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DOES MODERN MONETARY POLICY STABILIZE COMMODITY PRICES? THE PARADIGM DURING COVID-19

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Abstract

The recovery of the global economy from the COVID-recession accompanied by expanding liquidity, monetary loosening, and fiscal expansion led has led to rising commodities prices across the world including Ghana. Using VEC model, we examined the effect of monetary policy expansion in Ghana on commodity prices (including cocoa, gold and crude oil). The empirical evidence suggests a short run and long run relationship between Ghana's monetary policy and commodity prices. The long run and short-run relationship shows that Ghana's monetary policy shock leads to an immediate rise in cocoa and gold prices index but negative impact crude oil price index which possibly reflect high production cost and an aggregate bias. In addition, whiles the analysis found that the aggregate commodity price index is positively related to monetary policy, the period characterized by COVID-19 mirrored exactly opposite the relationship found during the 2008 financial crisis. We recommend that policy makers should recognize the source of inflation before engaging in expansionary monetary policy. Also, the design of core inflation targeting is essential to inflation targeting.

Keywords: *Monetary policy; Commodity price; VEC; COVID-19; Exchange rate.*

INTRODUCTION

Though periods of changes in interest rate affect many different sectors of the economy such investment, savings, export, capital flow, exchange rate and other developments. The importance and impact of monetary policy on sectorial commodity prices cannot be overemphasized. Most research trace the impact of monetary policy on commodity prices through exchange rate transmission

mechanism with emphasis on agricultural commodities. Whiles demand and supply factors can explain the fluctuations in commodity prices, other factors such as monetary and fiscal policy variables play important roles (Hamilton, 2009). Alquist and Kilian (2010) showed that precautionary demand shocks increase demand and thus causes commodity prices to increase as the future become more uncertain.

The recovery of the global economy from the pandemic accompanied by policies of expanding financial liquidity, monetary loosening and expansionary fiscal policy has led to rising commodity prices. In the first two quarter of this year, Blomberg's general commodity price index increased more than 20%. This is largely driven by a 44.5% spike in energy prices followed by an increase in agricultural good price index by 20.5% and another 17.5% rise in industrial metal prices (Beatriz Villafranca, 2021). Supply chain problems, labor supply shocks, and demand shocks has led to increasing volatility in producer prices index, import, and export prices and has impacted commodity prices across the world. Notwithstanding that, the monetary policy continues to play major roles in inflation determination.

The prices of Oil, gasoline, copper, and corn more than doubled over the past 20 years and continued to increase through the pandemic. According to Ghana commodity exchange index (2021), gold price and cocoa price index has more than doubled since the start of the pandemic whiles crude oil price has seen similar hikes in prices. Other locally produced commodities such as maize, soyabean, have seen similar hikes in price. During the same period monetary policy rate decrease from 16% to 12.5%. Whiles M2 representing broad money supply has increase from $137,548.40 million dollars to 13,542.85 million dollars in the first ten months of 2020. Monetary tools have been employed to diagnose the problem whiles fiscal expansion continues.

This paper deals with the impact of monetary policy of sectorial commodity prices. By discretion, most central banks usually use interest rate changes as a monetary tool to stabilize inflation and maintain low level of unemployment. Inflation targeting rules that use interest rate changes as tool to regulate employment affect commodity prices adversely. For example, during the 2020 economic lockdown due to the pandemic, most central banks reduced interest rate in order to induce borrowing and stimulate investment. This led to some transitory changes in the general price level resulting in more than proportionate increases in many commodities prices.

The goal of this paper is to find the time path of monetary policy shock on the aggregate commodity prices index and also the three major commodities in Ghana's export composition. The paper adopted a Vector Error Correction Model (VECM) and bounds testing technique to determine the impact of monetary policy on commodity prices in the long-run and the short-run (separate the effect for periods of crisis and

no-crisis). The paper hypothesizes that expansionary monetary policy have structural implications for commodity prices.

LITERATURE REVIEW

The short-term interest rate is an important tool in promoting economic growth and price stability. The theoretical foundation of interest rate changes and changes in the general price level is rooted in interest rate parity (Hammoudeh et al., 2015). According to Frankel (1986), the relationship between interest rate and commodity prices is ingrained in the no-arbitrage condition which posit that the expected rate of change in commodity prices minus its storage cost is equal to the short-term interest rate. Another empirical perspective on monetary shock and commodity price relationship posits that, the general rise in price level due to interest rate shock is proportional to the changes seen in commodity prices (Franke & Hardouvelis, 1985).

Also, Frankel (1984) show that an expansion in money supply increases the real prices of the commodities because prices of many other goods display rigidity in the short term. Again, Frankel & Rose (2010) investigated the monetary policy interest rate nexus, and concluded that, interest rate does not fully show the impact of monetary shock on commodity prices. Another empirical work by Azuini et al., (2012) shows that monetary policy affect commodity prices through demand and supply forces as such interest rate were the main driving force of commodity prices. Demand forces from low interest rate reduces the opportunity cost of holding money, increase money demand and thereby leading to an increase in commodity prices. Conversely, supply forces from low interest rate affect inventory negatively, reduce supply level and raise market price.

A number of previous works used standard VAR and Bayesian framework to assess the impact of monetary policy on commodity prices. Christiano et al., (2005) used monetary policy shock in the US and found large and negative effect of monetary policy contractions on the aggregate commodity price index. They argued that including commodity price index in the system of endogenous variables help solve the price obscurity. Sousa (2010) used data from the euro area found substantial effect of monetary policy on commodity price index after accounting for household composition wealth effect. Malik and Sousa (2012) investigated the effect of monetary policy on commodity prices using data from the BRICS. They reported that contractionary monetary policy results in an immediate fall in aggregate commodity prices. Carolina et al., (2014) showed that commodity prices overshoot their long run equilibrium in response to a contractionary shock using that from the US. and, in contrast to literature, they found that the response of the individual commodity prices

is stronger than what has been found in the aggregate commodity prices. Furthermore, they found that the monetary policy explains a major share of the fluctuations in prices.

Anzuini et al., (2008) performed a structural VAR estimation (SVAR) which allows identifying monetary policy shocks by assuming structural restrictions on their contemporaneous impact on the system. The results posits that the monetary effects on aggregate commodity prices are statistically significant and that the short-run response usually has an overshooting during the first year after the shock. The paper also finds the shock on inflation and growth expectations as the main transmission channel.

Hammoudeh et al., (2015) reported that monetary contraction leads to immediate increase in broad commodity prices index, however the shock disappears after some time as the interest rate increase and liquidity drainage take a grip. Akram (2013) suggest that an explanation for the possible weakness in the relationship between monetary policy and commodity prices may be due to the possible weakness in controlling for macroeconomic variables like the real exchange rate and economic activities. There exists endogeneity between commodity prices and interest rate, low interest rate implies high commodity prices and high commodity prices can lead an increase in aggregate price indices and subsequently a contractionary monetary policy.

From the literature, it could be noted that empirical relationship between monetary policy and commodity prices does not always result in a consensus. More importantly, the use of aggregate measures for commodity prices enshrouds important price reactions of different sectors of the economy. This analysis tries to bridge the gap in existing literature by using the case of small open economy Ghana whiles controlling for the impact of real exchange rate, GDP, and other macroeconomic variables.

METHODOLOGY

Data

The scope of this study is to find out the effects of Ghana-monetary policy on commodity prices. The study uses a time series data on the Ghana from 2000: 1 to 2021: 3. Data for empirical analysis will be extracted from the Word development Indicators and the Bank of Ghana. The macroeconomic variables used in the estimation include GDP, GDP deflator, private consumption and investment, Monetary policy rates (MPR), M2, as money supply measure instrument for the analysis. The MPR and M2 data is extracted from the Bank of Ghana and growth rate of M2 calculated. Aggregate commodity price index is an aggregation of sectorial activity price level change and therefore these different commodity categories will be explored. The commodity price

index data cover the monthly commodity prices on cocoa (COC), gold (GLD) and crude oil (CRU) was obtained from the Bank of Ghana. and food (Maize, soyabean) index from Ghana commodity exchange database. These commodities are the major export commodities of Ghana.

Econometric Model

The variables are non-stationary and co-integrated hence, the study uses the Vector Error Correction (VEC) model to make the most of the information on long-run stochastic relations while preserving the properties of the time series data. The model is explained below:

If two non-stationary variables y_t and x_t are integrated of order 1: $y_t \sim I(1)$ and $x_t \sim I(1)$ and proved to be cointegrated, so that:

$$y_t = \beta_0 + \beta_1 x_t + e_t \quad (1)$$

The VEC model is a special form of the VAR for I (1) variables that are cointegrated. The model can be specified as:

$$\Delta y_t = \alpha_{10} + \alpha_{11} + (y_{t-1} - \beta_0 - \beta_1 x_t) + v_t^y \quad (2)$$

$$\Delta x_t = \alpha_{20} + \alpha_{21} + (y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + v_t^x \quad (3)$$

Equation (2) and (3) can be expanded as

$$y_t = \alpha_{10} + (\alpha_{11}+1)\, y_{t-1} - \alpha_{11}\beta_0 - \alpha_{11}\beta_1 x_{t-1} + v_t^y \quad (4)$$

$$x_t = \alpha_{20} + (\alpha_{21}+1)\, y_{t-1} - \alpha_{21}\beta_0 - (\alpha_{21}\beta_1 - 1)\, x_{t-1} + v_t^x \quad (5)$$

The coefficients α_{11}, α_{21} are error correction co-efficient and they show how much and respond to the cointegrating error $y_{t-1} - \beta_0 - \beta_1 x_{t-1} = e_{t-1}$. The model allows to examine how much dependent variable will change in response to a change in the explanatory variable (the cointegration part, $y_t = \beta_0 + \beta_1 x_t + e_t$, as well as the speed of the change (the error correction part, $\Delta y_t = \alpha_{10} + \alpha_{11}(e_{t-1}) + v_t^y$ where e_{t-1} is the co-integrating error.

This estimates a unique and stable long-run cointegrating vector between monthly data and the long-term interest rate. The Johansen–Juselius (1990) methodology was used to estimate the long-run cointegrating vector from a VEC of the form:

$$\Delta x_t = (L)\, \Delta x_t + DZ_t + \alpha\beta[x_{t-1}] \quad (6)$$

where x_t is a vector of endogenous variables (MPR, COC, GLD CRU), $\Gamma(L)$ is a matrix of parameters for a fourth-order lag process, Z_t is a vector of stationary exogenous variables, and D is the matrix of parameters associated with the exogenous variables. The parameters measure the speed at which the variables in the system adjust to

restore a long-run equilibrium, and the vectors are estimates of the long-run cointegrating relationships between the variables in the model.

Long run relation

$$ECM = \beta_0 lnMPR + \beta_1 lnCRU + \beta_2 lnCOC + \beta_3 lnGLD + C \quad (7)$$

Short run relation

$$\Delta\, lnMPR_t = \alpha_0 ECM_t + \alpha_1 \Delta lnMPR_{t-1} + \alpha_2 \Delta lnMPR_{t-2} + \alpha_3 \Delta lnCRU_{t-1} + \alpha_4 \Delta CRU_{t-2} + \alpha_5 \Delta lnCOC_{t-1} + \alpha_6 \Delta lnCOC_{t-2} + \alpha_7 \Delta lnGLD_{t-1} + \alpha_8 \Delta lnGLD_{t-2} + k \quad (8)$$

The monetary policy is characterized by

$$\acute{I}_t = f(\Omega_t) + \varepsilon^i_t \quad (9)$$

i_t represent the central banks target interest rate, f is the linear function, Ω_t is the information set and ε^i_t is the shock to monetary policy rate(MPR).

here ECM is the error correction term for both the long and the short run relationship, MPR, CRU, COC and GLD. The framework above followed the work of Hammoudeh et al., (2015), Hendry & Adam (2002), Boateng et al., (2020) among others in estimate the model with all the variables.

RESULTS AND DISCUSSION

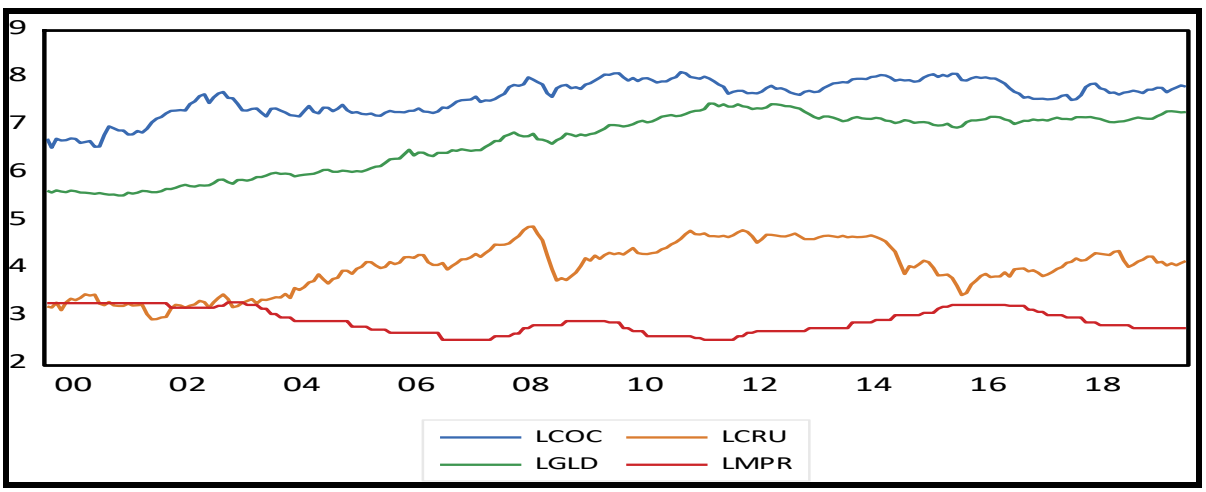

FIG 1. TREND ANALYSIS AND SUMMARY STATISTICS

The time series plot of Monetary policy rate shows a downward trend in monetary policy rate from 2000-2008. During same time, the selected commodities prices gold, crude oil and cocoa showed an upward trend in price. From 2008-2010, Monetary policy rate saw an upward revision. This was accompanied by a mix reaction from commodity prices. Initial upward adjustment in 2008 in monetary policy rate led to drop in crude oil prices sharply. Cocoa price and oil gold price index dropped but less proportionately. The period between 2010 through 2012 experienced another

decreasing trend in monetary policy rate. During the same time, cocoa price index decreased whiles crude oil price and gold price experienced an increase in price. The increase in crude oil price could be attributed to a demand shock after the economic recovery from the prior global financial crises. From 2012-2016 saw another upward in monetary policy rates and began decreasing again prior to the 2019 Covid pandemic. Around the same period, the series plot for cocoa and gold showed an upward trend before dipping at the end to 2016 through 2019. The trend in crude oil price was exactly opposite the other commodities. Overall, the price of gold and cocoa fairly showed upward trend for the from 2000 through 2019. Gold prices trend keenly followed business cycles adjustments.

TABLE 1. MODEL RESULTS

Results For LR and SR model			
Variables	Short Run Model		Long Run Model
MPR	Δ(1)	Δ(2)	LR
lnMPR	0.987**(0.066)	-0.0235(0.0684)	1
lnCOC	0.0663*(0.0327)	-0.0512(0.0326)	0.077*(0.0269)
lnCRU	0.0164(0.0263)	0.0039(0.0255)	0.0423(0.0362)
lnGLD	-0.1356*(0.0598)	0.122*(0.061)	-0.028*(0.0408)
lnEXCH			- 0.0856*(0.0122)
lnGDP			-0.0140866
lnallcom			0.808(0.0522)
lnGDPI			0.223*(0.0108)
lnGDPC			0.0327*(0.0122)
lnGDPDEF			0.223*(0.0108)
Constant/ECM	0.5967*(0.1561)	-0.00511(0.0303)	4.310**(0.0192)
Observation	36	32	238
R-squared	0.971	0.916	0.984

Standard errors are in parentheses* p < 0.1**, p < 0.05*** p < 0.01

From the long-run model, the VECM shows that monetary policy rate is positively related to the exchange rate, and gold price index. This positive relationship is insignificant at 5% for gold and significant for the exchange rates. A 1% increase in exchange rates, and gold price index leads to 0.085% and 0.028% decrease in monetary policy rates respectively. Also, Monetary policy rate is negatively corelated with crude oil prices and cocoa prices. A percentage increase in crude oil price index by 1% cause monetary policy rates to increase by 0.042%. The model again predicts a positive impact of cocoa price on monetary policy rates. MPR increase by 0.077% when cocoa price increase by 1%. It's worth mentioning that Ghana is the second largest exporter of cocoa beans and thus not surprising to see cocoa price index have the largest impact on monetary policy rates. The lag of monetary policy is positively correlated with

itself. This implies that today's monetary policy rates depend on yesterday's monetary policy rates. About 0.98% of monetary policy rate today is determined by yesterday's monetary policy rates.

The short run model revealed different dynamics. The first lag of monetary policy rate is positively related to itself whiles the second lag negatively correlated with monetary policy rate. However only the first lag is significant. The first and second lag of crude oil price index is positively influence monetary policy rate in Ghana though not statistically significant. The first lag of cocoa price index is significant and positively impact monetary policy rate. The second lag is negatively monetary policy rate but rather insignificant. The first and second lag of gold price index are jointly significant and positively correlated with monetary policy rate in Ghana.

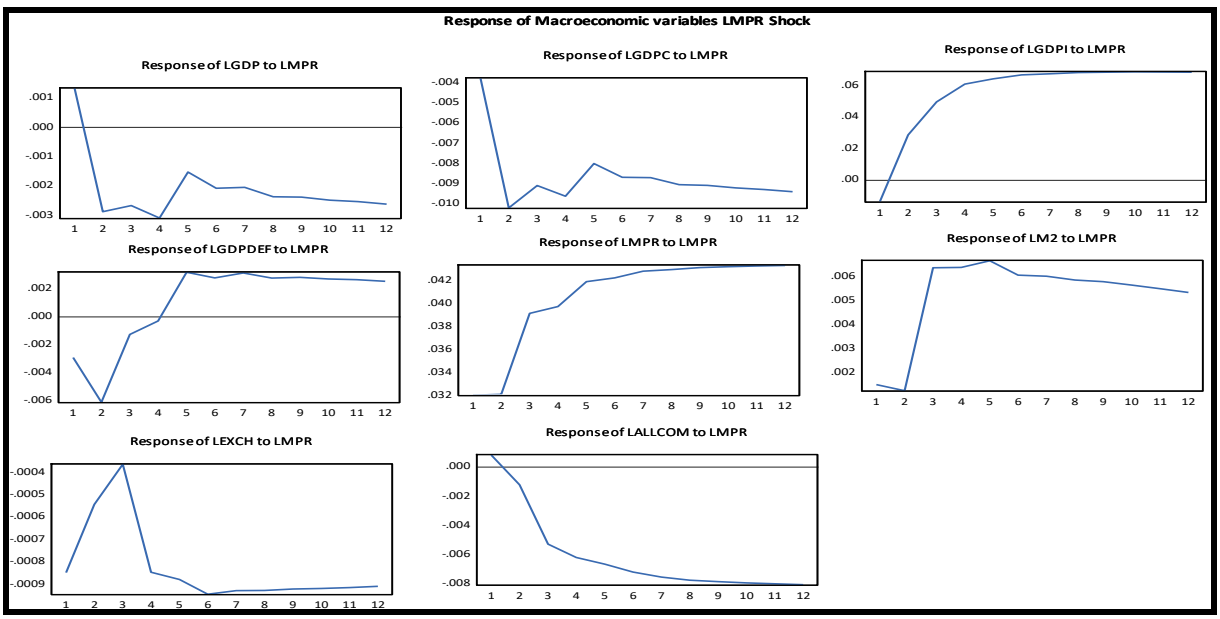

FIG 2. RESPONSE OF MACROECONOMIC VARIABLES

The empirical analysis shows that Monetary policy in Ghana leads to an immediate increase in broad commodity price index which reflect aggregate bias, high production cost and greater expected inflation or overshooting due to overreaction. The response of GDP and consumption due to contractionary monetary policy is negative but the response of GDP comes with a lag. The initial response of Investment (GDPI) and GDP deflator to monetary policy shock is negative. GDP deflator response turn upward but negative until month 4 and positive from month 4 to 12. The response of both monetary policy rate and growth rate of broad money(M2) is persistently positive with the lag. Thus, following an expansionary monetary, the aggregate price level increase, M2 growth increase reflecting an increase in liquidity. The exchange rate response is negative but increasing until month 3 and turned persistently negative.

TABLE 2. COINTEGRATION RANK TEST (TRACE)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.158285	69.16740	69.81889	0.0463
At most 1	0.071106	30.22442	47.85613	0.7075
At most 2	0.030188	13.55451	29.79707	0.8646
At most 3	0.019316	6.626881	15.49471	0.6214
At most 4	0.009769	2.218644	3.841465	0.1364

The Granger cointegration test popularized in 1981 was done to provide statistical basis on which an error correction model can be run, and this help to establish the long-run equilibrium relationship between the variables and the short-term disequilibrium of the generation of dynamic process. After this test, the short-term model was estimated with variables Monetary policy rate, gold, crude oil and cocoa. The lag of 2 was chosen for VEC model based on the results of the AIC and SC selection criterion. The AIC suggested an optimal lag of 3 whiles the SC suggested and optimal lag of 2. The final decision on lag of two was based on how significant these lags impact our VEC model.

Test Of Stationarity

TABLE 3. ADF UNIT ROOT TEST

Variable	Level t-value	P-value	Difference-Statistic	Prob.
MPR	-1.648606	0.4561	-8.518025	0.0000
GLD	-1.406506	0.5789	-13.61952	0.0000
CRU	-2.095438	0.2468	-12.06211	0.0000
COC	-2.938734	0.0425.	-13.96599	0.0000

TABLE 4. PP UNIT ROOT TEST

Variable	Level t-value	Level Value	Difference t-Statistic	Difference P-Value
MPR	-1.744034	0.4078	-16.23657	0.0000
GLD	-1.36905	0.5972	-13.59957	0.0000
CRU	-1.953588	0.3073	-12.04478	0.0000
COC	-2.356681	0.15535.	-13.99936	0.0000

Non-stationary time series contains unit roots or structural breaks. A time series is non-stationary, if it has a time varying mean and variance (Gujarati & Porter, 2009). The Augmented Dicker-Fuller test and Philips-Pearson unit roots test was carried out.

The p-values of the level variables were greater than 0.05 thus we failed to reject the null hypothesis that there the series are stationary. The first-difference p-values of both the ADF and PP showed that the variables are not stationary since their p-values is less than 0.05% level of significance.

TABLE 5. GRANGER CAUSALITY

Null Hypothesis:	Obs	F-Statistic	Prob.
LEXCH does not Granger Cause LMPR	226	10.7047	4.E-05
LMPR does not Granger Cause LEXCH		1.14768	0.3193
LCRU does not Granger Cause LMPR	238	2.29517	0.1030
LMPR does not Granger Cause LCRU		7.27243	0.0009
LCOC does not Granger Cause LMPR	238	2.26658	0.1059
LMPR does not Granger Cause LCOC		3.75033	0.0249
LGLD does not Granger Cause LMPR	238	2.72888	0.0674
LMPR does not Granger Cause LGLD		5.18298	0.0063
LCRU does not Granger Cause LEXCH	226	1.60129	0.2040
LEXCH does not Granger Cause LCRU		0.63094	0.5330
LCOC does not Granger Cause LEXCH	226	0.25315	0.7766
LEXCH does not Granger Cause LCOC		1.63422	0.1975
LGLD does not Granger Cause LEXCH	226	2.22532	0.1104
LEXCH does not Granger Cause LGLD		1.61175	0.2019
LCOC does not Granger Cause LCRU	238	0.17099	0.8429
LCRU does not Granger Cause LCOC		1.08238	0.3405
LGLD does not Granger Cause LCRU	238	2.90541	0.0567
LCRU does not Granger Cause LGLD		0.18427	0.8318
LGLD does not Granger Cause LCOC	238	1.62345	0.1994
LCOC does not Granger Cause LGLD		0.77340	0.4626

The results presented in table shows monetary policy rates granger cause gold price and crude oil prices. However, there is bi-directional causality between exchange rates and monetary policy rates as expected. The F-statistic of 2.91 and p-value of 0.05 implies that gold price also granger cause Crude oil price. There is also bi-directional granger causality between monetary policy rates and gold at 10% level of significance. From empirical observations, there granger causality between monetary policy rate and gold price, and exchange rate is expected.

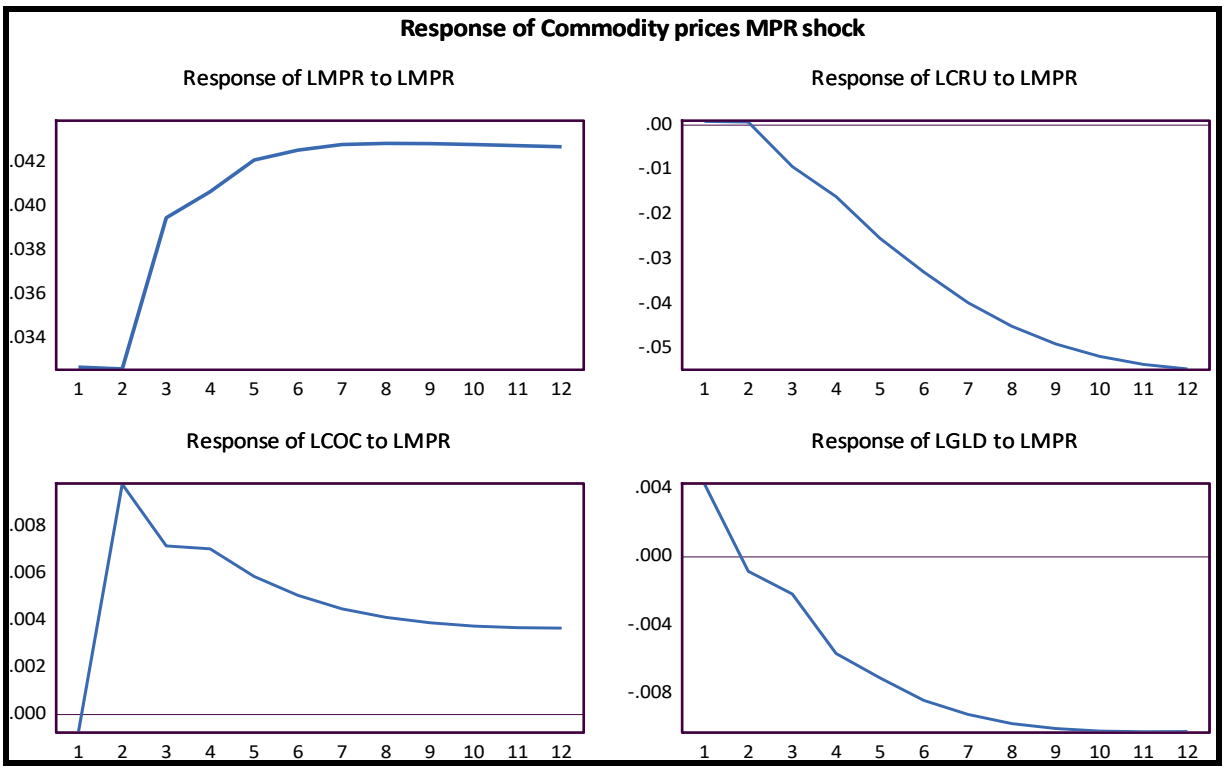

FIG 3. IMPULSE RESPONSE ANALYSIS

The impulse response analysis indicates that monetary policy rates have positive and persistent impact on itself. Today's MPR is dependent on yesterday's monetary policy rate. Also, the positive shock of monetary policy rate on exchange rate initially decreases and the turn positive after 12 periods and continued to be positive but quasi-convex. The positive shock of monetary policy rate on gold prices, crude oil prices is negative. The shock has persistently greater and positive effect on cocoa price.

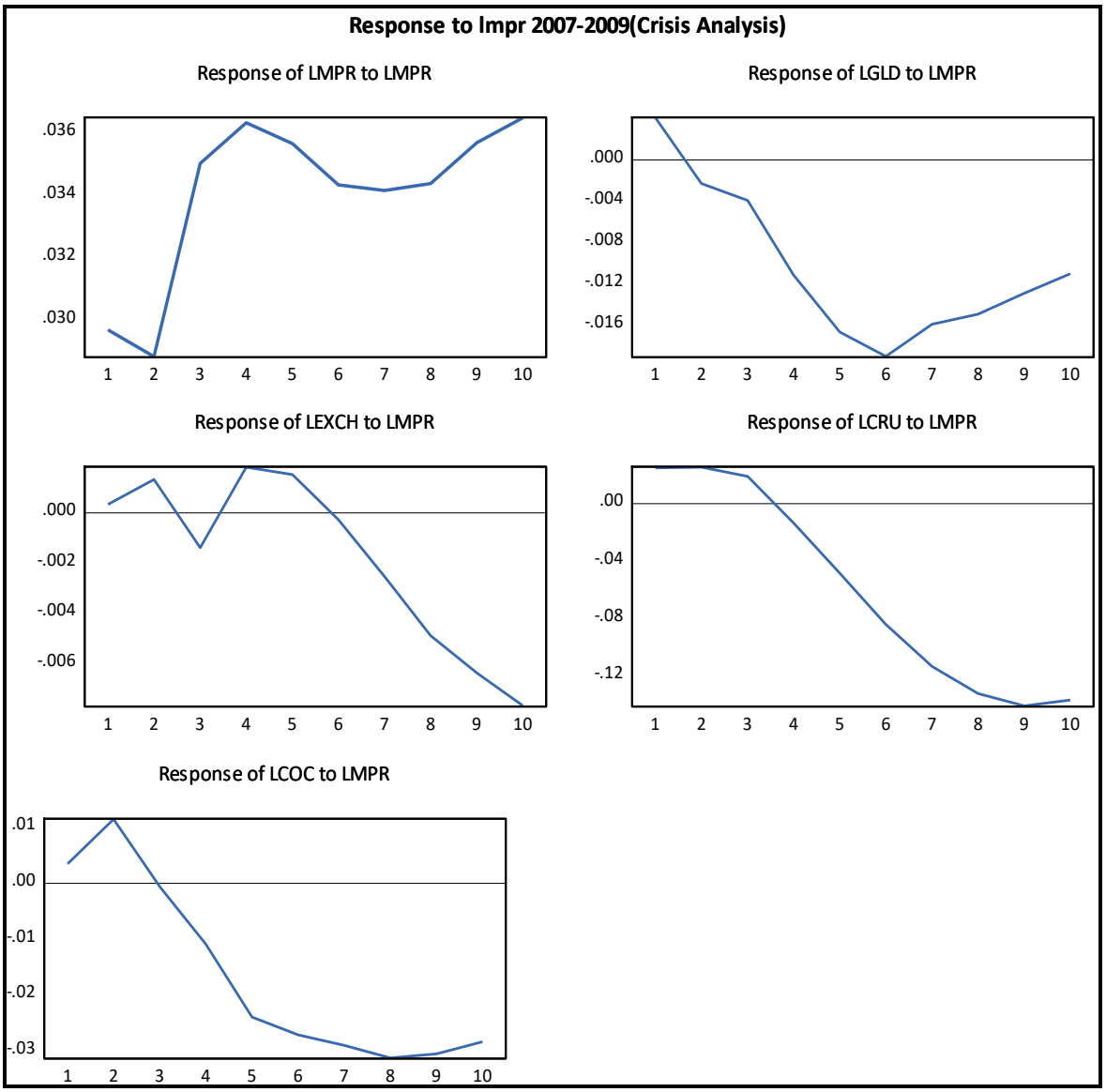

FIG 4. RESPONSE COMMODITY PRICES DURING 2007-2009 FINANCIAL CRISIS TO LMPR.

Between 2007 to 2009, Monetary policy responded positively to itself initially, dropped small by period 2 and begun to increase. Throughout the crisis monetary policy rate response was persistently positive. The initial response of exchange rate was near zero but begun to decrease to period 3 and, increased back positive in period 4 before finally decreasing. The initial response of all three commodity prices were positive but decrease to negative by period 2 for gold and between period 3 and 4 for crude oil and cocoa.

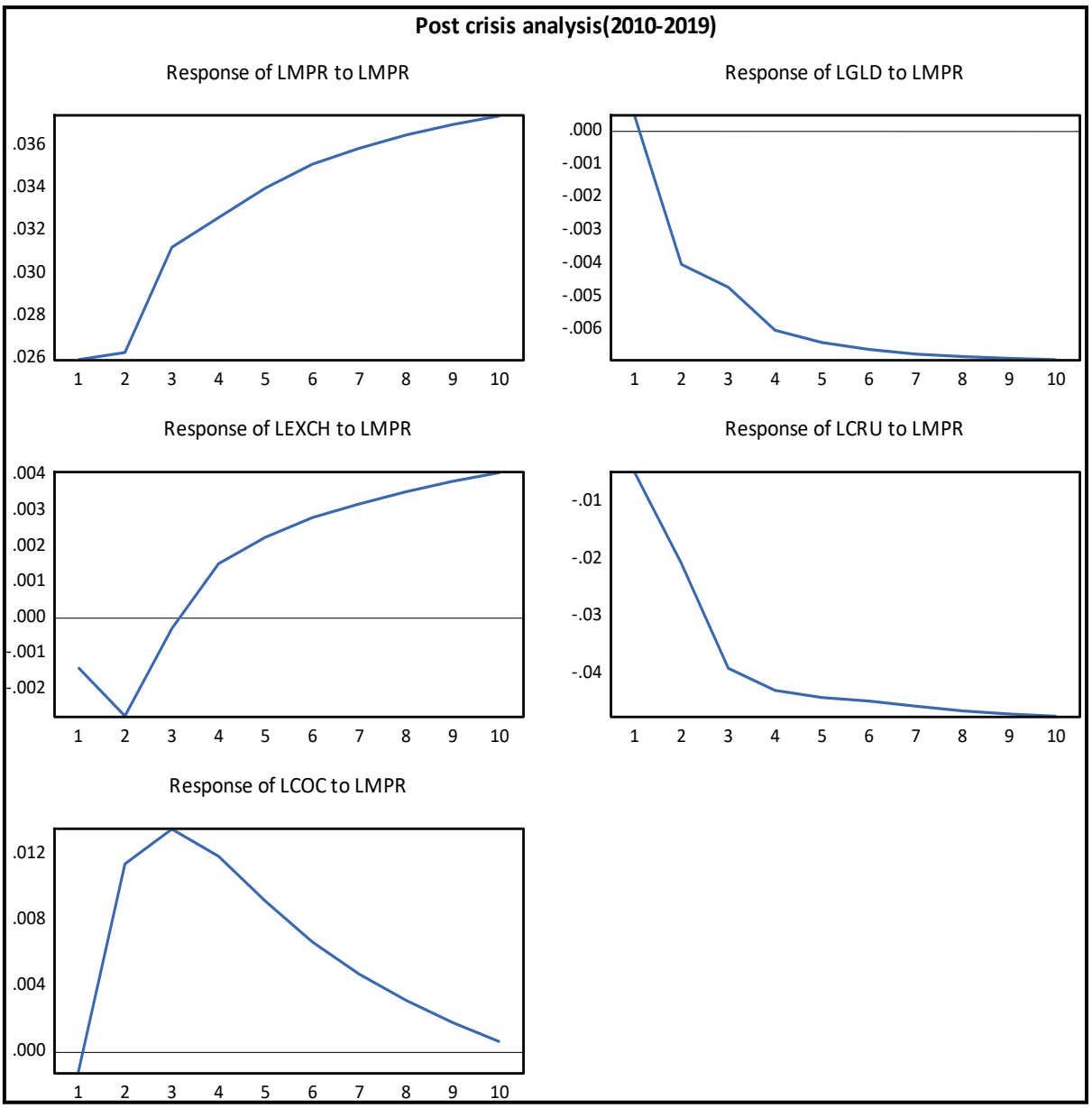

FIG 5. RESPONSE COMMODITY PRICES FROM 2010-2019 TO LMPR.

During the more stable period of 2010 to 2019, monetary policy rate responded the lag of lmpr positively. The response of exchange rate was initially negative but become positive by period 3. Cocoa price index response was persistently positive. The initial response of gold price and crude oil prices were positive but become negative by period 2.

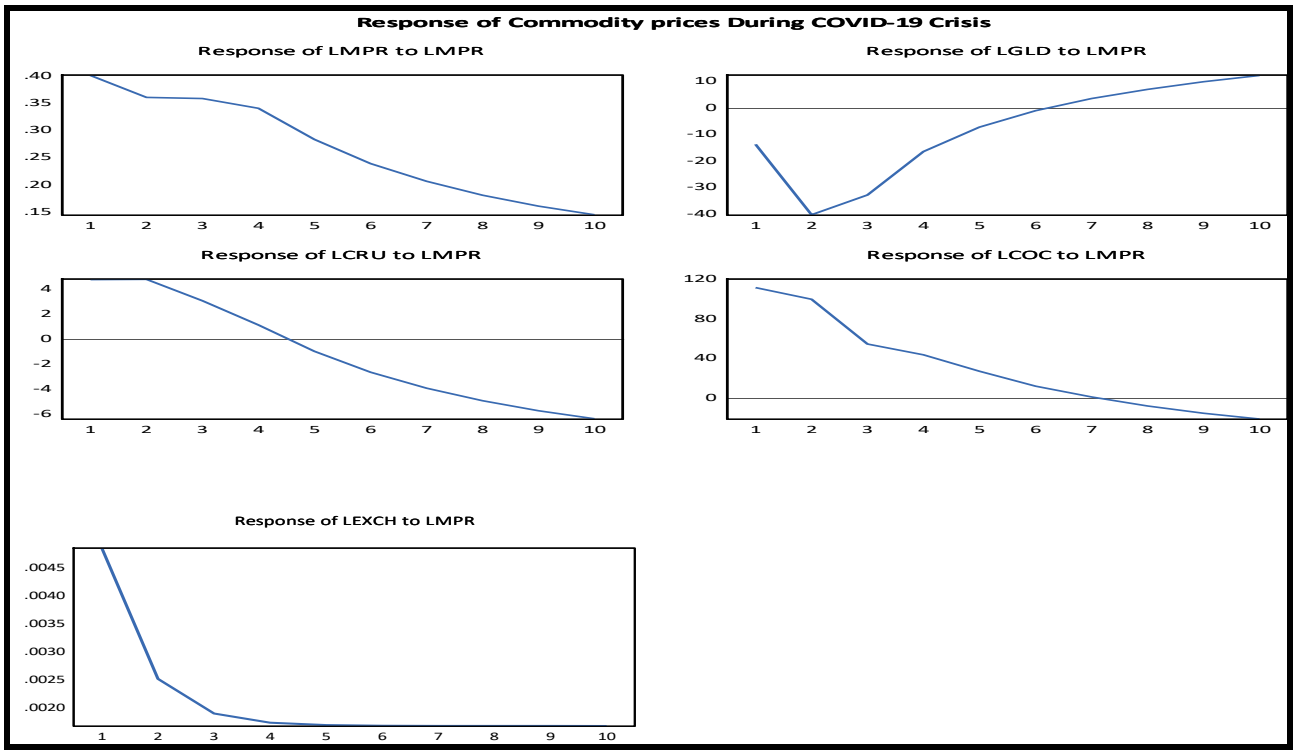

FIG 6. RESPONSE OF COMMODITY PRICES TO MPR DURING COVID-19 CRISIS

The response of commodity prices during the COVID-19 crisis is different compared to the 2008 financial crisis. The response of MPR to the lag of MPR is positive but persistently decreasing. The impact of monetary policy rates on gold price index and cocoa price index mirror exactly opposite the findings of the 2008 financial crisis. Cocoa price index initially responded positively to monetary policy rate but disappeared over time while gold price index responded negatively initial but upward overtime before diminishing to zero. Crude oil price index responded positively to monetary policy rates but turn negative by the 5th period. Though both the period of 2008 financial crisis and the COVID pandemic saw expansionary monetary policy, the responses are different. It should be noted that one major challenge that characterized the period of the pandemic is supply chain issues. The different dynamics is similar to the findings of Hamilton (2010) when demand supply scenarios are taken into consideration.

Variance Decomposition

We analyze variance decomposition of our set of commodity prices over the 200 months forecasting horizon. It shows the percentages contribution of variance to the prediction error made in forecasting a variable at a given horizon due to structural shocks. The tables 4.7.1 shows the variance decomposition for monetary policy rates contribution to all commodity prices. Gold, cocoa, and crude oil contributed about 3.41%, 5.36% and 8.07% by the end of the first year respectively. This increased to 10%, 4.63% and 14.37% by the

200th months of the considered period. That's MPR variance contribution to cocoa price decreased overtime. The MPR variance contribution to exchange rates were highest. That's 6.62% by the 12th month and increased to about 42% in the 200th month. The impact of MPR variance on itself decreased overtime.

It's evident from the appendix that the variance contribution of exchange rates to gold price and crude oil price is high. The exchange rates contribute about 26% to gold price by the 12th period and about 12% to crude oil prices. However, this contribution just by a point when the period is extended to cover over 200 months period. The variance contribution of all commodities to itself are often much higher but decreases overtime. It could be noted from the above analysis that structural monetary policy shocks as well as the exchange rates are very important in determining commodity price fluctuations.

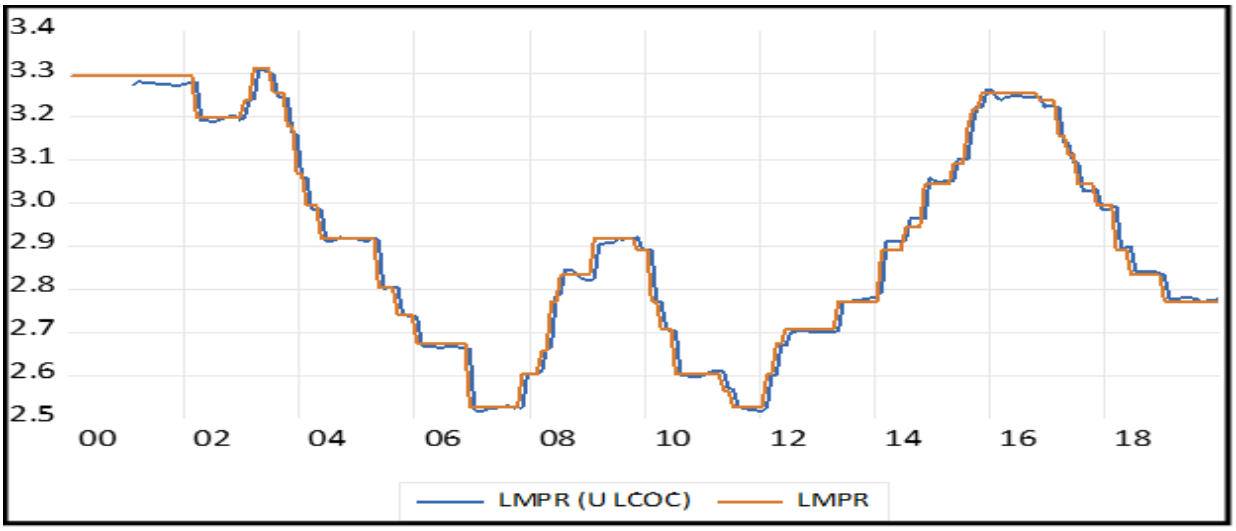

FIG 7. FORECASTED MONETARY POLICY RATE VS ACTUAL MONETARY POLICY RATES.

The graph above shows predicted monetary policy rate against the actual monetary policy rates. It could be noted that, when MPR is decreasing the predicted policy rates is higher than the actual and when MPR is increasing the predicted is lower the actual policy rates.

However, the predicted policy rates and the actual policy rates closely moved together overtime. This implies that commodity prices is a good and close measure of monetary policy rate in Ghana under the assumptions of this analysis.

TABLE 8. DIAGNOSTIC TEST

Test	Hypothesis	Test statistics	P-value	Decision
Hetroskedasticity	Ho: Homoskedasticity	Chisq =14.026	0.9721	Homoskedastic
Autocorrelation	Ho: No serial correlation	Chisq =2.258	0.132	No serial correlation
Model stability	Ho: Model is dynamically stable	The CUSUM plot lie within the 5% level of significance		

The analysis used the White's test of hetroskedasticity and the Breush-Godfrey test for autocorrelation and the CUSUM test of stability was used to test for the validity of the results. The CUSUM plot test for the stability of the VEC model and do not require prior determination of where the break occurs (Ozturk and Acaracvi 2010). The results of the CUSUM plot are based on the cointegration test and recursive residuals and does not show evidence of statistically significant breaks and therefore the model is dynamically stable. The results showed that there is no autocorrelation in the errors and the error variances are homoskedastic.

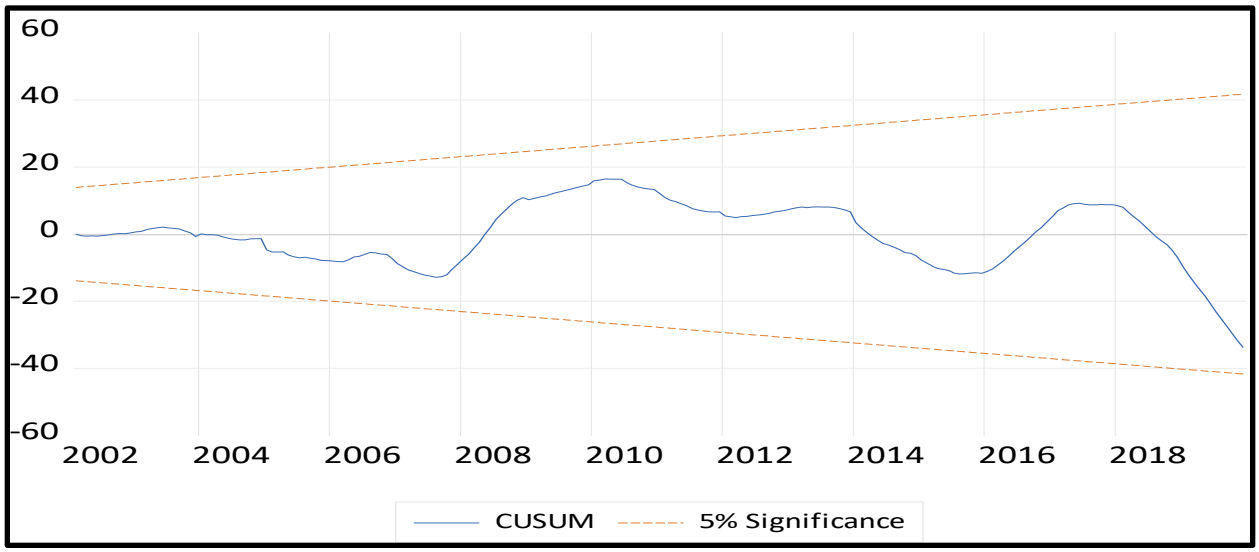

FIG 8. CUSUM TEST OF STABILITY

CONCLUSION

The study used the Vector Error Correction (VEC) model to analyze the impact of monetary policy rate on commodity prices in Ghana. The empirical results indicates that there is a long-term equilibrium relationship among MPR, cocoa, crude oil, and gold prices**.** Monetary policy rate responds to previous policy rates positively for most part of the period under consideration. Cocoa price index has positive and persistent response to positive monetary policy shock. The positive persistent shock of LMPR to cocoa price is not surprising as cocoa production form a major part of Ghana's export. Gold price

index has positive response to monetary policy rates. crude oil price index negatively responds to monetary policy rate. Exchange rate is important to commodity price index in Ghana. There is a negative correlation between exchange rate and monetary policy. The response of commodity price indices to monetary policy mirrored exactly opposite relationships. Here, we argue that different in dynamics though similar policy response for the two periods could be attribute the supply shock that is associated with the COVID crisis.

The short run model revealed different dynamics. The first lag of monetary policy rate is positively related to itself whiles the second lag negatively correlated with monetary policy rate. However only the first lag is significant. The first and second lag of crude oil price index is positively influence monetary policy rate in Ghana though not statistically significant. The first lag of cocoa price index is significant and positively impact monetary policy rate. The second lag is negatively monetary policy rate but rather insignificant. The first and second lag of gold price index are jointly significant and positively correlated with monetary policy rate in Ghana. It is evident from the variance decomposition and the impulse response that the shock to gold, cocoa and crude oil is primarily caused by changes in the variable themselves and the monetary policy rate has the greatest impact on crude oil price index.

The dynamic relationship of the macroeconomic variables considered in the VEC model established a long run relationship with monetary policy. Due to the inability of the VEC model to deal with many variables, only the exchange rate was keenly considered throughout the analysis, though the identification process considered a wider range of macroeconomic variables as shown in the first impulse response graphs. The exchange rate plays a major in analyzing commodity prices in Ghana and therefore was closed analyzed with the commodity price indices. The monetary policy rate variance contribution to exchange rates is about 41%, the highest for the long-run model.

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APPENDIX

Variance Decomposition

Variance Decomposition of LMPR:

Period	S.E.	LMPR	LEXCH	LCRU	LCOC	LGLD
1	0.032014	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.044803	99.41785	0.119806	0.222116	0.157503	0.082723
3	0.054461	98.18825	0.386680	0.682750	0.483613	0.258706
4	0.062564	96.45194	0.783771	1.321652	0.933864	0.508773
5	0.069724	94.34016	1.292600	2.084983	1.467695	0.814565
6	0.076245	91.96848	1.894705	2.927076	2.050204	1.159536
7	0.082300	89.43414	2.572744	3.810873	2.652784	1.529456
8	0.087992	86.81587	3.311120	4.707458	3.253009	1.912544
9	0.093389	84.17522	4.096253	5.595114	3.834053	2.299359
10	0.098533	81.55878	4.916603	6.458169	4.383891	2.682556
11	0.103455	79.00057	5.762546	7.285838	4.894455	3.056588
12	0.108173	76.52446	6.626166	8.071163	5.360821	3.417394
199	0.230747	29.36584	41.65489	14.36785	4.631871	9.979549
200	0.230803	29.35808	41.63458	14.37758	4.630206	9.999559

Variance Decomposition of LEXCH:

Period	S.E.	LMPR	LEXCH	LCRU	LCOC	LGLD
1	0.023969	0.015030	99.98497	0.000000	0.000000	0.000000
2	0.033643	0.030199	99.93212	0.003997	0.025127	0.008561
3	0.040905	0.048536	99.83383	0.011548	0.077624	0.028466
4	0.046897	0.068826	99.69887	0.021078	0.151602	0.059627
5	0.052068	0.090080	99.53459	0.031377	0.242038	0.101918
6	0.056648	0.111502	99.34709	0.041544	0.344681	0.155188
7	0.060775	0.132466	99.14138	0.050934	0.455956	0.219264
8	0.064540	0.152491	98.92156	0.059112	0.572875	0.293957
9	0.068004	0.171212	98.69094	0.065817	0.692965	0.379068
10	0.071215	0.188370	98.45213	0.070925	0.814189	0.474385
11	0.074207	0.203789	98.20721	0.074423	0.934889	0.579693
12	0.077008	0.217364	97.95775	0.076388	1.053729	0.694767
197	0.169227	3.981798	55.79171	11.55120	1.688737	26.98655
198	0.169280	3.988979	55.76114	11.56604	1.689511	26.99433
199	0.169331	3.995977	55.73151	11.58047	1.690281	27.00177
200	0.169381	4.002797	55.70279	11.59449	1.691048	27.00888

Variance Decomposition of LCRU:

Period	S.E.	LMPR	LEXCH	LCRU	LCOC	LGLD
1	0.079806	0.083088	0.150900	99.76601	0.000000	0.000000
2	0.105334	0.415599	0.094160	99.42290	0.000145	0.067200
3	0.120854	0.992005	0.080717	98.68967	0.000234	0.237379
4	0.131284	1.822135	0.124984	97.52728	0.000213	0.525389
5	0.138728	2.903342	0.240914	95.91386	0.000244	0.941643
6	0.144354	4.218409	0.440548	93.85014	0.000662	1.490239

7	0.148887	5.735167	0.732538	91.36275	0.001903	2.167637
8	0.152808	7.408222	1.120959	88.50414	0.004420	2.962257
9	0.156440	9.182738	1.604672	85.34878	0.008599	3.855207
10	0.159999	10.99964	2.177414	81.98619	0.014683	4.822068
11	0.163625	12.80124	2.828585	78.51205	0.022736	5.835388
12	0.167404	14.53624	3.544546	75.01921	0.032631	6.867378
199	0.381297	17.99552	36.49251	29.30554	0.822591	15.38385
200	0.381363	17.99315	36.48087	29.30609	0.822470	15.39743

Variance Decomposition of LCOC:

Period	S.E.	LMPR	LEXCH	LCRU	LCOC	LGLD
1	0.062437	0.029493	0.960022	4.594390	94.41609	0.000000
2	0.085966	0.086417	1.061400	4.151476	94.69824	0.002463
3	0.102555	0.167561	1.164862	3.758915	94.90017	0.008494
4	0.115402	0.269776	1.269767	3.413013	95.02901	0.018435
5	0.125797	0.390167	1.375497	3.110310	95.09142	0.032610
6	0.134423	0.526070	1.481463	2.847574	95.09357	0.051323
7	0.141701	0.675043	1.587098	2.621782	95.04122	0.074856
8	0.147916	0.834851	1.691869	2.430112	94.93971	0.103463
9	0.153269	1.003450	1.795276	2.269921	94.79398	0.137370
10	0.157913	1.178979	1.896852	2.138739	94.60866	0.176769
11	0.161964	1.359747	1.996167	2.034252	94.38802	0.221817
12	0.165517	1.544220	2.092830	1.954291	94.13602	0.272636
199	0.216120	7.386400	3.332179	9.147970	70.14639	9.987064
200	0.216125	7.386676	3.334206	9.148706	70.14321	9.987199

Variance Decomposition of LGLD:

Period	S.E.	LMPR	LEXCH	LCRU	LCOC	LGLD
1	0.036084	0.714031	0.669351	0.620838	2.446520	95.54926
2	0.050925	0.393027	0.654244	0.311706	3.067902	95.57312
3	0.062420	0.285120	0.634007	0.376968	3.675146	95.02876
4	0.072294	0.349864	0.609996	0.740472	4.247013	94.05266
5	0.081203	0.549123	0.583409	1.331808	4.770065	92.76560
6	0.089471	0.849126	0.555247	2.089601	5.237133	91.26889
7	0.097275	1.221297	0.526319	2.962651	5.645734	89.64400
8	0.104723	1.642297	0.497261	3.909700	5.996646	87.95410
9	0.111880	2.093597	0.468556	4.898436	6.292760	86.24665
10	0.118789	2.560838	0.440567	5.904179	6.538207	84.55621
11	0.125477	3.033137	0.413559	6.908527	6.737731	82.90705
12	0.131964	3.502426	0.387724	7.898096	6.896263	81.31549
199	0.351159	12.98144	3.740331	28.52827	4.707446	50.04251
200	0.351173	12.98099	3.746025	28.52682	4.707569	50.03860

cholesky ordering: lmpr lexch lcru lcoc lgld