

## **Does gold future hedge global uncertainty in crude oil futures? Evidence from DCC-GARCH model**

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### **ABSTRACT**

The crude oil prices experience high volatility during the last two decades. These crises mainly include the global financial crisis (GFC) and the COVID-19 pandemic. Subsequently, the global crude oil market has become highly volatile and suffered substantial losses due to the reduced demand for crude oil during both crises. Investors can rely upon other commodities to hedge their investments and diversify their portfolios. Global events such as GFC and COVID-19 play a critical role in investments and hedge funds to diversify a portfolio. This paper focuses on the empirical investigation of the time-varying correlation between crude oil futures and gold during GFC and the COVID-19 pandemic by employing the DCC GARCH model and found that gold futures do not play as a haven against crude oil futures.

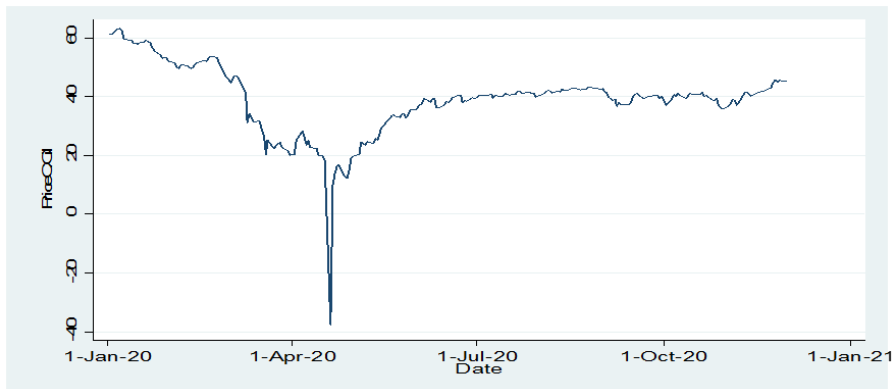
**Keywords:** Hedge, crude oil, gold futures, DCC GARCH model, GFC, COVID-19.

### **INTRODUCTION**

The recent outbreak of the COVID-19 pandemic has shaken the global financial system. The international commodity market has been experiencing a significant decline due to the outbreak of COVID-19, the novel coronavirus. Since December 2019, the outbreak of COVID-19 has influenced the prices of crude oil in the international market. On March 11, 2020, the World Health Organization (WHO) had announced this deadly virus named COVID-19, the pandemic (Anon 2020.). Since the date, a significant downfall in the futures of crude oil prices has been observed in the global oil market. Figure. 1 has displayed the sharp downfall in crude oil price. The crude oil price plummeted in the international market from USD 61.33 to USD 18.27 per barrel on April 17, 2020 (Dutta et al., 2020). In contrast, the international crude oil market experienced negative returns on April 20, 2020, at (37.63/barrels), the lowest price in the last 18 years. However, a sudden recovery was observed on April 22 2020, of USD 10.01 per barrel.

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<sup>1</sup>Federal Reserve Bank of St. Louis | Economic Data-The St. Louis Fed is one of the 12 Federal Reserve banks that—along with the Board of Governors in Washington, D.C

**Figure. 1**

Note: Crude oil price from January 2020 to January 2021 (Database: St. Louis)

The above figure1 represents the sharp downfall, even touches to negative, of crude oil prices in April 2020. However, that was reliant in two days after this depression. Moreover, prices of WTI (US West Texas Intermediate) are gravely affected as it has an extended period, in April 2020, a colossal crash has been observed in the crude oil market (He et al., 2020). Therefore, the demand was expected to increase as travel and tourism would resume. However, with the second wave of COVID-19, this expectation has dissipated. At the same time, metal prices are expected to be relatively increased modestly in 2021. In this scenario, the investors consider the gold market safer than the WTI market. The prospects of gold prices provide a cover to the investors than the declining prices of crude oil prices (Gil-Alana and Monge 2020; Phan and Narayan 2020).

During the first wave of COVID-19, there was a dramatic downfall in crude oil spot prices, and are unable to meet the pre COVID period. Even, there is a slowly rising trend in crude oil prices still the level is relatively low. While investigating the commodity market behaviour in the pandemic, it is found by the semi-annual report of Commodity Markets Outlook, the price level of metal has declined in a relatively modest way and found to be resilient as compared to the crude oil prices. However, the COVID-19 pandemic affects uneven commodities such as the pandemic hits the agricultural commodities differently, which is addressed in food insecurity research. It has a long-lasting effect on energy markets. The short-term decline in prices is bearable for an economy.

In contrast, the long-term economic depression is needed to be addressed, and there is a need to find some solution because the existing economic policy stimulus cannot buffer its effect. This paper examines whether the futures of gold plays a safe-haven for the investors against the crude oil futures crash during the COVID-19 pandemic. The global commodity and financial markets have become more integrated with increased

"financialization". This also affects the future contracts traded in both of these markets. An event in one market affects the other with different intensities. An extensive literature is available that deals with the effects of events on financial and commodity markets. The empirical evidence shows that SARS, INFLUENZA, EBOLA, and now COVID-19 pandemics negatively affect the commodity and financial markets. (Kwatra, 2020). The existing literature has focused on the relationship between spot prices of gold and crude oil.

Therefore, it is critical and significant to examine the volatility of futures contracts of gold and crude oil. The relationship between the spot prices of crude oil and gold prices has been studied and found a negative relationship during COVID19. Therefore, both commodities' futures are required to be investigated (Dutta et al., 2020). Moreover, the futures of crude oil are examined to be a factor that reflects in the spot prices (Bai et al. 2020). Therefore, the futures market of crude oil is influenced by the investor's sentiments. During COVID-19, investors withdrew their futures markets' funds to avoid losses (Huang and Zheng 2020). Some considered gold futures as a safer investment and relatively less volatile (Hood and Malik 2013). A vast literature has been explored that addressed the price relationship between oil and gold (Bedoui et al. 2019) and the economic effect on developing and developed countries. There found different behaviour in both the markets as the emerging markets are more sensitive to crisis while not efficient (Jebran et al., 2017). However, there is a need to understand the volatility of futures of crude oil and gold. To the best of our knowledge, this area needs to be explored.

This study explores whether the crude oil futures market is vulnerable to the COVID-19 pandemic, and futures of gold are considered a safe-haven for investing in futures of the crude oil market. The sample has been analyzed with two main splits, one for the global financial crisis (GFC) and the second for COVID-19. Moreover, this study will also compare the results with both commodities' spot prices during two crisis periods i-e GFC (Global financial crisis) and COVID-19. The previous research (Beretta and Peluso 2021; Chang et al. 2021; Papadamou, Kyriazis, and Tzeremes 2021; Manohar and Raju 2021; Yarovaya, Elsayed, and Hammoudeh 2021) motivates me to investigate this relationship. Although the definition of safe-haven assets, due to lack of theoretical background, can be controversial, yet the primary perception about safe-haven assets is that "an asset is negatively correlated or uncorrelated with other assets in a portfolio". In this way, a particular asset can diversify portfolio risk during market turmoil. According to this definition, the safe-haven -assets can help investors construct a portfolio for mitigating the downside market risk (Ji, Zhang, and Zhao 2020a). This paper addresses whether gold futures can continue to proclaim their unique role to

provide a safety net for the investors against the oil future market's crash risks induced by the COVID-19 pandemic.

This study contributes to existing research of spot price comparison by empirically investigating the dynamic conditional correlation between the futures (derivative) of gold acts and crude oil. This would contribute to the previously done work. This study concludes that there is a positive dynamic conditional correlation between futures of crude oil and gold. Moreover, the empirical contribution to the existing literature by employing a more sophisticated econometric tool. In the future, non-precious metals, agriculture futures, and other commodities can be used as a hedge or a safe-haven to diversify the portfolio risk during economic contraction. Furthermore, the crude oil futures can be compared with another metal or cryptocurrency with the aim of hedging.

## **LITERATURE REVIEW**

The novel outbreak of the COVID-19 pandemic has become a threat to the sustainability of the financial market, along with public health (Ali et al., 2020). There found a contagion effect of the pandemic on the financial and non-financial firms, evident by G7 countries (Akhtaruzzaman, Boubaker, and Sensoy 2020). The prices of internationally traded commodities also become highly volatile. The global financial crisis hit the prices of WTI, and the bubbles created volatility in the prices of WTI (Sornette and Woodard 2010). During the crisis, the spot and futures prices of crude oil have deteriorated (Kilian 2008; Charles and Darné 2009) even the investors switched to other commodities for hedging (Nguyen et al. 2020). Furthermore, the crude oil volatility index (OVX) has become highly volatile during the COVID19 period. The index showed substantial losses and investments on stake. Furthermore, the crude oil market has exposed the highest uncertainties due to the COVID-19 pandemic and slightly due to some political manoeuvring among crude oil producers during the pandemic (Liu, Wang, and Lee 2020; Njindan Iyke 2020). This framework has described the situation as the COVID-19 pandemic leads to a crash in the global crude oil market. So, the risk-averse investors search for safe investment during this pandemic (Adekoya and Oliyide 2020b). This behaviour of investors leads to the transfer of their funds from one market to another. This study focuses on two commodity markets to examine this phenomenon, crude oil and the gold market.

Among these, the price of crude oil futures is considered to be highly affected by the COVID-19, "the black swan" (Yarovaya, Matkovskyy, and Jalan 2020). There found two main reasons for this effect, firstly, the demand for crude oil fell rapidly, secondly, the investor's behaviour towards their

investment in crude oil futures. Being risk-averse, the investors withdrew their investments as they observed a declining trend in the crude oil futures market (Singh and Sharma 2018; Huang and Zheng 2020). Some previous studies have documented that financial instruments and gold prices are weakly correlated (Pan, Wang, and Yang 2014; Singhal and Ghosh 2016; Singh and Sharma 2018; Dutta, Bouri, and Roubaud 2019;). Many investors use gold to hedge funds in the bond or stock market of Germany, the UK, and the US (Ingalhalli, G., and Reddy 2016; Singh and Sharma 2018; Adekoya, Oliyide, and Oduyemi 2020; Bai et al. 2020). In the recent gold price evolution, the hedging property of gold could be seen as a priori. Since March 19, 2020, a new upward course has been exposed to the gold price. In recent years, the debate has been seen as in commodity market, gold and oil are mostly traded and are leading economic variables in recent research. Besides, gold and oil prices influence commodity and financial markets worldwide. Another study explored the same findings that the shift of investment from one commodity to another is considered to avoid losses (Pan et al., 2014; Singhal and Ghosh, 2016; Sephton and Mann, 2018). This change of asset from crude oil to gold or bitcoin.

Therefore, the superiority of assets is investigated with the hedging power against losses during pandemics (Bouri et al., 2017). Moreover, the hedging potential differs with the spot and futures of oil and gold. At the same time, the crude oil futures are more volatile (Gong and Lin 2020). So, the policymakers must formulate some effective regulatory policies so excessive speculation could be reduced (Yang et al. 2020). The incorporation of exogenous predictors has been investigated under structural breaks during the pandemic and found that crude oil futures are well predicted by adding equity market information (Luo et al., 2020). In contrast, the data collection with high frequency provides better results than adding mush information (Phan et al. 2009). Furthermore, the macroeconomic factors and investor's sentiments increase the volatility of crude oil futures and create a shift in investment (Sadik, Date, and Mitra 2019). The pairwise analysis found that crude oil futures influence the commodity market due to their interconnectedness (Balcilar, Gabauer, & Umar, 2020.). On the other hand, the existing literature also evidenced no co-integration or co-movement between crude oil and gold markets (Olson, Vivian, and Wohar 2014; Raza et al. 2016; Das et al. 2018; Wang, Sheng, and Zhang 2019). The investors, not necessarily switch to the gold market in case of depression in the crude oil market. However, some dynamic linkages between crude oil and gold markets have been widely documented with the influence of other factors (Ciner, Gurdgiev, and Lucey 2013; Souček 2013; Mo, Nie, and Jiang 2018; Adekoya and Oliyide 2020a). The COVID-19 disrupted financial markets and instruments. There found a sharp decline in crude oil prices due to a decline in demand. While the COVID-19 pandemic is the main reason

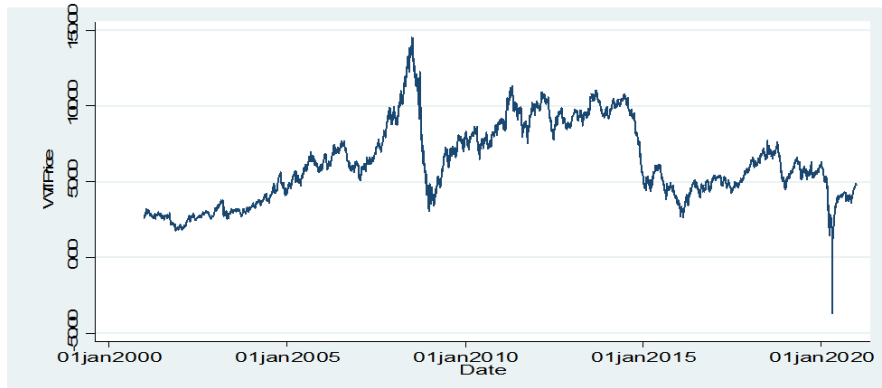
for reduced demand for crude oil, there are uncertain travel, tourism, and border closures. Resultantly, the crude oil futures price "West Texas Intermediate" (WTI) fell to negative on April 20, 2020. This extreme situation showed that uncertain market conditions significantly influenced commodity market spot and futures prices (Huang and Zheng 2020).

## **DATA AND METHODOLOGY**

### **Data Description**

The data of futures and spot prices of crude oil and gold have been obtained from the St. Louis FRED database. The sample comprises from the period of December 27 2000 to December 21 2020. The data has been divided into two-time spans, from the starting date i-e 2000 till December 2008. During this period, GFC's dummy has been created that captures the global financial crisis-era 2007-2008. The second split comprises the COVID-19 era, starting from January 1, 2020, until the end of the date, i-e December, 21st 2020, the pandemic period. The split of this time duration has been made based on the WHO report for reporting of COVID-19 cases. The second dummy has been created as Covid to measure both commodities' volatility during the COVOD-19 period.

**Figure. 2**



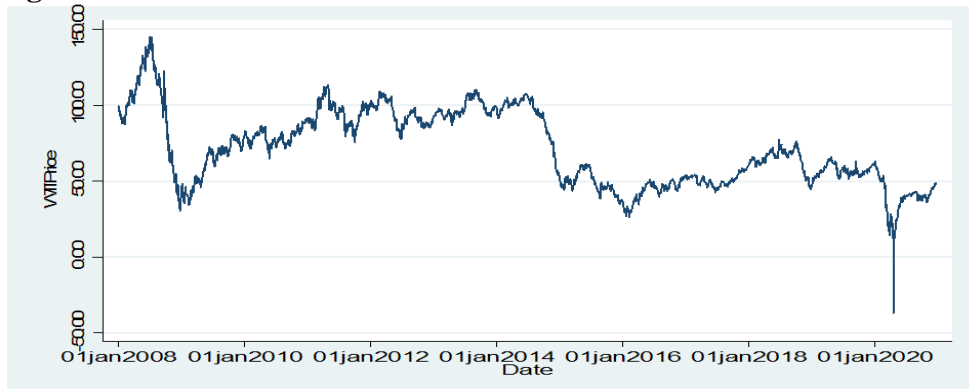
Note. Crude oil price evolution over the period 2000–2020. The futures prices USD per barrel. Source of Data: The St. Louis FRED database

Figure 2. Show the price fluctuation from January 1, 2000 to January 1, 2020. The crude oil futures prices have been raised during 2009-2010, right after the global financial crisis, while there found a sharp decline in April 2020 due to COVID-19.

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<sup>2</sup>On December 31, 2019 COVID-19 infected cases were first reported to WHO from the city of Wuhan (China). The Chinese authorities have confirmed the cases have registered between 12th and 19th December, 2019. Al though that infection was completely unknown and everyone was unaware of that virus yet that report created a tension. Based on the WHO report, in this paper, the COVID-19 period is considered to be started from January 1, 2020 to December, 21 2020 Sample range).

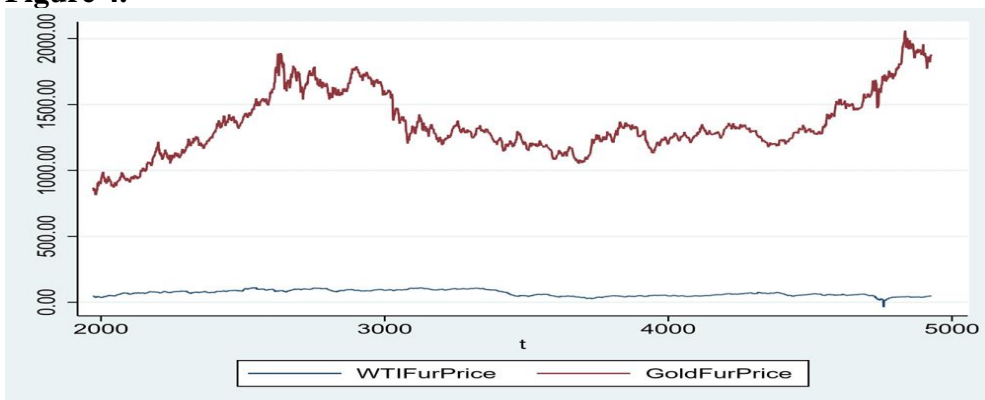
**Figure 3.**



Source: Graphical representation of Crude oil (futures) implied volatility index (OVX) for the period 2008–2020.

Figure 3 sheds light on the index for volatility expected by the market over 30 days and found an increase in volatility in the general futures price level after 2008. However, the market expects a downfall during the pandemic (COVID-19).

**Figure 4.**



Source: Response of Futures price of WTI and Gold

Figure 4. Shows the volatility of WTI and Gold futures returns from February 1, 2020, to December 21, 2020. The crude oil futures prices are more volatile with many fluctuations than gold futures prices during the time. So, the investors are more likely to shift the investment from crude oil futures to gold futures by considering it a safe haven.

Figure 5.



Source: response of WTI spot price, WTI Futures price, gold spot price, and gold futures prices during the whole sample period.

The response of WTI spot price, WTI Futures price, gold spot price, and gold futures prices have been collectively plotted and reported in Figure 5. The spot prices of WTI spot and futures prices have a slight difference, but it shows some volatility during GFC, which might not be noticeable. In contrast, there is a significant difference in gold spot and futures prices. The futures of gold are considered to be more volatile during the crisis and pandemic period. Whereas oil, being an essential commodity used by all industries, shows less fluctuation. However, there found a volatile behaviour in WTI futures prices during GFC and according to figure 1. A sharp decline in Futures of gold and WTI has been found during the COVID-19 period.

Table 1. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Gold Future Returns	1972	497.12	199.94	256.7	1023.5
WTI Future Returns	1914	0	0.03	-0.17	0.16

Note: All variables are in logarithmic form by calculating log returns from Futures prices of gold and WTI from December 2000 to December 2008.

Table 1 describes the descriptive statistics of WTI futures returns and gold futures returns for December 2000 and December 2008. WTI futures volatility is relatively high during this period, i-e 199.942 and 0.026 in gold futures, too low. Given that gold futures are less volatile, one reason could be an extended period or investors' preferences (Olson et al., 2014). In contrast, no event was separately treated during this period.

Table 2. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
WTI Spot Returns	1940	0	0.072	-0.52	0.523
Gold Spot Returns	1926	0.00	0.03	-0.38	0.40



Note: All variables are in logarithmic form by calculating log returns from spot prices of gold and WTI from December 2000 to December 2008 From Jan2000 to December 2008.

The results of Table 2 revealed that the WTI spot returns are more volatile during the first span of 0.072, while gold spot returns during this period are relatively less volatile 0.03.

**Table 3. Descriptive Statistics**

<b>Variable</b>	<b>Obs.</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
Gold Future Returns	241	1769.93	142.26	1472.35	2061.5
WTI Future Returns	232	0.00	0.07	-0.281	0.42

Note: All variables are in logarithmic form by calculating log returns from futures of gold and WTI From January-2020-Dec2020.

Table 3 sheds light on the second penal from January 1, 2020, to December 21, 2020. The spot returns of WTI show high volatility during this period 142.26. In contrast, the returns of gold futures have less volatility of 0.072, not much changes than the last two decades. It has less risk than WTI spot returns. There found a considerable change in risk factor associated with WTI spots returns due to the COVID-19 pandemic (Luo et al. 2020).

**Table 4. Descriptive Statistics**

<b>Variable</b>	<b>Obs.</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
WTI Spot Returns	236	-0.00	0.09	-0.48	0.41
Gold Spot Returns	235	0.00	0.08	-0.65	0.67

Note: All variables are in logarithmic form by calculating log returns from spot prices of gold and WTI From January-2020-Dec2020.

Table 4 presents descriptive statistics of WTI spot and gold spot returns from January 1, 2020, to December 21, 2020. During this span of COVID-19, the volatility of the WTI spot returns is 0.095 while 0.087 for gold spot returns. However, it is observed that the difference between the volatility of both commodities is low during this time. The gold spot returns also show volatile behaviour during COVID-19. However, The existing literature found an inverse relationship between the spot prices of WTI and gold ( Ciner et al., 2013; Souček 2013; Adekoya and Oliyide 2020a). Therefore, the investors who have already hedged their investments in gold futures are not much affected (Huang and Zheng 2020). The standard deviations are observed to the highest from January 2020 to December 2020. In contrast, the standard deviation of gold futures returns is observed to be very low. Though the conditional correlation between futures of both the commodities is low but with theoretical support, it is found that during the COVID-19 period, gold futures markets play a safe-haven role for the investors to hedge their funds. In this scenario, the magnitude of the correlation between both commodities are found to be high (Bildirici and Turkmen 2015; Seyyedi 2017; Singh and Sharma 2018; Ansari and Sensarma 2019; Chen and Xu

2019; Dutta, Bouri, and Roubaud 2019; Jin et al. 2019; Gharib, Mefteh-Wali, and Jabeur 2020; Adekoya, Oliyide, and Oduyemi 2020).

**Table 5. Matrix of correlations**

Matrix of correlations			Matrix of correlations		
Variables	1	2	Variables	1	2
1 WTI Spot Returns	1.00		1 WTI Future Price	1.00	
2 Gold Spot Returns	0.02	1.00	2 Gold Future Price	0.92	1.00

Notes: All variables are expressed in logarithmic form. This table reports the pairwise Pearson correlation coefficients for daily returns of WTI futures and gold futures from January 2000 to December 2008.

Table 5 shows the results of pairwise Pearson correlation coefficients for the first period. The correlation is low in the spot returns of WTI and gold 0.0518, while the futures prices of WTI and gold are highly correlated with 0.916.

**Table 6. Matrix of correlations**

Matrix of correlations			Matrix of correlations		
Variables	1	2	Variables	1	2
1 WTI Future Returns	1.00		1 WTI Spot Returns	1.00	
2 Gold Future Returns	-0.08	1.00	2 Gold Spot Returns	-0.03	1.00

Notes: All variables are expressed in logarithmic form. This table reports the pairwise Pearson correlation coefficients for daily returns of WTI futures and gold futures from Jan 2020- Dec 2020.

Table 6. Shows the results of pairwise Pearson correlation coefficients for the period from January 1, 2020, to December 21, 2020, and found negative correlation i-e -0.0749 between futures of WTI returns. Gold futures returns during the first wave of COVID-19. This correlation is restively high than in the previous period. The correlation during this period went negative. (Inverse relationship). Moreover, the WTI spot returns are minutely correlated to the gold spot returns during the same period.

## **METHODOLOGICAL APPROACH**

To empirically examine gold futures as a safe-haven for crude oil futures during the COVID-19 pandemic period. The volatile behaviour of WTI futures pushed the investors towards gold futures. To investigate this relationship empirically, the DCC GARCH model has been employed. The DCC-GARCH approach was proposed in 2002 and attained considerable attention for investigating the dynamic conditional correlation of volatile series (Engle 2002) and time-varying correlation structures of financial markets (Bouri et al. 2017). Concerning previous studies (Kumar 2014; Al

Maadid et al. 2017; Shrydeh et al. 2019; Corbet, Larkin, and Lucey 2020; Zheng and Su 2020), the model has been framed as:

$$R_t = L + \tau \tau' - 1 + \varepsilon_t \quad (2)$$

Where;  $\varepsilon_t = H^{1/2} \eta_t$

Where  $R_t$  is a log-return for price indexes, and  $L$  is the matrix of fixed-parameter.  $\tau$  is the coefficient matrix of the cross-mean transmission of own-lag values,  $\varepsilon_t$  is the error,  $\eta_t$  is the iid innovation matrix.  $H^{1/2} \eta_t$  is a conditional volatility matrix.

The covariance matrix;

$$H_t = D_t R_t D_t \quad (3)$$

Where;  $D_t = \text{diag}(\sqrt{h_t^x}, \sqrt{h_t^y})$  is the diagonal matrix of time-varying standard deviations at time  $t$  for asset  $x$  and asset  $y$  i-e,  $\text{diag}(\sqrt{h_t^{\text{Coil}}}, \sqrt{h_t^{\text{gold}}})$  is the time-varying standard deviations for futures of Crude oil and gold. While  $R_t$  expresses the conditional correlation matrix.  $\varepsilon_t$  denotes standardized returns.

$$R_t = \text{diag}(Q_t)^{-1/2} Q_t \text{diag}(Q_t)^{-1/2} \quad (4)$$

In the above equation,  $Q_t$  denotes time-varying conditional correlation of error term of

$$Q_t = (1 - \emptyset_1 - \emptyset_2) \bar{Q} + \emptyset_1 \xi_{t-1} \xi_{t-1}' + \emptyset_2 Q_{t-1} \quad (5)$$

Where;  $\emptyset_1$  and  $\emptyset_2$  - the non-negative scalar parameters, while  $\emptyset_1 + \emptyset_2 < 1$  and  $\bar{Q}$  denote unconditional correlation matrix of standardized error term  $\xi_t$ .

The following regression model is considered for estimating the dynamics of the conditional correlations for the WTI-gold pair.

$$\rho_{xyt} = \alpha_0 + \delta_1 \text{GFC}_t + \delta_2 \text{Covid}_t + \varepsilon_t \quad (6)$$

In the above equation,  $\rho_{xyt}$  expresses the conditional correlation between WTI and gold at time  $t$ , derived from the bivariate DCC-GARCH approach. A dummy variable "Covid<sub>t</sub>" took a value "1" during the COVID-19 period (From January 2020 to December 2020) and was otherwise considered to be zero.  $\text{GFC}_t$ , additionally, is also considered to be a dichotomous variable that controls the DCC estimates during the turmoil period. In this study, April, with theoretical support, is considered as the peak period of crisis. The prices fell to negative, and the crude oil industry suffered huge losses (Yousaf and Ali 2020), and the investors switched to another market for hedging. These incudes, mainly cryptocurrency and gold (Corbet et al. 2020). In this regard,

this study found that gold futures have less fluctuation during the full sample period than crude oil futures. During GFC, the crude oil prices showed volatile behaviour. However, that fluctuation was low as compared to the COVID-19 period. While in April 2020, crude oil futures are observed to have high volatility (Figure 6).

Figure 6.

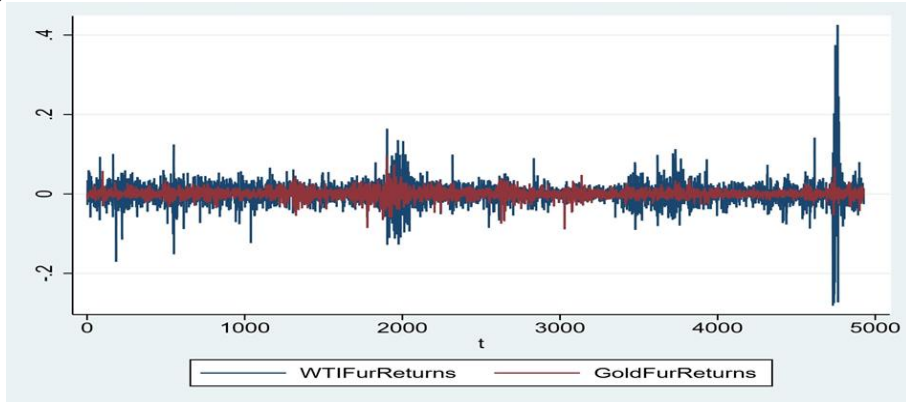


Table 7. Dynamic conditional correlation MGARCH model

WTI Future Returns Gold	Coeff.	St. Error	t-value	p-value	[95% Conf	Interval]	Sig
Constant	0.01	0	2.93	0.00	0	0.00	***
L.arch	0.19	0.01	12.17	0	0.16	0.22	***
L.garch	0.76	0.01	40.87	0	0.73	0.80	***
Constant	0	0	5.44	0	0	0	***
Constant	0	0	1.66	0.09	0	0	*
L.arch	0.12	0.01	11.72	0	0.10	0.14	***
L.garch	0.87	0.01	72.96	0	0.85	0.89	***
Constant	0	0	1.98	0.05	0	0	**
Constant	0.06	0.02	3.67	0	0.03	0.09	***
$\delta 1$	0.02	0.01	2.72	0.01	0.01	0.03	***
$\delta 2$	0.84	0.07	12.36	0	0.71	0.97	***
Mean dependent var	0.00	SD dependent var		0.01			
Number of obs	4698.00	Akaike crit. (AIC)		.			

\*\*\*  $p < .01$ , \*\*  $p < .05$ , \*  $p < .1$

Notes: This table reports the estimates of equation-6, \*\*\*, \*\* and \* indicate statistical significance at 1%, 5% and 10% levels respectively

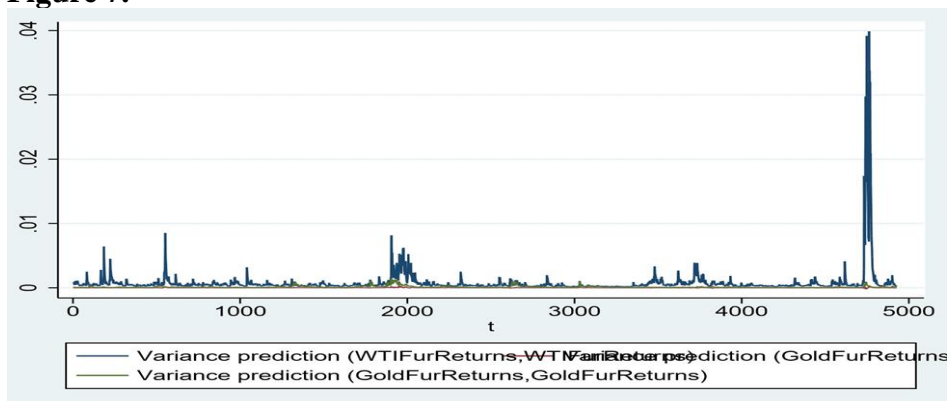
$$\hat{p}_{xyt} = \alpha_0 + \delta 1 \text{ GFC}_t + \delta 2 \text{ Covid}_t + \epsilon_t$$

$$= .001 + .022(\text{GFC}_t) + .845(\text{Covid}_t) + \epsilon_t$$

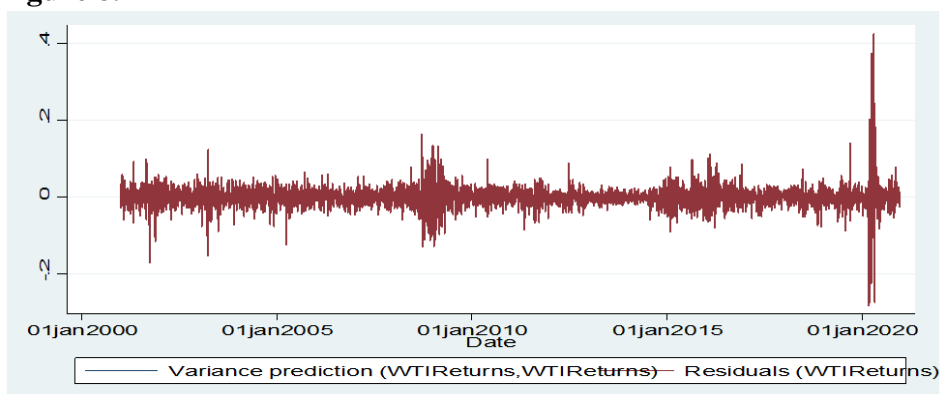
Empirical findings of DCC GARCH model, in Table 7, for the WTI and gold futures. It is also evident from Figure 6, that during the starting period

of COVID-19 there was a very low correlation between both commodities. The results from the above table, it is found that found a dynamic conditional correlation between WTI and gold futures as  $p < 5\%$ . Moreover, the volatility of both commodities. (L.GARCH) is high in Table 7 and equation 6, while estimating the volatility during GFC and COVID-19,  $\delta_1$  and  $\delta_2$  revealed a positive relationship of volatility. This correlation was relatively high during COVID-19 than GFC. One of the critical reasons is that there was a bearish trend in real estate prices than other commodities during GFC than crude oil (Joo et al. 2020). At the same time, COVID-19 has influenced the crude oil prices, even at the threshold, as the border was closed and restricted travelling activities (Narayan, 2020). The DCC-GARCH model results have revealed that .022 was the magnitude of the dynamic correlation between futures of crude oil and gold while .845 was during the COVID-19 period. In this case, gold does not play as a safe-haven against crude oil futures. Moreover, the variances (risk) of the DCC GARCH model have been plotted (Figure 7) and found that high risk is associated with WTI during the sample period, particularly during the COVID-19 period, then gold futures. In this situation, due to high volatility, the investors do not choose to hedge their funds by withdrawing from WTI and invest in gold futures (Zheng and Su 2020).

**Figure 7.**



**Figure 8.**



Noted: Variance prediction of WTI spot returns, WTI futures returns, and predicted residuals for the whole sample.

The above Figure 8. Reveals, by employing DCC-GARCH, that the residuals have no trend, while there is a variation in the residuals of returns of WTI futures. Thus, this study's empirical investigation concludes that the risk minimization of crude oil futures markets enables the investors to hold some investment in futures markets of crude oil as there found a sharp increase in futures of crude oil prices while the diversification is suggested by constructing a portfolio. However, the futures of gold, after this empirical evidence, are found to be positively correlated to crude oil futures. However, during the bearish period (COVID-19), the crude oil futures market has relatively high volatility than the gold futures market. The continuous fluctuations (Figure 4) have shown the volatile behaviour of crude oil futures. While the magnitude of correlation has been revealed that there found a dynamic correlation between both the commodity futures markets during 2020, there found an association between WTI and gold futures markets (Gil-Alana and Monge 2020).

## **CONCLUSION**

With the emergence of the COVID-19 pandemic, "the black swan," an economic recession has been encountering globally (Yarovaya et al., 2020). The overall slump leads to a downturn in the spot and futures prices of the financial and commodity markets. The global economic contraction increases the risk of the oil market being an internationally traded commodity. Similar to the global financial crisis (Sornette and Woodard, 2010). During this phase of economic depression, the demand and import of crude oil have been reduced due to lockdown, closure of borders, restricted travelling, and tourism. Resultantly, the prices of crude oil have been reduced, even went negative. The investors faced unexpected losses and tent to switch from the crude oil market to hedge their investment. There are some other instruments to diversify the portfolio, mainly the gold market. However, the selection of an alternate instrument depends upon the empirical analysis. The existing literature found that crude oil and gold spot prices are inversely correlated so that both commodities can be included in a diversified portfolio (Adekoya and Oliyide 2020a; Liu et al. 2020; Narayan 2020; Yarovaya et al. 2020).

This study focuses, for the sake of hedging investor's funds, on the futures of WTI and the gold market to explore the dynamic correlation between futures of both the commodities during GFC (Charles and Darné 2009) and COVID-19 (Sadik et al. 2019; Wang, Geng, and Meng 2019). The findings of existing research on this area, with spot prices, found that the gold market plays a role of safe-haven (Bedoui et al. 2019; Shahzad, Rehman, and Jammazi 2019; Tian, Li, and Wen 2020) for the investors of oil

market during COVID-19 (Syahri and Robiyanto 2020) and pre COVID period (Raza et al. 2016). Moreover, the performance of WTI with the gold market advocates the relationship. The widely used DCC GARCH model has been employed in this study to explore the dynamic relationship between WTI and gold futures (Tully and Lucey 2007; Jones and Olson 2013; Basher and Sadorsky 2016; Billio, Casarin, and Osuntuyi 2018; Gabauer 2020; Zhao 2020) and found the consistent results as the previous research explored (Bauwens, Laurent, and Rombouts 2006; Tully and Lucey 2007; Chen, Zheng, and Qu 2020; Ghosh, Sanyal, and Jana 2020; Wang et al. 2020; Yousaf and Ali 2020). This study concludes that there is a positive dynamic conditional correlation between futures of crude oil and gold. To address this study's research question, there found a positive DCC in the volatility of crude oil and gold futures during both crises, GFC and COVID-19, by applying the DCC-CARCH model.

While searching for a safe-haven asset, since long, there found many assets like currencies, exchange rate, foreign exchange, commodities, gold, silver palladium, and platinum (Baur and Lucey 2010; Baur and McDermott 2010; Ranaldo and Söderlind 2010; Sari, Hammoudeh, and Soytas 2010; The et al. 2015). While gold, among the metals, is considered a better option for hedging due to its less volatile nature (Adekoya and Oliyide 2020c). Since conditional-volatility is more persistent for gold and silver than other metals, non-financial businesses invest in non-precious metals than gold due to price concerns. Furthermore, the market news, good or bad, also influences the price of gold and silver (Hammoudeh and Yuan 2008). Due to this, the investors keep searching for other assets to hedge or diversify the portfolio risk. After GFC, 2008, a digital currency named Bitcoin was introduced and was used as a diversifier (Malladi and Dheeriya 2021).

Moreover, during the last decade, Bitcoin has been included in this debate. However, due to the volatile behaviour of Bitcoin, it is still unexplored that whether it behaves as a hedge or diversifier (Ali, Alam, and Rizvi 2020; Ji et al. 2020a; Ji, Zhang, and Zhao 2020b; Joo et al. 2020). However, oil price volatility influences some metals' volatilities. The investors in the commodity market look for the assets in terms of value or pricing options which can play a safe-haven for crude oil price volatility. So, oil price volatility provides an opportunity to switch from more volatile assets to less volatile assets for more diversification in portfolios and reduce risk. This study has some limitation regarding time constraints and availability of data. Secondly, it is difficult to find its implications on developing countries due to micro and macroeconomic level constraints.

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