# A Comparative Analysis on the Role and Market Linkages of Gold Backed Assets During COVID-19 Pandemic

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**Abstract**

Gold is a traditional favorite investment avenue for investors all over the globe, particularly during the crisis period. Irrespective of the nature of the crisis, investors are allocating their funds to different gold-backed assets. This paper uses various globally traded gold-backed assets to identify its role and market linkages during the Covid 19 pandemic. Daily prices of assets from March 2020 to January 2022 were employed. DCC GARCH model is used to ascertain time-varying correlations and quantile regression was employed to examine the relationship between assets in different quantiles. Based on the analysis, safe haven property of all the assets is revealed and it is associated with the severity of the stock market crash as specified by the quantiles. Moreover, double exposure of gold mining stock results in different flights to quality. Co-movement of gold bullion, gold futures, and gold volatility index is visible during this crisis. Gold Exchange Traded Funds and gold-backed cryptocurrency offer diversification by decoupling with gold bullion in the portfolio. The paper highlights the importance of the choice of gold-backed assets along with gold bullion in the investment portfolio based on its role and market linkages.

## 1. INTRODUCTION

Gold is a traditional favorite asset of investors all over the globe, and they consider it as a secured and safe investment during a crisis. Investors strongly believe that including gold in the portfolio will improve the portfolio's performance in terms of superior risk-adjusted returns during the crisis. This belief is rooted in the historical performance of gold prices during crisis and the unique investment characteristic of gold. Gold was considered a store of value, portfolio stabilizer, and a source of liquidity in times of unsettled market episodes (Chemkha *et al.*, 2021). According to Blose and Gondhalekar (2013), the primary driver of the gold price is based on key adverse events in the market. The Covid 19 pandemic has

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recently affected millions of lives and created a significant impact in the financial market. Among the financial assets, gold maintained its value when other markets declined and the gold price reached an all-time high during Covid 19 (Ji *et al.*, 2020). As per the World Gold Council report, the global gold demand raised to 4021.3 tons in 2021. The increase entailed gold bar and gold coins demand soaring at 31% compared to the previous year. There was a decrease in gold Exchange Traded Fund (ETF) demand compared to a record high of 874-tonne increase in 2020 (World Gold Council, 2022). Accordingly, we expect a shift in investment demand of gold-backed assets during different phases of the Covid 19 crisis. Consequently, it is imperative to study what role each asset exhibits during the recent pandemic and the market linkages on the various occurrences in gold market. The study seeks to provide information enough for the investors to make better portfolio decisions. The existing studies have mainly focused on the gold bullion and gold mining stocks leaving out the role of other gold-backed assets as a potential research gap. This study attempts to identify the role of each gold-backed asset in serving as hedge and safe haven instruments against international equity during the Covid-19 crisis. In addition, we also examine the degree of gold market linkages in terms of flight to quality, decoupling, and contagion during the Covid 19 crisis. The paper contributes to the extant literature in two main ways. Firstly, the study contributes to safe haven literature by identifying the role of alternative gold assets during Covid 19 rather than merely focusing on gold bullion. The study by Pullen *et al.* (2014) has already contributed in this regard but failed to identify the role during Covid 19 period. The second contribution is that this is the first study that identifies the dependence of gold and alternative gold assets in the gold market during Covid 19.

## 2. LITERATURE REVIEW

The present study is based on Modern Portfolio Theory advocated by Harry Markowitz in 1952. It states that the choice of an asset to include in the portfolio should be based on its correlation with other assets in the portfolio to minimize risk and diversify the portfolio. It means that a portfolio must be a combination of financial assets that are less perfectly correlated. In short, the basic idea behind the theory is not to "put all your eggs in one basket". The first theoretical model based on this theory was proposed by Baur and Lucey (2010) and extended by Baur and McDermott (2010). According to him, gold can act as a hedge in normal conditions, and in extreme market conditions or crisis periods, gold can serve as a safe haven. For this study, a significant negative correlation between gold or alternative gold assets and international equities during extreme market conditions or financial turmoil and a significant negative correlation on average will indicate gold's safe haven and hedging property and alternative gold assets.

Another crucial theoretical understanding is about market linkages during crisis time. Among the most common market dependence, contagion is most studied in literature and defined as "a strong co-movement between markets without fundamental linkages" (Forbes & Rigobon, 2002). This pattern is seen during the period of market turmoil. A hedge against equity can tend to co-move with equity during market turmoil due to investors' simultaneous selling of those assets. On the contrary, some assets do not commove with other assets that negatively correlate with stocks. Flight to quality can occur in such circumstances. A boom in one market accompanied by a crash in another market can be called the flight to quality (Hartmann *et al.*, 2004). Decoupling is another market linkage where there will be switching

of correlation from positive to negative during the crisis period (Forbes & Rigobon, 2002). For the present study, the definition for flight to quality, contagion, and decoupling is based on the Baur and Lucey (2010) model. The flight to quality is confirmed if the gold-stock correlation is positive during the normal period and becomes negative during the crisis or negative during normal period, and a significant negative change is seen in the crisis period. On the contrary, if there is a negative correlation between stock and gold during normal period and it becomes positive during turmoil period or if there is a significant increase in correlation which results in a positive correlation during turmoil period, it is considered a contagion. Decoupling is identified if there is a significant negative change in the stock-gold correlation, but the correlation remains positive during the turmoil.

Literature that explains the benefits of including gold-backed products in the portfolio and its hedging and safe haven characteristics is growing nowadays. Though literature which is available for the comparative role of different gold-backed instruments, except for gold bullion and gold mining stocks, pieces of evidence for all the other products are emerging in nature. The paper which expounds the performance of gold backed assets and the relevant literature in this regard is discussed below. The literature on the role of gold bullion is abundant. The first theoretical model in this regard is proposed by Baur and Lucey (2010) and they found that the safe haven property is based on the severity of stock market shock. By employing a 30 years sample, Baur and McDermott (2010) found that gold acts as a safe haven against developed markets during the crisis. The recent literature provides mixed results. Chkili (2016) shows that there is a negative relationship between gold and stock market during European debt crisis and global financial crisis imply the safe haven property of gold during crisis. Drake (2022) concluded that gold is neither a hedge nor a safe harbor in times of economic stress. According to Yousaf and Yarovaya (2022), gold offers protection for investors and portfolio managers against losses in a few of the Asian stock markets during the COVID-19 outbreak. Many other literature recently explores the safe haven property by studying the correlation between gold and stock market and concludes with mixed results (Naeem et al., 2022; Tronzano, 2022; Wen et al., 2022).

The literature on gold backed assets other than gold bullion is emerging in nature. Jaffe (1989) examined the impact of adding gold and gold mining stock into the portfolio and found that gold mining stock is not superior to gold since it increases its risk. At the same time, gold mining stock increases the portfolio's risk-adjusted return when replacing gold in the portfolio during the period of stock market losses. Chua et al. (1990) reported the diminishing diversification benefits of gold mining stocks due to an increase in beta value over the years. Conover et al. (2009) opined that adding a significant proportion of precious metal equities will enhance the portfolio's performance. According to Johnson and Lamdin (2015), gold mining stocks behave more like gold than equity, and they can be considered as a substitute in the diversified portfolio. As far as the risk reduction utility is concerned, gold is more preferred than gold stocks since the correlation between gold and equities is less than gold mining stocks. According to Areal et al. (2015), gold mining stocks are not a perfect substitute for gold since they do not act as a safe haven in financial turmoil. Lucey and O'Connor (2017) questioned the ability of gold mining stocks to act as a safe haven instrument since gold price is leading the gold mining stock. Paul et al. (2019) provides evidence for a positive correlation between gold and gold stocks. According to him, there is high coherency between gold and gold stocks, whereas it behaves independent of equity price resulting in diversification benefits of gold and gold stocks. The study by Dar et al. (2019) confirmed the weak safe

haven potential of the gold mining stock against equities, and it behaves more like gold in the US and UK. Baur *et al.* (2021) found that the performance of the gold stock as a safe haven depends upon the severity of the crisis. The safe-haven property of gold mining stock is evident during less extreme turmoil. More recently, Baur and Trench (2022) found that there is decoupling of gold mining stock price from gold price during the Covid 19 crisis.

There is a growing body of literature on other gold-backed products like gold futures, gold ETF, gold-backed cryptocurrencies, gold volatility index, etc. Gorton and Rouwenhorst (2006) argued that commodity futures in the portfolio would increase the portfolio's performance. According to Chong and Miffre (2009), commodity futures can be used as a better tool for strategic investment decisions, and the benefits of diversification can be attained even in turbulent periods. Ming *et al.* (2020) examined the gold's property of safe haven and hedge from the point of view of the Chinese investors by using gold futures as proxy and concluded that gold is not a hedge but a safe haven to domestic investors. On the contrary, Jaiswal and Uchil (2018) confirm that gold futures can be used to hedge against bond and stock movements in India but can not be considered as a robust safe haven. Mukul *et al.* (2012) found that gold ETF is negatively correlated with equities and therefore can hedge against risk. Emmrich and McGroarty (2013) pointed out that, although gold ETF can substantially reduce the portfolio's overall volatility, the gold bullion can provide a better risk-adjusted return. Cheng *et al.* (2020) reported that gold ETF is a strong safe haven against extreme fall in leading or lagged stock market and against exchange rate risk, similar to the characteristics of gold. Tanin *et al.* (2021) examined the effect of the gold volatility index on gold prices. They found that positive volatility diminishes the price of gold during the Covid 19 period, whereas the impact is negative in the pre covid period. Panagiotou (2021) pointed out that gold proxied by the volatility index can better protect the financial market uncertainty. It is evident from the quantile regression results that a decrease in gold volatility under average and extreme market conditions changes the value of ETF. Jalan *et al.* (2021) empirically tested the role of five gold-backed cryptocurrencies and gold against equities during the pandemic. They found that gold-backed cryptocurrencies do not show safe haven property like gold.

Although there is literature on the comparative performance of gold and gold-backed instruments and its role, a comprehensive examination in a dynamic perspective on major gold-backed instruments is lacking. One exception is the study of Pullen *et al.* (2014), in which he examined the safe haven and hedging characteristics of gold bullion, gold mutual funds, gold ETF, and gold stocks. The study reported that gold bullion has both the hedge and safe haven property, whereas gold ETF acts as a diversifier and safe haven. All other instruments are relatively less important to investors. Most of the gold-backed products have a recent origin, and studies are giving more attention to gold bullion and gold stocks, leaving room for further analysis of the role of other gold-backed products. Most of the studies are country-specific, and a global perspective is lacking. Further, the results of the present literature are inconclusive. The present study tries to fill all these gaps by identifying the role of gold and gold-backed instruments against international equities in a dynamic and global perspective and comparing the performance of gold and gold-backed financial instruments to determine their potential in the diversified portfolio. Regarding the linkages of various gold backed instruments, this is the first study that portrays the flight to quality, contagion, and decoupling in the gold market.

### 3. METHODOLOGY

The present study is undertaken in two stages. Initially, the time-varying conditional correlation was estimated using the DCC GARCH model, and the hedging and safe haven property of gold and gold-backed instruments is tested using it. In the second stage, the phenomenon of flight to quality, contagion, and decoupling were identified in the gold market using a model proposed by Baur *et al.* (2021). For the first objective, the study determines the contemporaneous dynamic correlation between the variables to examine the time-dependent relationship between the return of the stock, gold and alternative gold assets. DCC-GARCH model of Engle (1982) is employed for estimating the dynamic correlation. Since the model will provide a dynamic correlation between two or more time series, it is more suitable for the present study than other GARCH models. There are two steps involved in estimating the DCC-GARCH model. Parameters of the GARCH model will be computed firstly, and subsequently, dynamic conditional correlation (DCC) will be estimated. The equation for the same is:

$$H_t = D_t R_t D_t \tag{1}$$

$H_t$ represents n × n matrix of conditional covariance; $R_t$ represents the matrix of conditional correlation and diagonal matrix with dynamic standard deviations are provided by matrix $D_t$.

$$D_t = diag\left(h_{1,t}^{\frac{1}{2}}, \dots h_{n,t}^{\frac{1}{2}}\right) \tag{2}$$

$$R_t = diag\left(q_{1,t}^{-1/2}, \dots q_{n,t}^{-1/2}\right) Q_t \, diag\left(q_{1,t}^{-1/2}, \dots q_{n,t}^{-1/2}\right) \tag{3}$$

The symbol h represents univariate GARCH models. For the GARCH (1,1) model, $h_t$ is represented by the following equation:

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \varepsilon_{i,t-1}^2 \tag{4}$$

where $Q_t$ stands for symmetric non-negative definite matrix.

$$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} + \theta_{1z_{t-1}z'_{t-1}} + \theta_2 Q_{t-1} \tag{5}$$

where Q be a symbol of n × n matrix of unconditional correlation of the standardized residuals

$$Z_{i,t}\left(Z_{i,t} = \varepsilon_{i,t}/\sqrt{h_{i,t}}\right) \tag{6}$$

The parameters $\theta_1$ and $\theta_2$ are positive. The model determines only these parameters, which seems to be one of the merits of this model to arrive at an optimum solution.

The correlation estimator is

$$\rho_{i,j,t} = \frac{q_{i,j,t}}{\sqrt{q_{i,j,t}q_{j,j,t}}} \tag{7}$$

The present study will focus on $q_i,j$, and t representing the correlation between the returns of MSCI world equity index and gold or each alternative gold asset.

After estimating the dynamic conditional correlation for each asset, the next step is to run a regression with dummy variables of quantiles representing the extreme market conditions to ascertain the safe-haven role of gold and alternative gold assets against international equity.

The quantile regression of the estimated DCCs and binary variables is given as

$$DCC_i = \beta_0 + \beta_1 D_{q1} + \beta_2 D_{q5} + \beta_3 D_{q10} + \text{€} \qquad (8)$$

where DCC$_i$ represents the dynamic conditional correlation between gold and each asset with that of international equity and dummy variables $Dq_1$, $Dq_5$, and $Dq_{10}$ representing extreme market conditions at 1%,5%, and 10% quantile of DCC, which will take the value equal to 1 below 1%,5%, and 10% quantile or 0 otherwise. This model is consistent with the safe-haven literature and follows the model of Wang *et al.* (2019).

The study is based on the definition of Baur and Lucey (2010). Accordingly, "a hedge (safe-haven) asset is an asset that is uncorrelated or negatively correlated with another asset or portfolio on average (in times of market stress or turmoil). A diversifier asset is an asset that is positively correlated with other assets on average". Gold and each alternative asset are a strong (weak) hedge if $\beta_0$ is significantly(insignificantly) negative. Gold and alternative gold assets are strong(weak) diversifiers if $\beta_0$, $\beta_1$, $\beta_2$, and $\beta_3$ significantly (insignificantly) positive.

To achieve the second objective, the model of Baur *et al.* (2021) was employed. The equation for the same is

$$r_{i,t} = a + \beta_1 r_{Gold,t} + \beta_2 r_{Gold,t} 1\{r_{s,t} < q_5\} + e_{i,t} \qquad (9)$$

where $r_{i,t}$ is the return of each alternative gold asset, $r_{gold,\,t}$ represents the return of gold, and $r_{s,t}$ is the return of stock at 5% quantile. Contagion, decoupling or flight to quality is examined by checking and justifying the signs of β1 and β2. A flight from alternative gold assets to gold is recognized if β2<0 and β1 + β2<0. A contagion between alternative gold assets and gold is identified if β2>0 and β1 + β2>0. Decoupling is confirmed if β2<0 and β1 + β2>0. This is in accordance with the safe-haven literature and consistent with that of Chang *et al.* (2021). For robustness check, GARCH (1,1) model is replaced with GARCH (2,1) model during the first stage of DCC-GARCH model and fitted the DCC-GARCH model.

## 4. DATA AND PRELIMINARY ANALYSIS

The present study aims to identify the role of gold and gold-backed assets against international equity through their time-varying relationship measured by Dynamic Conditional Correlation (DCC). It also identifies flight to quality, contagion, and decoupling phenomenon in the gold market during Covid 19. The study period is from 1$^{st}$ March 2020 to 31$^{st}$ January 2022, marked as the period of the Covid 19 crisis. However, the crisis started in December 2019; the study confines to the aforementioned period due to data availability for all the variables. The variables are daily prices of gold bullion (gold price in US dollar), gold mining stock (S&P/TSX Global gold index), gold ETF (SPDR gold shares), gold-backed cryptocurrency (Tether gold (XAUT)), gold futures (COMEX gold futures), CBOE gold volatility index (GVZ), and international equity (MSCI world equity index). The criteria for choosing these assets are the most traded asset proxies in the asset class. The details are given in Table no. 1.

**Table no. 1 – Details of variables**

| Sl No | Variables | Variable proxy | Source |
|---|---|---|---|
| 1 | Gold bullion | Gold price in US dollar | World Gold Council |
| 2 | Gold mining stock | S&P/TSX Global gold index | S& P Global |
| 3 | Gold ETF | SPDR gold shares | Singapore stock exchange |
| 4 | Gold backed cryptocurrencies | Tether gold (XAUT) | Coinmarketcap.com |
| 5 | Gold volatility index | CBOE gold volatility index (GVZ) | CBOE |
| 6 | Gold futures | COMEX gold futures | Nasdaq |
| 7 | International equity | MSCI world equity index | MSCI |
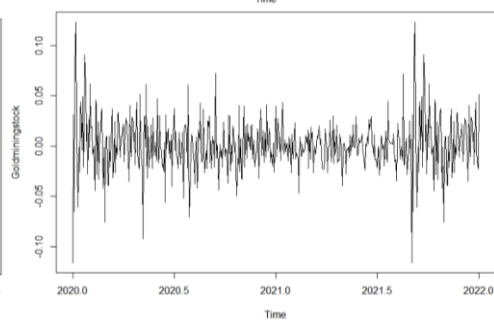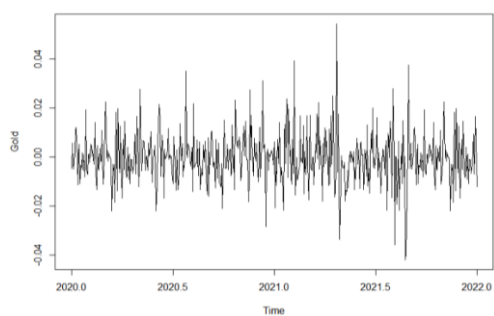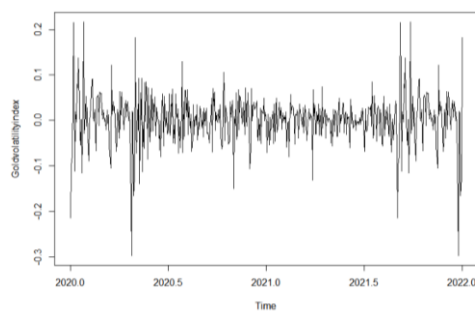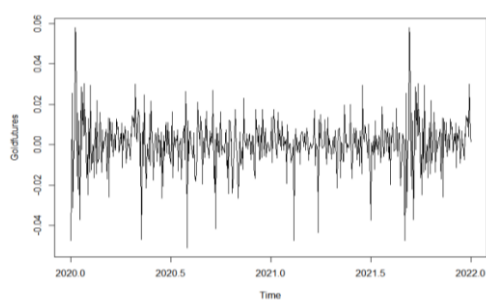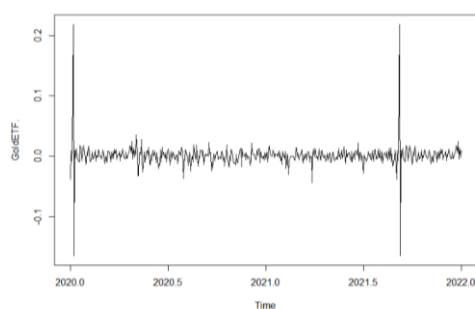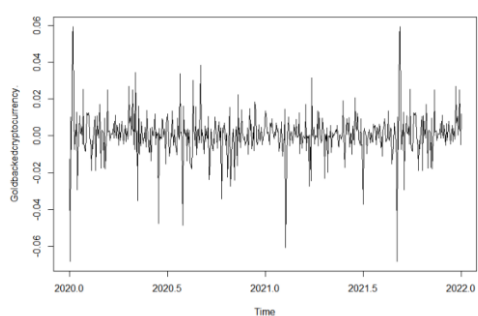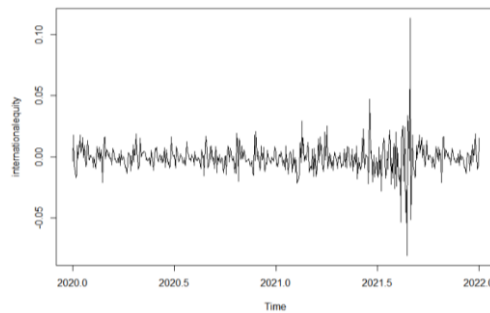
**Figure no. 1 – Return of gold bullion, gold backed assets and international equity**

The changes in the volatility of returns are depicted by time-series graphs of returns (Figure no. 1). There is volatility clustering present in each time series, which further provides evidence of ARCH effects in each series. The confirmed conditional heteroscedasticity also validates the use of GARCH(1,1) to depict the volatile nature of the returns. Hence all these results confirm that the GARCH model is appropriate.

The descriptive statistics of the variables are provided in Table no. 2. Panel A represents descriptive statistics of the returns, and panel B is the unit root test of the returns

**Table no. 2 – Summary statistics of variables**

| | | | | PANEL A | | | |
|---|---|---|---|---|---|---|---|
| **Descriptive statistics** | **MSCI All Country Equity Index** | **Gold Bullion** | **Gold volatility index** | **Gold mining stock** | **Gold futures** | **Gold ETF** | **Gold backed Crypto-currency** |
| Observations | 444 | 444 | 444 | 444 | 444 | 444 | 444 |
| Mean | -0.001231 | -0.000328 | 0.001496 | 0.000293 | 0.000289 | 0.000349 | 0.000296 |
| Median | -0.001563 | -0.000510 | 0.004367 | -0.000933 | 0.000818 | 0.000423 | 0.000410 |
| Maximum | 0.113330 | 0.054291 | 0.216817 | 0.123459 | 0.058053 | 0.218821 | 0.059298 |
| Minimum | -0.080689 | -0.041877 | -0.297680 | -0.116227 | -0.051140 | -0.165397 | -0.068139 |
| Std.Dev | 0.012020 | 0.010672 | 0.049514 | 0.023817 | 0.012142 | 0.016195 | 0.011292 |
| Skewness | 1.129659 | 0.425590 | -0.500947 | 0.193974 | -0.404029 | 2.971216 | -0.653548 |
| Kurtosis | 26.75096 | 6.087894 | 8.23514 | 6.795101 | 7.2155728 | 100.4457 | 12.17862 |
| Jarque_Bera | 10530.45 | 189.8025 | 525.5985 | 269.2360 | 189.8025 | 176326.4 | 1590.178 |
| (Probability) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| | | | | PANEL B | | | |
| **Unit root test** | **MSCI All Country Equity Index** | **Gold Bullion** | **Gold volatility index** | **Gold mining stock** | **Gold futures** | **Gold ETF** | **Gold backed crypto currencies** |
| ADF | -12.902*** | -20.192*** | -21.851*** | -21.380*** | -22.644*** | -28.302*** | -21.427*** |
| PP | -23.175*** | -20.352*** | -22.482*** | -21.487*** | -23.040*** | -30.982*** | -21.909*** |
| KPSS | 0.6650 | 0.2104 | 0.0543 | 0.2153 | 0.1678 | 0.2668 | 0.1991 |

*Note*: *** Significant at 1% level

The mean returns of all the variables are almost close to zero. The standard deviation of the variables indicates that the gold volatility index is the most volatile asset, followed by gold mining stocks and gold futures. In contrast, gold bullion is the least volatile asset. Kumar (2020) also identified gold bullion as the least volatile asset. Gold volatility index and gold ETF are characterized by extreme fluctuation as evident from the maximum and minimum

values. Mean returns for all the series are close to zero. The coefficient of kurtosis shows that the time series' returns were not normally distributed, and the series is leptokurtic. Furthermore, the JB test confirms that the distribution is not normal as the null hypothesis is rejected at 1% significant level for all the variables. The stationary tests, ADF, PP tests indicate the significant test statistics at 1% significance level, which means the rejection of the null hypothesis. It means that the variables are stationary and thus appropriate for further econometric analysis. The null hypothesis of the KPSS test is 'returns are stationary', which is accepted in the all-time series, indicated by an insignificant coefficient.

**Table no. 3 – Pearson Correlation matrix**

|  | MSCI All Country Equity Index | Gold Bullion | Gold volatility index | Gold mining stock | Gold futures | Gold ETF | Gold backed Crypto-currency |
|---|---|---|---|---|---|---|---|
| MSCI All Country Equity Index | 1 | 0.192*** | -0.014 | 0.016 | 0.040 | -0.014 | 0.157*** |
| Gold Bullion | 0.192*** | 1 | 0.019 | -0.006 | 0.073 | 0.031 | 0.069 |
| Gold volatility index | -0.014 | 0.019 | 1 | 0.139*** | 0.085 | 0.136*** | -0.009 |
| Gold mining stock | 0.016 | -0.006 | 0.139*** | 1 | 0.012 | 0.257*** | 0.219*** |
| Gold futures | 0.040 | 0.073 | 0.085 | 0.012 | 1 | 0.173*** | 0.157*** |
| Gold ETF | -0.014 | 0.031 | 0.136*** | 0.257*** | 0.173*** | 1 | 0.173*** |
| Gold backed Cryptocurrency | 0.157*** | 0.069 | -0.009 | 0.219*** | 0.157*** | 0.173*** | 1 |

*Note*: *** Significant at 1% level

Pair-wise correlation between asset classes shows that gold and gold-backed products are positively correlated during the Covid 19 period except for gold and gold mining stock, gold volatility index and gold-backed cryptocurrencies. Gold mining stocks decrease in value when there is an increase in the gold price, which implies flight to quality between gold and gold mining stocks. A similar relationship is also found between the gold volatility index and gold-backed crypto currency. Regarding the relationship of gold and gold-backed assets with the international equity index, there is a negative correlation between the gold volatility index and gold ETF with that of the international equity index.

**Table no. 4 – ARCH and Ljung-Box Q test**

|  | Q | ARCH(1) | ARCH(5) |
|---|---|---|---|
| Gold Bullion | 91.756*** (Q1) | - | 27.262*** |
| Gold volatility index | 101.35*** (Q1) | 6.8809*** | 30.187*** |
| Gold mining stock | 11.902 (Q4) | 10.774*** | 14.691*** |
| Gold futures | 15.997*** (Q6) | 8.6197*** | 19.294*** |
| Gold ETF | 35.901*** (Q1) | 81.00*** | 424.78*** |
| Gold backed Cryptocurrency | 4.4120*** (Q3) | 6.9947*** | 44.576*** |
| International equity index | 21.674 (Q4) | 16.291*** | 237.55*** |

*Note*: *** Significant at 1% level

There will be issues related to serial correlation in time series data. Under such a situation, the most appropriate model is the GARCH model. Table no. 4 provides the test statistics for serial correlation and heteroscedasticity. It was found that the serial correlation is present in all variables. In addition, the Engle (1982) test was significant, indicating the presence of heteroscedasticity in returns. The presence of serial correlation and ARCH effects justify the choice of GARCH model to study the dynamic link between gold, gold-backed assets, and the international equity index.

## 5. RESULTS AND DISCUSSION

The first step is to estimate the GARCH(1,1) model parameters to compute the dynamic variance of the return series. The computed parameters are provided in Table no. 5. The parameters of ARCH and GARCH estimated are $\alpha$ and $\beta$ respectively. The results indicate a high level of volatility persistence as interpreted from the addition of the parameters $\alpha$ and $\beta$, which is close to unity. This also shows the goodness of fit of the model. It was also observed that $\alpha$ has a low value and $\beta$ has a high value, which shows the resistance of correlation to shocks, and it relapses to mean very quickly. This is an indication of a stable correlation among variables. The value of the $\beta$ for all the return series is close to one. This indicates the high persistence of volatility over the period.

**Table no. 5 – Parameters of Univariate GARCH (1,1) model**

| Return | Parameters | Estimate |
|---|---|---|
| MSCI | C | -0.001066*** |
|  | $\alpha$ | 0.260618*** |
|  | $\beta$ | 0.738382*** |
| Gold bullion | C | -0.000154 |
|  | $\alpha$ | 0.014584*** |
|  | $\beta$ | 0.984416*** |
| Gold ETF | C | 0.000330 |
|  | $\alpha$ | 0.259773 |
|  | $\beta$ | 0.739227*** |
| Gold backed Cryptocurrency | C | 0.000158 |
|  | $\alpha$ | 0.002281*** |
|  | $\beta$ | 0.996005*** |
| Gold futures | C | 0.000086 |
|  | $\alpha$ | 0.008525*** |
|  | $\beta$ | 0.984910*** |
| Gold mining stock | C | -0.000190 |
|  | $\alpha$ | 0.028749** |
|  | $\beta$ | 0.959235*** |
| Gold volatility index | C | 0.000389 |
|  | $\alpha$ | 0.021478 |
|  | $\beta$ | 0.971576*** |

*Note*: *** Significant at 1% level

The present study estimated the DCC-GARCH model with a multivariate student t distribution to consider the non-normality in the return distribution. Table no. 6 provides the parameter estimates of the DCC GARCH model

**Table no. 6 – Parameter estimates of DCC GARCH (1,1) model**

| Return | Parameters | Estimate |
|---|---|---|
| MSCI -Gold Bullion | $\theta_1$ | 0.002199 |
|  | $\theta_2$ | 0.882289*** |
| MSCI- Gold ETF | $\theta_1$ | 0.025309 |
|  | $\theta_2$ | 0.961068*** |
| MSCI-Gold-backed cryptocurrency | $\theta_1$ | 0.014821 |
|  | $\theta_2$ | 0.838556*** |
| MSCI-Gold futures | $\theta_1$ | 0.000916 |
|  | $\theta_2$ | 0.979012*** |
| MSCI-Gold mining stock | $\theta_1$ | 0.000000 |
|  | $\theta_2$ | 0.919124*** |
| MSCI-Gold volatility index | $\theta_1$ | 0.003542 |
|  | $\theta_2$ | 0.987919*** |

*Note*: *** Significant at 1% level

The correlation was persistent, as implied by the parameters $\theta_1$ and $\theta_2$, of the estimated DCC model. The sum of $\theta_1$ and $\theta_2$ was closer to unity, indicating that the dynamic correlation was more apparent and stronger. The value of DCC coefficients fluctuates between $-1$ and $+1$. A closer coefficient to -1 indicates a strong and negative correlation between international stock and gold products. Coefficient more close to +1 implies a stronger positive correlation between the international stock index and gold products. A coefficient of zero indicates that there is no association between the variables.

**Table no. 7 – Estimate of regression analysis between DCC and dummy quantile variables**

| Variables | β0 | β1 | β2 | β3 |
|---|---|---|---|---|
| Gold bullion vs. MSCI world index | 0.1460017 | -0.0058188 | -0.0022186 | -0.0079343 |
|  | (686.883 )** | (-2.708 )* | (-1.642) | (-8.523)* |
| Gold Volatility Index vs. MSCI world index | -0.005771 | -0.072423 | 0.007519 | 0.027818 |
|  | (1.816 )*** | (-11.476 )* | ( 1.023) | (5.472)* |
| Gold-backed cryptocurrencies vs. MSCI world index | 0.017057 | -0.088768 | 0.026972 | 0.025338 |
|  | (7.590)* | (-14.163 )* | (3.419)* | (4.612)* |
| Gold ETF Vs. MSCI world index | 0.085886 | -0.312932 | 0.038404 | 0.091063 |
|  | (17.763) ** | (-19.663 )*** | (1.878 )*** | ( 6.341)* |
| Gold futures Vs. MSCI world index | 0.0758177 | -0.0007065 | -0.0005552 | -0.0056961 |
|  | (425.384)* | ( -0.393 ) | (-0.491) | ( -7.306)* |
| Gold mining shares Vs. MSCI world index | 0.00236 | -5.922 | -9.511 | -4.104 |
|  | (2050.30)* | (-0.2870) | (-1.417) | (8.955)* |

*Note*: ***significant at 1%  **significant at 5%   * significant at 10%

It could be observed from Table no. 7 that the value of $\beta_0$ is negative and significant only for the gold volatility index, which means that the gold volatility index is a strong hedge against the international equity market during Covid 19. All other gold products exhibit a positive and significant relationship with international equity and act as a diversifier, according to Baur and Lucey (2010). Gold bullion consistently shows safe haven property irrespective of severity, but the effectiveness of the safe-haven property varies with the severity of market conditions. Gold bullion is a strong safe haven at 1% and 10 % quantile, whereas the property weakens at a 5% level of severity. This is in line with the findings of Baur and Lucey (2010) that the safe haven property of gold depends on the severity of market conditions. Investors looking for safe-haven characteristics of gold investment cannot entirely

rely on alternative gold assets during Covid 19;instead, they will prefer to invest in bullion. This is consistent with the findings of Pullen *et al.* (2014).

Similarly, gold futures and gold mining stocks act as strong safe havens at lower quantiles, and the safe-haven characteristics weaken at extreme quantiles. It could be inferred from the table that the level of severity of market condition has an inverse relationship with the safe-haven property of gold mining stock and gold futures. This inference agrees with the comparable finding of Baur *et al.* (2021). According to him, investors prefer gold bullion in times of extreme market conditions due to its tangibility, whereas they are less concerned about tangibility in less extreme market conditions. All other gold products act as strong safe haven at 1% quantile and diversifier in lower quantiles and normal periods. This indicates that, although the gold ETF, gold volatility index, and gold-backed cryptocurrency solely derive returns from the gold bullion, they are not matching with the safe haven property of gold bullion in all quantiles. This finding is parallel to the findings of Panagiotou (2021) that investors may choose gold as a shelter during economic downturns.

## 6. CONTAGION, FLIGHT TO QUALITY, AND DECOUPLING ANALYSIS

To analyze the dependence of gold bullion and other gold products in the market, model of Baur *et al.* (2021) is employed to identify the phenomenon of flight to quality, decoupling, and contagion in the market. The results are depicted in Table no. 8.

**Table no. 8 – Identification of flights, contagion and decoupling among gold and gold like assets**

| Variables | β 2 | β1+ β2 | Remarks |
|---|---|---|---|
| Gold futures-Gold | 0.1207478 | 0.1528299 | Contagion |
| Gold volatility index-Gold | 0.116594 | 0.15316 | Contagion |
| Gold ETF-Gold | -0.0055716 | 0.0438078 | Decoupling |
| Gold mining stock-Gold | -0.2387750 | -0.1515726 | Flight to quality |
| Gold-backed crypto currency-Gold | -0.0195142 | 0.0618518 | Decoupling |

It is evident from Table no. 8 that during the period of Covid 19, flight to quality occurred from gold mining stocks and international equity to gold (Table no. 6) when there was a drastic fall in the stock market. Similar to the findings of Baur *et al.* (2021), there are two types of flight to quality among gold, gold mining stock, and international equities. When there is a fall in the stock market, investors prefer to invest in gold by shifting funds from gold mining stock during Covid 19. This is supported by the previous finding that the gold mining stock did not provide diversification benefits in the highly severe market, and gold bullion offers a strong safe haven. The flight to quality mainly happens in the highly severe market. The markets of gold bullion and gold futures, gold volatility index and gold bullion exhibit contagion. Whenever there is a crash in the gold bullion market, there will be a sell-off in gold futures and gold volatility markets. There is a positive correlation in these markets, which will reduce the benefits of diversification during Covid 19. The most dependent gold markets are gold futures, gold volatility index and gold bullion market. A severe decline in the stock market will also change the positive correlation between gold bullion and gold-backed cryptocurrencies, and gold bullion and gold ETF to negative offering diversification benefits in the portfolio during Covid 19. This is consistent with the findings of Mukul *et al.* (2012).

## 7. ROBUSTNESS ANALYSIS

As a check for the robustness of the results and to strengthen the findings, a robustness analysis with GARCH(2,1) model is conducted. In this analysis instead of GARCH(1,1), the first stage of DCC Model is performed with GARCH(2,1). The results are depicted in Table no. 9.

**Table no. 9 – Parameters of Univariate GARCH (2,1) model**

| Return | Parameters | Estimate |
|---|---|---|
| MSCI | C | -0.001129*** |
|  | $\alpha_1$ | 0.047841 |
|  | $\alpha_2$ | 0.401354*** |
|  | $\beta$ | 0.536786 |
| Gold bullion | C | -0.000156 |
|  | $\alpha_1$ | 0.000001 |
|  | $\alpha_2$ | 0.016730 |
|  | $\beta$ | 0.982269*** |
| Gold ETF | C | 0.000697 |
|  | $\alpha_1$ | 0.039549 |
|  | $\alpha_2$ | 0.300462*** |
|  | $\beta$ | 0.658989*** |
| Gold backed Cryptocurrency | C | 0.000164 |
|  | $\alpha_1$ | 0.001618 |
|  | $\alpha_2$ | 0.000198 |
|  | $\beta$ | 0.996528*** |
| Gold futures | C | 0.000061 |
|  | $\alpha_1$ | 0.000162 |
|  | $\alpha_2$ | 0.006231 |
|  | $\beta$ | 0.989180*** |
| Gold mining stock | C | -0.000250 |
|  | $\alpha_1$ | 0.000000 |
|  | $\alpha_2$ | 0.033602 |
|  | $\beta$ | 0.951883*** |
| Gold volatility index | C | 0.000304 |
|  | $\alpha_1$ | 0.000000 |
|  | $\alpha_2$ | 0.016202 |
|  | $\beta$ | 0.978032*** |

*Note*: ***Significant at 1% level

The parameters of univariate GARCH(2,1) model indicate that there is high persistence of volatility as indicated by the addition of ARCH and GARCH parameters. This also shows the goodness of fit model. The low value of ARCH parameters indicates that there is high resistance of correlation to shocks. The high value of GARCH parameter ($\beta$) shows the high persistence of volatility during the period. The second stage is to estimate DCC GARCH model using the initial univariate GARCH model and extract Dynamic Conditional Correlation from the model. The results of the DCC-GARCH model are depicted in Table no. 10.

**Table no. 10 – Parameter estimates of DCC GARCH (1,1) model**

| Return | Parameters | Estimate |
|---|---|---|
| MSCI -Gold Bullion | $\theta_1$ | 0.002199 |
| | $\theta_2$ | 0.882289*** |
| MSCI- Gold ETF | $\theta_1$ | 0.014827 |
| | $\theta_2$ | 0.973266*** |
| MSCI-Gold-backed cryptocurrency | $\theta_1$ | 0.014504 |
| | $\theta_2$ | 0.843189*** |
| MSCI-Gold futures | $\theta_1$ | 0.000000 |
| | $\theta_2$ | 0.942489*** |
| MSCI-Gold mining stock | $\theta_1$ | 0.000000 |
| | $\theta_2$ | 0.919763*** |
| MSCI-Gold volatility index | $\theta_1$ | 0.000000 |
| | $\theta_2$ | 0.921790*** |

*Note*: ***Significant at 1% level

The sum of parameters of estimated DCC model is close to unity indicating that the correlation is persistent and stronger. The DCC has extracted from the model and a regression analysis was performed using dynamic conditional correlation as dependent variable and 1%,5% and 10% quantile dummies as independent variables. The results are depicted in Table no. 11.

**Table no. 11 – Estimate of regression analysis between DCC and dummy quantile variables**

| Variables | β0 | β1 | β2 | β3 |
|---|---|---|---|---|
| Gold vs. MSCI world index | 0.141376 | -0.001324 | -0.001723 | -0.001196 |
| | (2631.22 )*** | (-11.893 )*** | (-27.462)*** | (-3.973)*** |
| Gold Volatility Index vs. MSCI world index | -0.002222 | -0.070930 | 0.005703 | 0.026018 |
| | (-0.788 ) | (-12.004 )*** | ( 0.815) | (5.370)*** |
| Gold-backed cryptocurrencies vs. MSCI world index | 0.018124 | -0.050121 | -0.072459 | 0.007927 |
| | (8.214)*** | (-11.449)*** | (-13.749)*** | (1.921)* |
| Gold ETF bullion Vs. MSCI world index | 0.059052 | -0.210880 | 0.020905 | 0.055198 |
| | (18.497) *** | (-20.017)*** | ( 1.544) | (5.802)*** |
| Gold futures Vs. MSCI world index | 0.07011 | 0.002883 | -0.000516 | -0.001748 |
| | (897.709)*** | (-7.665) | (-1.017)*** | (-2.236)** |
| Gold mining shares Vs. MSCI world index | 0.01889 | 0.001076 | -0.0097 | -0.00242 |
| | (3149)*** | (-1.272) | (-3.278)** | (-15.702)*** |

*Note*: ***significant at 1%   **significant at 5%   * significant at 10%

The findings are broadly in line with the previous findings using GARCH(1,1) model. The β0 is negative primarily for Gold volatility index indicating that it acts as a hedge during normal fluctuations in international equity. Since $B_0$ value for all other assets is positive, it implies that they can act as a diversifier in the portfolio of international equity as per Baur and Lucey (2010) definition. Gold bullion acts as a strong safe haven in all market conditions. Gold mining shares and gold futures exhibit safe haven property at lower quantiles during Covid 19. Gold ETF and Gold backed cryptocurrencies are safe haven in only extreme market conditions and the effectiveness of safe haven property decreases as the severity of stock market falls pile up during Covid 19.

## 8. CONCLUSION AND IMPLICATION OF THE STUDY

The present study examines the dynamic relationship between gold, alternative gold assets, and international equity during Covid 19. It also identifies the linkages between gold and gold backed investments to identify the phenomenon of flight to quality, contagion, and decoupling in the gold market during Covid 19. It was found that gold bullion was the ultimate safe haven during Covid 19, and gold futures and gold mining stocks resemble gold, particularly in lower extreme markets. Assets whose return solely focus on gold bullion, such as gold ETF, gold volatility index, and gold-backed cryptocurrencies, exhibit safe haven property only in higher extreme market conditions. The most dependent gold markets are gold futures, gold volatility index, and gold bullion market and thereby provides lesser diversification benefits in the portfolio. Decoupling occurs for gold bullion, gold-backed cryptocurrencies, and gold ETF, as a result, increasing the potential of including these assets in a diversified portfolio. In short, it could be concluded from both the analysis that gold futures, gold volatility index, and gold mining stock can act as close but not perfect substitutes for gold bullion in the portfolio. At the same time, gold ETF and gold-backed cryptocurrencies can become a complimentary product along with gold bullion in the portfolio during Covid 19. The study implies that, during a stock market fall, it is advisable to make a portfolio of alternative gold assets and other assets by considering the investment characteristics of the assets and the underlying phenomenon in the gold market. Including gold cryptocurrencies, gold ETF and gold bullion, and international equity will provide diversification benefits both in normal and extreme market conditions during Covid 19. Investors can add either gold bullion or gold volatility index or gold futures to the portfolio to get the benefits of diversification during Covid 19 period, since these are close substitutes for gold bullion. But the choice of these assets depends on the severity of market conditions. If there is a severe stock market fall, adding a gold volatility index or gold bullion to the portfolio is better; otherwise, gold futures are preferable. The study confines to the period of pandemic and explores the relationship between alternative assets represented by proxies for each asset. Future studies can use different proxies and verify the results of the current study. Coverage of other crisis periods is also added as scope for further research.

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