- The overall pre crisis evidence is that commodity prices; gold price and crude oil price, responds positively to interest rate and share index shocks and negatively to exchange rate shock.
- In the exchange rate equation TGARCH outperformed GARCH and EGARCH because the volatility coefficient in EGARCH signifies explosion and the asymmetry coefficient

is contrary to the a priori expectation in full sample, while in pre 2008 financial crises TGARCH outperform TGARCH and EGARCH because the volatility coefficient is greater than one and the asymmetry parameter is contrary to the empirical evidences and in post 2008 financial crises TGARCH is the best model because the EGARCH has a positive asymmetry coefficient. The volatility magnitude is 0.98, 0.99 and -0.14 for full sample, pre 2008 and post 2008 financial crises respectively.

- In gold price model GARCH outperformed TGARCH and EGARCH because the asymmetry coefficient is contrary to the a priori expectation in TGARCH and EGARCH in full sample, while in pre 2008 financial crises TGARCH outperform GARCH and EGARCH because the asymmetry parameters are contrary to the empirical evidences; and in post 2008 financial crises TGARCH model outperform EGARCH because it has a positive asymmetry coefficient. The volatility magnitude is 0.14, 1.11 and 1.15 for full sample, pre 2008 and post 2008 financial crises respectively.

- In the interest rate model TGARCH outperformed GARCH and EGARCH because the volatility coefficient in EGARCH signifies explosion and the asymmetry coefficient is contrary to the a priori expectation in full sample; while in pre 2008 financial crises is GARCH model is the best because the volatility coefficient is greater than one and the asymmetry parameter is contrary to the empirical evidences in TGARCH and EGARCH respectively; and in post 2008 financial crises TGARCH modelis the best because GARCH and EGARCH has a volatility greater than one. The volatiltiy magnitude is 1.04, 0.99 and 0.57 for full sample, pre 2008 and post 2008 financial crises respectively.

- In the oil price model GARCH outperform the other volatility models because the volatility coefficient in TGARCH and EGARCH signifies explosion in full sample, while in pre 2008 financial crises GARCH outperform other models because the volatility coefficient is greater than one in TGARCH and EGARCH and the asymmetry parameter is contrary to the empirical evidences in EGARCH; and in post 2008 financial crises GARCH outperform other model because TGARCH and EGARCH has a volatility greater than one. The volatility magnitude is 0.17, 0.99 and 0.92 for full sample, pre 2008 and post 2008 financial crises respectively.

- In the share price model GARCH model outperform other models because the volatility coefficient is greater than one in TGARCH and EGARCH and the asymmetry parameter is contrary to the empirical evidences in EGARCH in full sample, while in pre 2008 financial crises GARCH and TGARCH outperformed EGARCH because the volatility coefficient in GARCH signifies explosion and the asymmetry coefficient is contrary to the a priori expectation; and in post 2008 financial crises the GARCH and TGARCH model outperform other models because the EGARCH has a volatility greater than one. The volatility magnitude is 0.52, 0.98 and 0.9 for full sample, pre 2008 and post 2008 financial crises respectively.

: conclusions

Based on the above findings, the study made the following conclusions:

- Quantitatively, there is no different between pre and post financial crisis in terms of the stochastic and co-integrating properties of the commodity prices and financial variables
- Crude oil price and gold price were found to be related, which implies that, a change in the price of one variable will lead to a change in the price of the other.
- There is little relationship between commodity prices and financial variable, as gold and crude price exhibit relationship only with exchange rate.
- In terms of the volatility evidence, crude oil price and exchange rate were found to be more volatile than the other variables, this finding is consistent in both the full and sub-samples.
- In terms of the appropriateness of the univariate volatility model, the parsimonious of the model depends on the variable and the sample period, as the result indicates that different models performed in different sub-samples.

: Recommendation

Based on the empirical results, the study made the following recommendations

- Oil and gas exporting countries should collude in order to avoid over supply because it was observed that one of the causes of commodity price crash in glut.
- The management of oil and gold facilities should be privatized as it was found that one of the factors that lead to the inefficiency in their operation is the government ownership
- This study was carried out using time series and univariate volatility analysis, we

recommend a further study that will carry the examination using multivariate volatility model

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