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Investing in cocoa-gold sector and the crude oil price-exchange rate uncertainty in Ghana: Volatility transmission and hedging approach

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Abstract

Cocoa and gold are the major drivers of Ghana's economic growth and hence these two sectors have been identified by potential investors as the best options for portfolio allocation. This paper assessed the best investments options between the cocoa and gold sectors with in a fluctuating world crude oil price and a fluctuating domestic currency against the United States (US) dollar. A VAR (1)-BEKK GARCH model was applied to returns from four sectors spanning January 1990 to December 2015. Results confirmed that with the unstable oil prices, the agriculture and mining sectors are directly influenced by the Ghana Cedi's performance against the US dollar due to the stock market coupled with transportation and production costs. Cocoa presented the best option for investments compared to gold and this is attributed to improved premium prices for Ghana's cocoa.

Keywords: Volatility transmission; price uncertainty; cocoa; crude oil; exchange rate; gold; hedging.

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1. Introduction

Agriculture was the largest contributor (about 60%) to Ghana's GDP until the last 10 years to date when the sector's contribution declined by about 25% since 2007 (ISSER, 2015). But the major sub-sector in agriculture, which influences Ghana's GDP growth is the cocoa sub-sector. The cocoa sub-sector is the largest contributor to Ghana's GDP and hence a major driver of Ghana's economy. Aside, gold has played a major role in developing Ghana's economy and accounts for 90% of external revenue (Salifu *et al.*, 2013).

These two major commodities are the drivers of the Ghanaian economy and hence strategic in the national development agenda. But both cocoa and gold do not stand in isolation since they are traded on the stock exchange market. To this end, the connection between cocoa and gold as major trading commodities on stock market potentially creates a linkage in the price dynamics of these commodities to that of crude oil. And since inflation, exchange rate, income, economic growth and market confidence can be influenced by market shocks, stock prices will adjust to patterns in crude oil prices (Arouri *et al*., 2012; Lin *et al*., 2014).

Prices of these commodities are internationally determined in the world market and hence national premium prices are placed. Deals and negotiations are arrived at using the major trading currencies such as the Euro, US dollar and the Yen. Although Ghana contributes 20% of cocoa to the world's $9 billion cocoa bean market, less than 24% of cocoa beans are domestically processed; resulting in Ghana benefiting only 5% of $28 billion global intermediate cocoa industry (Mulangu *et al*., 2017).

This is attributed to high overall utility and import tariff for cocoa products exported to Europe and the USA. As such, strength of domestic currencies against these major currencies also affects prices of these commodities in the Ghanaian market. The exportation of raw forms of these commodities due to lack of processing facilities further exposes both cocoa and gold prices in the world market. But this is an advantage to the international investors and firms who require few foreign currencies to purchase both cocoa and gold from Ghana. The price behavior of world crude oil in the world market also drives the prices of cocoa and gold in the world market and hence influences GDP growth (Ewing and Farooq, 2013).

In the midst of the interaction between prices of crude oil, cocoa and gold, food prices receive the indirect shocks due to cost of production and processing activities, and the diversification of national economic drivers from cocoa and gold. The result is an adjustment in prices of both gold and cocoa towards meeting the price of crude oil within a strong foreign currency environment.

Similar to other developing countries, economic activities in Ghana are highly dependent on oil with minimal or no options for the transport and agriculture sectors. Furthermore, the manufacturing sector and mining sectors rely heavily on crude oil for production activities and these two sectors are ranked second largest in the Ghana Stock Exchange and the biggest in market capitalization. This has created price shocks in the short run which translate into price volatilities in the long run.

For raw material exporting countries like Ghana, extremely low prices in the international scene result in immediate balance of payments effects, and uncertainty may reduce investment and affect utilization leading to decline in economic growth. At the macro level it is important to distinguish between long and short run effects of commodity price volatility between importing and exporting countries (FAO *et al*., 2011).

A number of researchers have attempted measuring the price volatility transmissions between sectors in the world but none has access the volatility transmissions involving the products from agriculture, mining and macroeconomic variable in Sub-Saharan Africa countries such as Ghana. Based on this, this paper assesses the options for investment towards Ghana's GDP growth due to the strategic role of cocoa and gold as the major drivers of Ghana's economy in the face of fluctuating crude oil prices and exchange rates. We apply the BEKK-GARCH model and the optimal portfolio weights for optional investments for the analysis.

2. Literature review

Past researchers such as Hassan and Malik (2006) gave reasons on the relevance of applying a multivariate GARCH model to simultaneously estimate the mean and conditional variances within time-varying returns data. This was due to different financial assets traded based on sector indexes and the need for market actors to understand the volatility transmission across sectors for optimal portfolio allocations. This was arrived at using daily US sector indexes returns from January 1, 1992 to June 6, 2005. Findings revealed significant shocks and volatility transmissions among different sectors and support cross-market hedging and information among investors.

Ewing and Malik (2012) applied both univariate and bivariate GARCH models to examine volatility of gold and oil futures within structural breaks from July 1, 1993 to June 30, 2010. They found significant volatility transmission between gold and oil returns with structural breaks in variance. They followed up with optimal portfolio weights and hedge ratios to understand the risk involved within these two products and findings supported cross-market hedging and common information sharing among market actors. Rahman and Serlets (2012) investigated the relationship between oil prices and economic activities in Canada using quarterly data from 1974:1 to 2010:1. They applied an asymmetric BEKK model and found that a conditional variance-covariance estimates underlying output growth and changes in real oil prices showed significant non-diagonality. They concluded that increased uncertainty in oil prices implies low economic activities and reduction in output in Canada.

Mensi *et al*. (2013) employed a variance autoregressive (VAR)-GARCH model to assess the return links and volatility transmission between S&P 500 and commodity price of energy, food, gold and beverages during the turbulent period 2000-2011. A detailed understanding of commodity price behavior and the mechanism for volatility transmission and the stock exchanges due to its relevance for governments, traders, portfolio managers, consumers, and producers. Results showed significant transmissions among S&P 500 and commodity markets. S&P 500 lagged shocks and volatility strongly influenced oil and gold markets. Optimal weights and hedge ratios for commodities and S&P 500 showed important implications towards hedging for optimal portfolio allocations and effective risk management.

Ji and Fan (2012) questioned how oil price affects non-energy markets and this was necessary due to the role of biofuels and hedge strategies in rising inflation. This scenario has created a link between the oil market, agricultural markets and non-metals markets, considering 2008 financial crisis. This analysis was achieved by considering US dollar as an exogenous shock and hence estimated the volatility transmission between commodity markets using the EGARCH model. Findings showed crude oil had significant effects on non-energy markets.

Nazlioglu and Soytas (2011) applied panel cointegration and Granger causality methods to examine the relationship between oil prices and selected agricultural commodity prices within a changing relative strength of US dollar. Monthly prices from January 1980 to February 2010 and results showed strong impacts of world oil price effects on agricultural commodity prices. Contrary to other findings, world oil prices influence prices of several agricultural commodities with a positive effect of a weak dollar on agricultural prices.

Trujillo-Barrera *et al*. (2012) analyzed volatility spillovers of futures crude oil prices in the US and found that spillovers from crude oil to corn and ethanol markets are similar in timing and magnitude and stronger in ethanol market. Findings provided details into magnitude of volatility linkages between energy and agricultural markets within strong price variation due to increased demand for corn-based ethanol.

Nazlioglu *et al*. (2013) later examined volatility transmission between crude oil and a number of agricultural commodity prices (wheat, corn, soybeans, and sugar) using a causality in variance test and impulse response functions. This was applied to daily data from January, 1986 to March, 2011 to identify the effect of food price crisis categorized into: pre-crisis period (01 January 1986 to 31 December 2005) and post-crisis period (01 January 2006–21 March 2011). Results showed no direct risk between crude oil and agricultural markets in the pre-crisis period but volatility spillovers from crude oil to agricultural markets except sugar in the post-crisis period. Findings concluded a dynamic volatility transmission following food price crisis.

Beckman *et al*. (2015) provided a new perspective on the relationship between exchange rate and gold prices with in a framework of five different currencies. They closely monitored the relationship based on causalities and short-run volatility transmission and concluded that hedging of gold requires modeling of the volatility component. Among the five currencies, exchange rate depreciation had a negative effect on gold price. They further concluded that exchange rate volatility frequently results in strong hedging gold prices as gold denominates in the as the US dollar depreciates.

Zhu *et al*. (2014) investigated the impacts of world crude oil prices on gold among other precious metals using a causality test, generalized impulse response function, and the variance decomposition functions. Results showed that world crude oil prices plays an important role in price variation of precious metals such as gold both in short and long run but exchange rate effect was only common in the short run but gold price had return effect on world crude oil price in short-run. Arezki *et al.*, (2014) examined the link between South African Rand and gold price volatility using monthly data from 1979–2010. Objective was to determine whether prior to capital account liberalization, there was causality from the domestic currency to gold price volatility but findings revealed causality was in the opposite after liberalization. Finding further suggested that gold price volatility key to explaining both the extreme exchange rate and speculative tendencies of inflows which South Africa has managed since the beginning of a capital account launch.

Wang *et al.* (2014) argued that while the impacts of oil price changes on agricultural commodity markets are of great interest, past studies failed to differentiate between oil-specific shocks from aggregate demand shocks for investment decisions. This paper achieved this research gap using a structural VAR analysis and findings revealed responses of agricultural commodity prices to changes in oil price is hinged on either shocks due to: oil supply, aggregate demand or other oil-specific shocks driven by precautionary demand.

Mulangu *et al.* (2016) assessed Ghana's cocoa pricing options and its implication on poverty reduction and industrial growth. This was undertaken by constructing and simulating a structural dynamic stochastic model of processors who maximizes present value of current and future profits. Results showed that, with the current processing capacity, Ghana Cocoa Board should provide a 92% discount to processors to achieve the national goal of locally processing 40% of annual production. Bahmani-Oskooee *et al.*, (2014) concluded that risk has the tendency to increase or decrease trade, and those affected most are industries. This was arrived at after examining trade between the United States and Spain from 1962 to 2009 for 131 U.S. export and 88 import industries. Findings revealed that exchange rate volatility has both short and long-run effects in few cases with exports responding more to high uncertainties than imports. This fits in the investment decisions of gold and cocoa within the varying world crude oil prices and ever increasing weak domestic currencies against the US dollar.

Sadorsky (2014) also modelled volatility and correlations between emerging market stock prices and the prices of copper, oil and wheat using the VARMA-AGARCH and the DCC-AGARCH for volatility and conditional correlations. Correlation estimates revealed were high after 2008 and oil prices were cheapest in terms of hedging while copper was the most expensive. He gave a condition that, given the variability of hedge ratios, an investor should not depend on hedge ratios for investment decisions. Cabrera and Schulz (2015) investigated price and volatility risk due to linkages between energy and agricultural commodity prices in Germany. They quantified the volatility and correlation risk, which has high effects for investment and hedging strategies of market players and policymakers. This was undertaken by an asymmetric DCC-GARCH model including a multivariate multiplicative volatility and findings revealed shocks and volatilities linkages. They found that prices move together and maintain equilibrium in the long run, and the correlations are usually positive with persistent shocks and this is attributed to biodiesel discovery.

Ahmadi *et al.* (2016) recently questioned the effects of oil price shocks on volatility of agricultural and metal commodities. They categorized an oil price shock to its basic components, including macroeconomics and oil related shocks. This was achieved using the structural vector autoregressive (SVAR) model from April 1983 to May 2014. The analysis was further categorized into the pre-food crisis and change in U.S. ethanol production policy, hence before and after January 2008 for metals mindful of global financial crisis. Findings revealed that, volatility of each commodity to oil price shock varied highly based on the fundamental cause during both periods. Khalfaoui *et al.*, (2015) combined a bivariate BEKK-GARCH model with wavelet multi-resolution analysis to capture the varied characteristics of mean and volatility spillovers among oil and stock market prices. For investment decisions, optimal portfolio allocation was analyzed to assess the hedge ratio behavior and results showed significant presence of volatility spillovers between oil and stock markets within time-varying correlations for various market combinations. Findings also revealed that the decomposed volatility spillovers allow investors to adapt hedging strategies.

Nortey *et al*. (2015) modeled inflation and exchange rate in Ghana by applying a multivariate GARCH to monthly data from 1990:01 to 2013:12. They found time varied depreciation of the cedi against the US dollar even though inflation was stable. It is evident that none of the researchers applied the BEKK-GARCH parameterization in capturing short and long-run interaction between prices of cocoa, gold, crude oil and exchange rates in Ghana. We fill this research gap by relying on the BEKK- GARCH which hitherto is yet to be used in the existing literature.

3. Methodology

The initial step in time series data analysis is to observe the characteristics such as the presence of a unit root, prices ability to cointegrate in related markets and the presence of autocorrelation. According to Brooks (2014) commodity prices shows varies with time with a clustering behaviour. A relationship between real prices of cocoa, gold, oil and exchange rate returns are expressed in a mean equation as a first step in multivariate GARCH models (Engle and Kroner, 1995). The VAR (1)-BEKK GARCH model was applied on for returns of these four sectors and expressed as:

$$R_{i,t} = \mu_i + \alpha R_{i,t-1} + \varepsilon_{i,t} \tag{1}$$

where R_{it} is the return on series i between time t and $t-1$, μ_i is a long-term drift coefficient, and ε_{it} is error term for the return on series i at time t. Keeping in line with the literature on ARCH-class models.

Eq. (1) was estimated and residuals observed ARCH effect presence prescribed by Engle (1982). Results showed the presence of ARCH effects in each of the series. Based on this, the conditional variances of the Eq (1) were estimated using VAR (1) BEKK-GARCH (1, 1). For an estimated multivariate GARCH model to be credible, the conditional variance-covariance should be positive definite for all values of the error term. Based on this, Engle and Kroner (1995) proposed a quadratic form of the parameters to ensure positive definiteness always known as the BEKK model (Brooks *et al*., 2003). This is appropriate as the number of parameters increases linearly with number of assets. The BEKK model suitable for forecasting and hence referred to being parsimonious and applicable in large set of assets (De Goeij *et al*., 2004). The most popular non-linear models are the Autoregressive Conditional Heteroskedacity (ARCH) and the Generalized Autoregressive Conditional Heteroskedacity (GARCH). The VECH and DVECH and the BEKK are different multivariate GARCH specifications (Brooks, 2014). Based on the limitations of the VECH and the DVECH in terms of positive semi definiteness, the VAR (1) - BEKK GARCH model was applied. That is the Ht matrix becomes positive definiteness always and expressed as:

$$H_t = CC' + A'\varepsilon'_{t-1}A\varepsilon_{t-1} + B'\mathrm{H}_{t-1}\mathrm{B} + \mathrm{D'V}_{t-1}V'_{t-1}D \tag{2}$$

Where H_t is a 4x4 variance-covariance matrix, A, B, D 4x4 parameter matrices, C is 4x4 upper triangular coefficient matrix and V is a further lower triangular matrix. Asymmetries were captured by $\mathrm{D'V}_{t-1}V'_{t-1}D$ added to the conventional BEKK model.

$$H_{t+1} = CC' + \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \varepsilon_t \varepsilon'_t \begin{bmatrix} a_{11} & a_{21} & a_{31} & a_{41} \\ a_{12} & a_{22} & a_{32} & a_{42} \\ a_{13} & a_{23} & a_{33} & a_{43} \\ a_{14} & a_{24} & a_{34} & a_{44} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix} H_t \begin{bmatrix} b_{11} & b_{21} & b_{31} & b_{41} \\ b_{12} & b_{22} & b_{32} & b_{42} \\ b_{13} & b_{23} & b_{33} & b_{43} \\ b_{14} & b_{24} & b_{34} & b_{44} \end{bmatrix} \tag{3}$$

Following Kroner and Ng (1998), an asymmetric specification of the multivariate VAR (1)- BEKK GARCH model was specified to ensure covariance matrix is positive semi-definite for non-negativity of estimated variances and asymmetric. The variant of the multivariate GARCH model was then applied for volatility transmission between different series, including the persistence of volatility within each series. Based on this reason, the BEKK parameterization was used for the analysis.

Following the determination of VAR (1) - BEKK GARCH (1,1) volatility spillovers between prices of cocoa, gold, crude oil and real exchange rates, prudent investment decision can be achieved due to risk exposure and portfolio allocation from fluctuating crude oil and exchange rate. Based on this, Kroner and Ng (1998) and Hassan and Malik (2006) applied the portfolio weights to time varying covariance matrix to minimize the risk while maximizing returns. This can be achieved by keeping large stocks of crude oil in the stock market (Sattary *et al*., 2014; Mensi *et al*., 2013). This allows for keeping stock position relative to volatility of cocoa and gold prices in Ghana. This can be derived by assuming that expected returns are zero with a risk minimizing optimal portfolio weights expressed as:

$$w_{ij,t} = \frac{h_{jj,t} - h_{ij,t}}{h_{ii,t} - 2h_{ij,t} + hj_{j,t}} \tag{4}$$

Where w_{12}, t represents the optimal portfolio weight for sector 1 relative to a second sector at a time t. We further assumed a mean-variance utility function similar to Sardosky (2014), Hassan and Malik, (2006) and Lin *et al*., (2014) that;

$$w_{ij,t} = \begin{cases} 0, & if\ w_{ij,t} < 0 \\ wij,t, & if\ 0 \le w_{ij,t} \le 1 \\ 1, & if\ w_{ij,t} > 1 \end{cases} \tag{5}$$

We assigned portfolio weights to two assets, $w_{ij},_t$ as the weight of asset *i* in a 1 cedi portfolio of asset two at time *t*, $h_{ij},_t$ is the conditional covariance between asset *i* and *j* while hjj,t is the conditional variance of variance of asset j. Hence the optimal weight for the second asset is 1-$w_{ij},_{t}$.

To identify an efficient investment sector among cocoa and gold sectors with in a fluctuating crude oil prices coupled with the weak cedi against the US dollar, optimal hedge ratio for each portfolio can be derived similar to Kroner and Sultan (1993). This is expressed as:

$$\beta_t = \frac{h_{12,t}}{h_{22,t}} \tag{6}$$

For risk minimization in a portfolio that is GH₵1 long in the first sector, an investor must short GH₵ β of the second sector (Hassan and Malik, 2006).

3.1. Data and preliminary findings

Monthly nominal price from January, 1990 to December, 2015 for cocoa, gold, crude oil and exchange rate were obtained from the Bank of Ghana (BoG). These prices were deflated into real prices while nominal exchange rate was converted into effective exchange rate. Table 1 below presents descriptive statistics of the price and effective exchange rate returns with the various correlation coefficient estimates.

Monthly gold price returns of GH₵1.688 was the highest among cocoa, gold and crude oil while real effective exchange rate was GH₵1.532. Cocoa price return was the lowest at GH₵0.765 with the least in volatility in all series. This can be attributed to effect of domestic financial policies such as exchange rate on cocoa pricing in Ghana compared to gold.

Asymmetric distribution was determined to avoid biasness of coefficient estimates among return series. The kurtosis coefficient indicates that returns are leptokurtic (fat-tail) in distribution. The leptokurtic distribution of the return series indicates the presence of ARCH effect in series. Return series were not normally distributed and this was evident from the Jarque-Bera statistic. According to the Ljung-Box statistics results, indicating whether the price and return series have autocorrelation, except for cocoa, gold, crude oil and exchange rate showed the presence of autocorrelation. This shows that past price behavior has an effect on current behavior.

Except for cocoa, the other three series exhibited ARCH effects with high fluctuations (heteroscedascity) in time dimensions, an indication that residual squares are not constant but vary over time. For reliable information and forecasting, the multivariate GARCH is more effective than the individual ARCH tests.

Correlation coefficient estimates between series as presented in Table 1 below showed gold and exchange rate at 0.960. Cocoa and gold showed the lowest correlation estimate of 0.057.

Table 1: Descriptive Statistics Price and Effective Exchange Returns

Descriptive Statistics	**Cocoa**	**Gold**	**Crude Oil**	**Exchange Rate**
Mean	-0.765	1.688	0.5669	1.532
Variance	1081.220	176.319	257.614	163.9762
Skewness	-8.647***	-0.823***	-1.246***	-0.674***
Kurtosis	134.355***	37.2100***	26.7187***	41.929***
Jarque-Bera	237788.632***	17977.007***	9331.194***	22804.775***
LM- Arch	0.065	8.181***	3.951**	8.458***
LB-Q (20)	14.210	94.447***	43.665**	87.982***
LB-Q2 (20)	1.008	77.594***	39.324**	76.637***
MLM-test (20)	359979.23*** (2000)			
Correlation (Series)				
Cocoa	1			
Gold	0.057	1		
Crude Oil	0.168		1	
Exchange Rate	0.110	0.960	0.952	1
Correlation (Returns)				
Cocoa	1			
Gold	0.358	1		
Crude Oil	0.468	0.801	1	
Exchange Rate	0.372	0.966	0.826	1
Correlations (Returns Square)				
Cocoa	1			
Gold	0.200	1		
Crude Oil	0.618	0.857	1	
Exchange Rate	0.204	0.997	0.864	1

Note: ***, ** and * represents significance at 1%, 5% and 10% respectively. There are 131 Observations

Lag selection of 6 was chosen based on the Aikaike Information Criteria compared SBC/BIC and HQ. This was necessary for pairwise relations. This is shown in Table 2 below.

TABLE 2: VAR LAG SELECTION FOR PRICE AND EFFECTIVE EXCHANGE RETURNS (N =131)

Lag	AIC	SBC/BIC	HQ
0	30.0553415	30.1047334*	30.075043
1	29.9172693	30.1623997	30.0139478*
2	29.9804917	30.4183427	30.1511293
3	30.0266091	30.654036	30.2680612
4	29.8954293	30.7091538	30.2044175
5	29.8900788	30.8866807	30.2631828
6	9.8041809*	30.9800901	30.2378307
7	29.8251017	31.1765895	30.3155686
8	29.8950743	31.4182432	30.4384608
9	29.993524	31.6842982	30.5857543
10	30.0224597	31.8765735	30.6592681
11	30.0427119	32.0556979	30.719631
12	30.1633518	32.3305278	30.8756994

4. Results and discussions

Beyond the preliminary findings presented above, this section presents findings on the empirical study. We begin by examining the mean parameter estimates based on the empirical technique.

4.1. Mean parameter estimates

Results from the mean equation obtained from the VAR (1) - BEKK GARCH as shown in Table 3 below showed that monthly cocoa price return was positively affected by gold price returns but negatively by returns of crude oil price and exchange rate. This confirms that prices of crude oil and gold are exogenous and beyond the control of government. Also, mean gold price return was positively influenced by its own lag price return and the exchange rate return. Mean crude oil price return was negatively influenced by returns of cocoa but positively by its own lag return and confirms that crude oil price returns are influenced by past price returns. Exchange rate returns was positively influenced by its own lag returns but negatively by mean gold price returns (Ahmadi *et al*., 2016).

TABLE 3: MARGINAL EFFECTS OF VOLATILITY TRANSMISSION BETWEEN GHANA'S COCOA, GOLD, CRUDE OIL AND EFFECTIVE EXCHANGE RATE

Mean Estimate	**Cocoa (i= 1)**	**Gold (i=2)**	**Crude Oil (i=3)**	**Exchange Rate (i=4)**
Panel A: Conditional Estimates				
Const.	-0.045 (-0.121)	0.740*** (5.319)	0.151 (0.343)	0.768*** (6.037)
ψ_{i1}	-0.025 (-0.434)	-0.013 (-1.257)	-0.057* (-2.305)	-0.007 (-0.736)
ψ_{i2}	0.175** (2.803)	0.111** (3.108)	0.140 (1.381)	-0.038* (-1.926)
ψ_{i3}	-0.065* (-1.655)	-0.018 (-0.930)	0.301*** (5.669)	0.001 (0.075)
ψ_{i4}	-0.140* (-1.938)	0.126* (2.444)	-0.030 (-0.232)	0.293*** (4.543)
Panel B: Variance Estimates				
C_{i1}	1.011 0.834)	1.478 (0.978)	-7.870** (-2.836)	-0.115 (-0.511)
C_{i2}		3.201*** (4.093)	5.379 (1.398)	-0.185 (-1.088)
C_{i3}			-0.003 (-0.0001)	-0.000 (-0.000)
C_{i4}				-0.000 (-0.000)
α_{i1}	0.671*** (8.330)	0.053 (0.322)	-0.200** (-3.029)	0.166 (1.081)
α_{i2}	-0.014 (-0.528)	0.364*** (3.439)	0.096* (2.558)	0.544*** (5.809)
α_{i3}	0.100* (1.957)	-0.043 (-0.217)	-0.146 (-1.444)	1.312*** (6.859)
α_{i4}	0.054* (1.872)	0.027 (1.019)	0.027 (1.276)	0.981*** (10.983)
b_{i1}	-0.269*** (-5.068)	-1.613*** (-12.410)	-0.037 (-0.146)	1.790*** (8.101)
b_{i2}	0.118*** (6.116)	-0.153 (-1.113)	-0.102* (-2.145)	0.515*** 3.46951
b_{i3}	0.045 (1.406)	-0.571 (-1.620)	-0.038 (-0.313)	0.771* (1.919)
b_{i4}	0.085*** (4.085)	-0.217*** (-4.091)	-0.016 (-0.425)	0.5445*** (7.344)
Shape par.	3.272*** (8.647)			

Note: ***, ** and * represents significance at 1%, 5% and 10% respectively.

For investment decisions, it is economically prudent to understand the short and long-run price returns effects. Based on this, findings showed that in the short-run, mean cocoa price returns received positive shocks directly from past cocoa price returns but indirectly from returns of crude oil price and exchange rate. Only lag gold price return transmitted positive price returns shock to gold itself. Mean crude oil price returns received shocks negatively and indirectly from cocoa price returns but positively from cocoa. Except for mean cocoa price returns, gold and crude oil including lag exchange rate returns transmitted shocks to exchange rate returns. This can be attributed to misinformation, news and speculation in cocoa, gold and crude oil price markets. Indirectly crude oil seem not play a direct role in pricing fixation but indirectly.

The long-run mean variance estimates showed that mean cocoa price returns received direct price return volatility negatively from its lag but indirectly, it received positive and indirect mean price volatilities from gold and exchange rate returns. Mean returns of cocoa and exchange rate transmitted negative and indirect volatilities to mean gold price returns and show how in the long run, agricultural products such as cocoa transmits volatilities during a stable domestic currency period. Only mean gold price returns transmitted negative price volatility to domestic crude oil prices. Except for cocoa price returns, in the long-run, gold, crude oil and lag exchange rate transmitted volatilities to exchange rate returns. The strength of the cedi to the US dollar can also be attributed to the performance of Ghana's gold and cocoa in the stock market.

4.2. Conditional variance-covariance estimates

Marginal effects of the conditional variance- covariance as presented in Table 4 below showed the direct and indirect volatility transmissions obtain by the delta method. This was arrived at after estimating the parameters of the log-likelihood function.

4.3. Shock transmissions

Short-run estimates of the conditional variance as shown in Table 4 below showed own and positive price shocks among cocoa, gold and exchange rate. Current and lag exchange rates transmitted indirect but positive price volatilities to gold and domestic crude oil prices. This shows that, in the short-run, the exchange rate of the cedi against the US dollar causes shocks and disturbance in non-agricultural product markets.

Cross and negative shock transmissions were also observe from lag cocoa and crude oil prices to current cocoa prices. Gold prices received indirect and positive shocks from the combined news of own gold price, with crude oil and exchange rate and also from crude oil and exchange rate. That is, news and speculation from gold prices combines with the energy sector and also macroeconomic factors causes shocks in gold market. A combined effect of news and speculations from the cocoa and exchange rate transmitted positive shocks to domestic crude oil price and exchange rate in Ghana and confirms that all the four sectors alone do not influence price determination but cross-sector speculations do especially with crude oil (Nazlioglu and Soytas, 2012; Abbot *et al*., 2008).

TABLE 4: SHOCK TRANSMISSION BETWEEN GHANA'S COCOA, GOLD, DOMESTIC CRUDE OIL PRICES AND EFFECTIVE EXCHANGE RATE

Mean Estimate	**Cocoa (i=1)**	**Gold (i=2)**	**Crude Oil (i=3)**	**Exchange Rate (i=4)**
$\varepsilon^2_{1,t}$	0.4505*** (0.1081)	0.0002 (0.0008)	0.0101 (0.010)	0.0030 (0.0032)
$\varepsilon^2_{2,t}$	0.0028 (0.0174)	0.1327* (0.0771)	0.0018 (0.0173)	0.0007 (0.0014)
$\varepsilon^2_{3,t}$	0.0398 (0.0262)	0.0093 (0.0073)	0.0213 (0.0296)	0.0007 (0.0011)
$\varepsilon^2_{4,t}$	0.0277 (0.0512)	0.2960** (0.1019)	1.7211*** (0.5018)	0.9618*** (0.1751)
$\varepsilon_{1,t}\varepsilon_{2,t}$	0.0710 (0.2202)	-0.0105 (0.0199)	-0.0086 (0.0405)	0.0029 (0.0035)
$\varepsilon_{1,t}\varepsilon_{3,t}$	-0.2678** (0.1001)	-0.0027 (0.0055)	-0.0293 (0.0235)	0.0029 (0.00276)
$\varepsilon_{1,t}\varepsilon_{4,t}$	0.2235 (0.2121)	-0.0157 (0.0306)	0.2632* (0.1372)	0.1065* (0.0572)
$\varepsilon_{2,t}\varepsilon_{3,t}$	-0.0211 (0.0685)	0.0704* (0.0365)	0.0126 (0.0571)	0.0014 (0.0015)
$\varepsilon_{2,t}\varepsilon_{4,t}$	0.0176 (0.0410)	0.3964*** (0.0922)	-0.1137 (0.5368)	0.0539 (0.0522)
$\varepsilon_{3,t}\varepsilon_{4,t}$	-0.0664 (0.0653)	0.1052** (0.0394)	-0.3837 0.2847)	0.0531 (0.0428)

Note: ***, ** and * represents significance at 1%, 5% and 10% respectively.

4.4. Direct and indirect volatility transmission

Long-run price transmissions results in direct and indirect volatilities among sectors. This is observed in Table 5 below. Own volatility transmissions were observed for cocoa prices but at the same time, cocoa received positive price volatility transmissions from current and lag prices of gold and exchange rates at 1% significance level. Gold prices received indirect volatilities from current and lag gold prices and exchange rates. Own price volatility transmissions were observed among exchange rates and also from current and lag gold prices.

Effective exchange rate combined with cocoa and gold to transmit indirect but negative price volatilities to cocoa but positively from cocoa and gold. Exchange rate further combined with cocoa to negatively transmit volatility to gold but positively with crude oil price. Cocoa combined with gold to negatively transmit volatility to domestic crude oil price but positively with exchange rate. Cocoa combined with gold to negatively transmit volatility to current exchange rate but positively with exchange rate itself. Findings confirm the role of the cedi against the US dollar in doing business in Ghana. Domestic crude oil price alone has no significant effect on prospective investments drive since processing of gold and cocoa are undertaken outside the shores of Ghana.

Table 5: Direct and Indirect Volatility Transmission between Ghana's Cocoa, Gold, Domestic Crude Oil prices and Effective Exchange Rate

Mean Estimate	Cocoa (i=1)	Gold (i=2)	Crude Oil (i=3)	Exchange Rate (i=4)
$h^2_{1,t}$	0.0725* (0.0286)	0.0139** (0.0045)	0.0020 (0.0029)	0.0073 (0.0036)
$h^2_{2,t}$	2.6024*** (0.4194)	0.0236 (0.0424)	0.3268 (0.4034)	0.0470* (0.0229)
$h^2_{3,t}$	0.0014 (0.0195)	0.0103 (0.0096)	0.0014 (0.0095)	0.0002 (0.0011)
$h^2_{4,t}$	3.2053*** (0.7912)	0.2656* (0.1531)	0.5941 (0.6190)	0.2965*** (0.0807)
$h_{1,t}h_{2,t}$	0.8688*** (0.1818)	-0.0363 (0.0306)	-0.0521* (0.0314)	-0.0372** (0.0122)
$h_{1,t}h_{3,t}$	0.0203 (0.1383)	-0.0240* (0.0131)	-0.0035 (0.0104)	-0.0027 (0.0067)
$h_{1,t}h_{4,t}$	-0.9642*** (0.1932)	0.1216*** (0.0318)	0.0703* (0.0367)	0.0935*** (0.0204)
$h_{2,t}h_{3,t}$	0.1217 (0.8323)	0.0313 (0.0292)	0.0441 (0.1564)	0.0068 (0.0156)
$h_{2,t}h_{4,t}$	-5.7764*** (0.9378)	-0.1585 (0.1861)	-0.8813 (0.9875)	-0.2361** (0.0748)
$h_{3,t}h_{4,t}$	-0.1350 (0.9404)	-0.1049* (0.0557)	-0.0594 (0.2134)	-0.0172 (0.0403)

Note: ***, ** and * represents significance at 1%, 5% and 10% respectively.

4.5. Portfolio weights and hedge rationing

Based on estimates of the BEKK-GARCH model, efficient investment decisions can be obtained due to the connection between crude oil and stock market prices in Ghana. As shown in Table 6 below, optimal portfolio weight for cocoa/ crude oil is 0.595, indicating that for a GH₵1 portfolio, 60 Ghana pesewas (GP) should be invested in cocoa and 40 GP in crude oil. The average portfolio weight for gold-crude oil was 0.930, indicating that for a GHS1 portfolio, an investor should invest GP93 s in gold and GP7 in crude oil.

TABLE 6: OPTIMAL PORTFOLIO WEIGHTS AND HEDGE RATIOS FOR INVESTMENT DECISIONS

Optimal Portfolio Weight ($W_{ij,t)}$/ Hedge Ratio ($ß_{ij,t}$)	**Cocoa/ Crude Oil**	**Gold/Crude Oil**
$w_{ij,t}$	0.595	0.930
$ß_{ij,t}$	0.189	0.193

Source:Author's Estimation, 2019.

The hedge ratio for cocoa and crude oil was GP19, indicating that a GHS1 long run position in cocoa should be hedged for GP19 in crude oil market. Hedge ratio for gold and crude oil was found to be 0.193, indicating that, on average a GH₵1 long run position in the gold market can be hedged for GP19 in the crude oil market. Hedge ratio estimates shows that for developing countries such as Ghana, oil sector provides the cheapest hedge for an investment in emerging markets and this was confirmed by Sadorsky (2014) and Choi and Hammoudeh (2010). Due to the over reliance of Ghana economy on crude oil and crude oil-related agricultural inputs, diversification of the economy energy efficiency as an integral part of a diversified portfolio of cocoa and gold since this will form part of the risk adjustment for investing in Ghana.

5. Conclusion

It is still evident that domestic crude oil prices directly do not significantly transmit volatilities to cocoa and gold prices but indirectly and in combination with cocoa, gold and exchange rates. Potential investors in the cocoa and gold sub-sectors should seek for real time price information and also the performance of the domestic currency against major trading currencies, especially the USD. This is due to the role of speculation, misinformation and news of crude oil and rate of the cedi by market actors hence causing shocks in the markets.

Risk minimizing hedge ratios for cocoa and gold in the midst of the fluctuating currencies showed that the cocoa sub-sector is the best options market compared to gold due to the increased demand for cocoa by the confectionary industries. Within this framework, crude oil sector should be an integral part of a diversified portfolio of assets since Ghana has started drilling oil. The oil sector will enhance risk adjustment of the hedged portfolios and Ghana government should continue with private-public partnership of exploring alternative sources of energy sources for transporting and processing.

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