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Do oil, gold and metallic price volatilities prove gold as a safe haven during COVID-19 pandemic? Novel evidence from COVID-19 data

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ABSTRACT

The spreading COVID-19 outbreak has wreaked havoc on the world's financial system that raises an urgent need for the re-evaluation of the gold as safe haven for their money because of the unprecedented challenges faced by markets during this period. Therefore, the current study investigates whether different asset class volatility indices affect desirability of gold as a safe-haven commodity during COVID-19 pandemic. Long run and the short run relationship of gold prices with gold price volatility, oil price volatility, silver price volatility and COVID-19 (measured by the number of deaths due to COVID) has been analyzed in the current study by applying ARDL Bound testing cointegration and non linear ARDL approach on daily time series data ranging from January 2020 to Dec 2021. Findings of the study suggest that in the long run, oil price volatility and gold price volatility positively affect the gold prices, whereas the effect of silver price volatility on gold prices is negative in the long run. However in the short run, all the three indices negatively impact the gold prices. In contrast, the impact of COVID-19 is positive both in the short run and in the long run that proves the validity of gold as safe haven asset in the time of the deadly pandemic. The findings of this study have significant implications and offer investors with some indications to hedge their investments by considering the gold's ability of safe haven during this era of pandemic.

1. Introduction

Since its beginning in early 2020, the COVID-19 health disaster has been bringing disaster and suffering all over the world. The World Health Organization (WHO) classified this contagious infection a pandemic on March 11th' 2020. The novel Corona disease spread rapidly and infected 215 states (China, Iran, Italy, Spain, France, the United Stated, the United Kingdom, etc). As a consequence, a variety of measures were implemented in many nations to help curb the spread of disease. Social separation, workplace closures, the restriction of air travel and transportation, and the implementation of partial or complete lockdown are mentioned as precautionary measures taken by the governments to prevent its spread. According to the Raven Pack site, the intensity of press discourse about Corona virus fear or panic reached on March 30th. The COVID 19 panic index has the following figures on this date: in the world (9.24), Italy (13.39), USA (11.33), Iran (36.87), Brazil (36.57) (Atri, Kouki, & imen Gallali, 2021).

The effect of the COVID 19 pandemic is not restricted to deaths, infections, psychological harm but also has a significant economic impact. This historic global health catastrophe is wreaking havoc on the

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economy causing financial instability and posing a global threat. COVID-19 affects the whole financial sector including banking, insurance and stock markets (Goodell and Huynh, 2020). Financial markets are declined and become exceedingly volatile since the outbreak of this pandemic, followed by a decline in oil and metal pricing. This outbreak has also caused an unprecedented collapse in commodities markets that are fluctuating in response to pandemic information crippling the economy. Borders were closed and communities have been quarantined as a result of the COVID-19 outbreak, which has slowed activity and limited trading in products and commodities among countries. The supply of commodities frequently greatly exceeded demand in this situation, resulting in a decline in commodity prices. Following the financial crisis and the subsequent financial market panic, global investors switched their investments toward commodities markets, which was accompanied by a chaotic financial and macroeconomic situation as well as increased geopolitical concerns (Bampinas and Panagiotidis, 2015; Chaya et al., 2021; Haaskjold et al., 2021; Rodríguez et al., 2021).

The principal representative commodities of the commodity market have been the oil and gold primarily (Tuan et al., 2022). Basically gold is the most valuable metal in each century (Hoang, et al., 2015; Hoang, et al., 2015; Hoang et al., 2019; Hoang, et al., 2018). It has traditionally played a significant political and economic role. As a result, gold prices, along with oil prices, are two crucial indications in global markets Eryiğit (2017). In addition, Silver, like gold, has a wide range of uses and can even be used as an inflation hedge. Silver, in comparison to gold, is seen to have greater volatility according to metal experts Yaya et al. (2021). This health issue is wreaking havoc on transportation-related energy supplies, particularly oil. The oil price in particular has dropped at the worst possible time in 2020 Dutta et al. (2020). Other global factors, such as disputes among oil-producing nations are also contributing to the oil price drop Ali et al. (2020). In the context of excessive oil production, the oil export ban destabilized the market, resulting in an oil crash. On the other side, industries have been closed and industrial activity has been suspended in order to ensure physical separation in the workplace. As a result of such emergency measures, not only did energy consumption fall, but so did metals demand. Metals prices, which are highly related to world economy decreased in 2020 as a result of production and logistics chain disruptions as well as export restrictions. As a result of these circumstances, investors are becoming increasingly concerned about the increase in commodity prices during this worldwide health crisis. Alternatively, despite an increase of COVID-19 instances, the gold price was quickly rising (Atri et al. (2021)Given all of these changes, we believe the COVID-19 outbreak has prompted global investors to look flight-to-safety by purchasing an asset that as a safe-haven asset Tanin et al. (2021).This phenomenon has caught the interest of investors and regulators, resulting in a surge in investment demand for certain commodities. As a result, it is indeed critical for portfolio managers, policymakers and investors to grasp the dynamic relationships between oil, gold, and silver prices (Abubakari, 2021; Alawi, 2021; Alsahlawi, 2021; Dang et al., 2021)

To escape the complication, many investors (particularly non professionals) have typically put their money in gold, which has long been regarded as a trouble-free and safe haven Eryiğit (2017). Gold became a popular alternative hedge asset in various investment selections in the years after the financial crisis Kirkulak Uludag and Lkhamazhapov (2014). As a result, gold is seen as a safe-haven asset for all classes of investors especially in times of crisis as it helps them deal with economic and financial concerns. Agyei-Ampomah et al. (2014), Balcilar et al. (2016), Baur and McDermott (2010), Baur and Lucey (2010), Beckmann et al. (2015), Bilgin et al. (2018), Bouoiyour et al. (2018), Gürgün and Ünalmış (2014), Reboredo (2013b), Tanin et al. (2021) are among who found that gold is a safe haven in times of financial crisis(Afandi et al., 2021; Alkhaldi, 2021; Brüntrup, 2021;Fok et al., 2021;Gupta, et al., 2021Pierdzioch et al., 2022; Hu, 2021).

In light of the foregoing arguments, the present study seeks to examine how the various commodities indices under examination affect gold prices and its safe haven position. We specifically focus on three volatility indices namely gold price volatility index, silver price volatility index and oil price index (Maghyereh, and Abdoh, 2022;Arfaoui and Yousaf, 2022). Moreover, in current era of COVID-19 pandemic, the study also seeks to analyze the impact of COVID 19 pandemic on gold to evaluate whether gold keeps its safe haven properties in the period of pandemic or not. This research objective is significant from policy perspective as the financial markets, including the crude oil market are vulnerable to pandemics. The low volatility of gold, as well as its capacity to maintain wealth during inflation and protect investment during financial crises/uncertainties, are the primary reasons for its selection for this hedging purpose R. Chen and Xu (2019); Jebran et al. (2017); Uzo-Peters et al. (2018).The second reason for choosing gold is because Selmi et al. (2018)concluded that gold is a good hedging asset in the face of extreme oil price fluctuations. The third and strongest motivation for the study emanates from Q. Ji et al. (2020)who find strong hedging role for gold during COVID-19 pandemic when other potential asset classes are less effective. The study is going to answers the following research questions:

(a) Have various commodities volatility indices any effect on gold prices?
(b) Is there any effect of COVID-19 on the safe haven property of the gold?

There are two main contributions of our study toward the literature: first, instead of investigating the impact of commodity prices, our study estimates the impact of volatility in commodity markets on the gold prices because for new investors and producers, metal market volatility is an attractive topic. The implied volatility estimate is superior to the other aforementioned measures, according to the relevant literature. Implied volatility index is calculated from option pricing and published by the Chicago Board Options Exchange (CBOE). We suggest that implied volatility is indeed a better estimate of future volatility as compared to historical volatility because most option traders are well-informed professional traders. Implied volatility indices, in this way, reflect not just past volatility data, but also expectations of investors for future market circumstances Liu et al. (2013). As a result, they serve as a forward-looking indicator of market risk Bouri et al. (2017).However, the impact of commodity market volatility has not extensively been studied in the literature in the context of COVID 19 period. Therefore our study accompanies these few studies in the literature and is going to be a novel contribution to the present literature. Secondly, our study applies recently introduces ARDL bound testing co-integration approach, which has advantage over Johansen Cointegration approach as various benefits accompany this technique to estimate the long run relationship among the variables of the study Le and Chang (2016).Most importantly, it ignores the order in which the variables are integrated and can easily be applied no matter variables are integrated of order 0 or 1. However they should not be integrated of order 2 otherwise this technique does not work. Third, the findings of the study are significant in terms of policy recommendations for the investors and portfolio managers to select appropriate portfolio to hedge themselves from unforeseen fluctuations in financial markets during this ongoing deadly pandemic.

The rest of this paper is structured as follows: Section 2 gives brief review of the existing literature. Section 3 explains the data and the methodology employed in the study. Section 4 gives the results and their explanations. Section 5 concludes the study and provides policies to implement.

2. Literature review

In the existing literature, a number of studies are available that studied the safe haven properties of gold against volatility in different commodity and financial markets. For instance, Lodha (2017)studied

the short run and the long run interdependence between gold prices, crude oil prices and exchange rate. Applying Johansen Cointegration test, the findings reveal the absence of any long run interdependence among these variables. However, a bi-directional Granger causality was found to exist between exchange rate and crude oil, whereas unidirectional Granger causality was found to be running from crude oil prices to gold prices. Similarly, Dutta (2018) also found that in case of different commodities, there was no significant impact of oil prices on these commodities when he applied modified GARCH-jump models to estimate the impact of oil prices on different industrial and precious metals such as silver, gold and copper markets. In the same vein, Eryiğit (2017) estimated the important energy and metal variables that affected the gold prices. The findings of the VAR analysis revealed that gold prices had a short run correlation with palladium prices and silver prices, as well as a short run correlation was found between palladium prices and silver prices. In contrast, crude oil prices and gasoline did not find to have any long run association with gold prices. Reboredo (2013a) also concluded the same while he studied the role of gold as safe haven against the oil price movements over 2000 to 2011. According to the study's primary findings, the significant and positive average dependence between oil and gold, which would indicate that gold, was not a hedge against oil price, while the tail independence indicated that gold could act as an effective safe haven against oil price fluctuations.

In continuation, Wang and Chueh (2013) studied the long run and short run dynamic association among gold prices, oil prices, and U.S. dollar. Employing the threshold ECM model and threshold cointegration model over 1989 to 2007, the study found that gold price was positively related with crude oil prices in the short run. Moreover, a positive effect of oil prices was observed on gold future prices. Kearney and Lombra (2009) revealed a positive association between platinum and gold prices over period from 1985 to 2006. The positive correlation was observed in the years from 1996 to 2001 in the short run, and a negative association turned out in the later years. Likewise, Le and Chang (2012) tried to estimate the effects of oil price fluctuations on gold returns, over 1994 to 2011 period by applying the structural vector autoregressive (SVAR) model. They determined that the shocks in oil prices had a significant and positive association was observed between oil price shocks with real gold return. Moreover, the effect was found to be symmetric and non-linear(Miller and Wager, 2017).

Z. Chen et al. (2021)analyzed the impact of investor sentiments and VIX on volatility of five energy assets namely WTI oil spot and futures, Brent oil spot and natural gas spot and futures. VIX affected the five energy assets and investor sentiment and WTI oil futures and spot in significant and positive way in in-sample analysis. The investor sentiments appear to be significant predictor only for the three crude oil-related assets and VIX, and had no predictive ability for gas futures and spot in out of sample results. Hao et al. (2021) considered BRICS countries to analyze the combined effect of remittances inflow and FDI spillovers on real effective exchange rate (Pitts, 2017). In addition, authors also considered institutional quality and knowledge spillovers to test Dutch disease in the selected countries. The authors concluded that institutional quality and knowledge spillovers were helpful in raising the real effective exchange rate in the selected economies (Rao, 2017). X. Ji et al. (2021) In nineteen Euro zone countries, he observed that renewable energy funds underperformed conventional peers and market benchmarks and lacked market and volatility timing. Umar et al. (2021) studied the effect of resource curse on the banking sector of oil producing countries during periods of varying oil prices. The findings showed that during price boom period the banking performance worsened. These findings confirmed the validity of the resource curse and indicated that countries that rely on natural resources had lower financial progress. Yang et al. (2021)studied asymmetric role of natural resources namely oil and gas on economic growth in Russia using NARDL approach and concluded that positive shocks in natural gas rents was the cause of resource curse, but positive and negative shocks caused GDP to grow in Russia (Yang et al., 2021).focused on evaluating the absence or presence of resource curse hypothesis in G-7 economies through linkage between natural resources and financial development. According to their findings, resource curse was absent in G-7 countries primarily because of financial development. Su et al. (2020) studied the effect of oil prices on inflation in the presence of geo-political risk. In short and medium run, co movement was observed between oil prices and inflation. In the long run the correlation between oil prices and inflation is observed in the presence of geopolitical risk. The authors concluded for aggregate model that geopolitical risk is an important factor for oil prices as reflected in inflation. Umar et al. (2020)a,b explained the causal effects of financial development, transportation infrastructure and innovations on CO_2 emissions controlling for GDP over 1971 to 2018 period. Using wavelet coherence approach and combined cointegration, the authors concluded that a significant vulnerability was present between financial development, transportation infrastructure, innovation and CO_2 emission at different time frequencies. Moreover, the of wavelet coherence approach findings showed that innovation significantly predict CO_2 emissions over 2007 – 2013 and financial development and CO2 emission were negatively related in the long run (iii) over 1985 – 1989 and 2000–2015 period, transportation was a significant cause of CO_2 emissions. Taking transportation sector of the USA in consideration Umar et al. (2020)a,b estimated the role of fossil fuel energy consumption, biomass energy consumption and economic growth on CO2 emission. The estimations obtained from Hatemi-J cointegration, cointegration regression, Spectral Breitung-Candelon causality test and Gregory-Hansen cointegration indicated that GDP and biomass energy consumption had negative effect whereas fossil fuel energy had positive effect on CO2 emission from transportation sector in the USA. Taking China as case study Umar et al. (2020)a,b estimated the impact of natural resources, financial development, globalization and economic growth on CO2 emission and concluded that natural resources had positive impact on CO2 emission in China.

In current era of COVID 19 pandemic, the studies primarily focused on the spillover effects between different commodities markets as well as the role of different metals playing as hedgers or safe haven in this era of global pandemic. For example, Huang and Wu (2021) explored the role of COVID-19 pandemic in influencing the asymmetric spillover impacts in the gold and oil markets. The findings obtained through BEKK-AGARCH model provided the evidence for spillover effect from the oil market to the gold market that was comparatively stronger over the pandemic period. Moreover, the negative information shock in the oil market was found to have a larger impact on the volatility of gold return as compared to the positive shock, intensified during the pandemic period. Shafiee and Topal (2010), Jin et al. (2019), Bildirici and Turkmen (2015), Jain and Ghosh (2013) also observed the same role of gold against fluctuations in oil prices before COVID period. Salisu et al. (2021) also reached the same conclusion that gold was a safe haven against risks in oil prices. In addition to previous study, however they also proved that gold was a safe haven for three other important metals, namely platinum, palladium and silver in this study. Different metal prices volatility were taken into consideration by Tanin et al. (2021) who estimated whether different assets volatilities could affect the role of gold as safe-haven, during and before the COVID 19 period. In the long run, adverse Eurocurrency volatility lowered gold prices, but positive silver, gold, emerging market, and financial market volatility reduced gold prices in the short term during COVID-19 period. In contrast, during the pre COVID 19 period, energy, silver, gold, Eurocurrency and financial market volatility boosted gold prices, while in the short run, only oil volatility caused reduction in gold prices. By different Troster et al. (2019) used implied volatilities of gold, stock, silver and gold-mining in a quantile regression study of flights to safety. While testing for nonlinear and linear Granger causality across quantiles, a unidirectional causality was found to be running from the stock market volatility to the silver, gold and gold mining market volatilities. However, no causality was observed between volatilities in silver and gold

market. In the upper and lower tail quantiles, evidence was found for unidirectional causality from volatilities in gold, silver and stock market to volatility in gold-mining.

Recently, literature has growing trend towards the estimation of the effect of COVID-19 pandemic on commodity markets. The study by Musa, Maijama'a, Mohammed, and Yakubu (2020) is the first one which attempted to examine the effect of corona virus infected cases on the food price index and the crude oil price by applying the ARDL estimation from 20 Jan to 31 March 2020. The findings showed that the COVID-19 outbreak had a long run negative impact on oil prices and a favorable impact on the index of food price. However, the link between COVID 19 pandemic, food price index and oil prices was negative in the short run. the same conclusion was drawn by Albulescu (2020)for a study in the context of China. Johan (2020)investigated the economic aspects that determine investor demand for gold during the COVID-19 pandemic-induced recession. Their findings suggested that income and inflation, explained the choice of people for gold instead of the interest rate. Atri et al. (2021) studied whether COVID 19 panic, media coverage and news affected gold and oil prices. By applying the ARDL approach from January 2020 to June 2020, it was found that COVID-19 panic and deaths had negative impact on oil price. The media's propaganda, on the other hand, had a long run detrimental effect on oil prices. Moreover the study concluded that gold was not only a hedge against geopolitical and economic crises, but also a safe haven in COVID 19 pandemic crisis. Moreover, recently, Salisu et al. (2021) established COVID 19 World Fear Index through two factors: deaths and reported cases and investigated whether price returns of gold and agricultural commodities were predicted by this index. According to the study's findings, commodity price returns and fear index had a positive relation.

Hence, we identified from the above literature that there are numerous studies that analyzed the role of different asset markets on gold market prices. However in recent time of COVID 19, only a little number of studies can be found that estimated the association among gold prices and different commodities markets. Furthermore, most of the earlier studies estimated the link between natural resources and financial development and the assessment of the presence or absence of resource curse hypothesis has been the focus of these studies. Most of these studies estimated the impact of oil and different commodities prices on the gold market and estimated this association by applying different estimation methodologies e.g ARCH, GARCH, Quantile regression, etc. As far we know, except Tanin et al. (2021), none of the study can be found in the literature that estimated the impact of price volatilities of different assets classes on gold prices in current era of COVID pandemic. However the study applied NARDL approach and studied these associations during and before COVID era. Our study is different as it estimates the effect of gold price volatility, silver price volatility and oil price volatility on gold prices by estimating it through ARDL bound testing approach along with NARDL approach. as the mixed order of integration is found in the variable series in our model. Also our study goes a step further by estimating the effect of number of deaths due to COVID 19 on gold market, as this is a direct measure of how COVID impacts the safe haven property of the gold.

3. Data and methodology

3.1. Data description

We gathered Time-series daily data over the period from 25 Jan 2020 to 16 Dec 2021 (the closest ending date to our study) on gold prices, gold volatility index, oil volatility index and silver volatility index and number of deaths of corona virus. The data for gold prices is taken from World Gold Council, measured in terms of USD/per troy ounce, whereas the data for gold price volatility, silver prices volatility and oil price volatility is taken from Chicago Board Option Exchange (CBOE, 2021). We assessed the data of corona virus from the daily reports released by World Health Organizations (WHO).

3.2. Model specification

The recent theory of Optimal Asset Selection, proposed by Markowitz in 1952, can potentially explain ability of gold to serve as a safe haven or hedge Adewuyi et al. (2019); Elie et al. (2019); Shahzad et al. (2019).The theory states that key drivers of portfolio selection is the portfolio's expected returns (mean) and variance (risk). According to this hypothesis, financial asset investment is also a function of its relation to other alternative assets such as bonds and different metals etc. in order to achieve asset diversification and minimize risk. By defining a linear link between the expected rate of return on an asset and its associated risks, the Markowitz model was changed into the Capital Asset Pricing Model (CAPM)Arfaoui and Rejeb (2017); Hood and Malik (2013); Reboredo and Rivera-Castro (2014).The expected rate of return on a group of risky assets is the sum of the expected rate of returns on assets that are mutually independent with the market, plus a risk premium for keeping the assets. Through the International Capital Asset Pricing Model (ICAPM), the CAPM validated international evidences into its model by calibrating international market risk factors into its risk-return optimum resource selection, allocation, and portfolio diversification. The ICAPM allows investors to move money from a local horizon like stocks to a global horizon like oil, gold and other commodities mirroring domestic and international economic events and providing large arbitrage opportunities for investors. Several experts have stated that gold appears to be the best investment option (hedge or safe haven) in a period of deteriorating economic prospects marked by stock market crashes, negative exchange rates, and a weak commodities perspective. It's important to remember that gold's return (as defined by demand) is influenced by returns on alternative assets such as bonds, oil and the global risk factor. As a result, analyzing the risk and expected return associated with gold and oil requires a global risk-return (mean-variance) study.

The theoretical connection between gold status as a good hedge against oil and metal price risk is simple. There are two ways to see the nexus. First, an increase in oil prices is linked to increased inflationary pressures Aguilera and Radetzki (2017); Hunt (2006); Zhang and Wei (2010). When this occurs, looking for a safe haven becomes a wise financial decision, given the evidence that gold protects against inflation threats Bildirici and Turkmen (2015); Jin et al. (2019); Shafiee and Topal (2010). Second, in periods of high financial markets uncertainties like the one brought about by the COVID-19 pandemic Bakas and Triantafyllou (2020), risk aversion rises because investors are more concerned with cutting investment losses Hwang and Satchell (2010). Second, during periods of high financial market uncertainty, such as the one caused by the COVID-19 pandemic, risk aversion increases as investors become more concerned with minimizing investment losses. As a result, risk aversion motivates investors to seek safe alternatives to oil and metals in their portfolios, such as gold Conlon et al. (2020); Yaya et al. (2016).This second viewpoint is based on the argument that during pandemics, the gold market maintains its low volatility despite substantial uncertainty in the normal financial markets(Salisu et al., 2021).

In light of this theoretical link, the model of the study is specified as:

$$GP_t = \alpha_0 + \beta_1 GPV_t + \beta_2 OPV_t + \beta_3 SPV_t + \beta_4 CD_t + \varepsilon_t \quad (1)$$

Where, GP is the gold prices, GPV, OPV and SPV represents gold price volatility, oil price volatility and silver price volatility respectively, CD is the number of deaths due to COVID, t for time, and ε is error term.

3.3. Estimation techniques

3.3.1. Stationarity testing

It is important to study the integration order of study variables before doing formal data analysis for the estimation of correlations among model variables. The absence of a unit root in a sample data is known as stationarity, which means that the variance, auto covariance and mean

remain constant across time Brooks (2002). Moreover, I(0) represents the stationarity at level. Non-stationary data series, on the other hand, have variance, covariance and mean that is not constant across time that indicate the presence of unit root. The first and second differences of such a series can be taken to make it stationary and they are indicated by I(1) and I(2), respectively. In this study, the ADF test for unit root is used for this purpose. According to Gujarati et al. (2012), the functional version of the ADF test is shown in equation (2)

$$\Delta Z_t = \beta_1 + \beta_2 + \delta Z_{t-i} + \sum_{i=1}^{n} \alpha_i \Delta Z_{t-i} + \in_t \quad (2)$$

where, z_t represents series tested for the order of integration, zt-1 is the lagged value of series, $\Delta z_{t-1} = (z_{t-1} - z_{t-2})$ and $\Delta z_{t-2} = (z_{t-2} - z_{t-3})$ represent the first and second differences of the variable. t denotes the time subscript, and, εt is the error disturbance term. If the calculated ADF statistic value turns out to be greater than the test's critical value at 5 percent level of significance, we reject the null hypothesis that unit root is present. Hence we can conclude that the series is stationary at the level during this process of estimation of the integration order.

3.3.2. Optimal lag length selection for ARDL model

We select to apply the ARDL estimation technique developed by Peseran and Peseran (1997)for the estimation of parameter estimates, because it is strongly supported by evidence of mixed order of integration of specified variables. Pesaran et al. (2001)introduced the bound testing in this approach and modified this estimation. This method has a lot of advantages; To begin with, data series do not have to be integrated in the same order. Second, in the situation of a small sample size, this method ensures accurate estimates Peseran and Peseran (1997). Third, this method accounts for changing endogeneity among variables Pesaran et al. (2001). The lagged terms of the dependent and independent variables are included in the ARDL model. As a result, choosing an optimal and appropriate lag length is important for assessing short- and long-run model parameters. The following equation (3) gives the basic ARDL model.

$$\Delta GP_t = \alpha_0 + \alpha_1 GP_{t-1} + \sum_{i=1}^{l} \alpha_1 \Delta GP_{t-i} + \sum_{i=1}^{m} \alpha_2 \Delta GPV_{t-i} + \sum_{i=1}^{o} \alpha_3 \Delta OPV_{t-i} + \sum_{i=1}^{q} \alpha_4 \Delta SPV_{t-i} + \sum_{i=1}^{p} \alpha_5 \Delta CD_{t-i} + \beta_1 GPV_{t-1} + \beta_2 OPV_{t-1} + {}_3 SPV_{t-1} + \varepsilon_t \quad (3a)$$

Where, l, m, o and q are the optimal lags which are selected by using AIC (Akaike Information Criterion).

3.3.3. The ARDL bound test

After choosing the best ARDL model using a conventional lag length criterion, the next step is to see if the exogenous and endogeneous variables in the study are cointegrated. Because it does not need any prerequisite order of integration for the series, this method for assessing cointegration is more consistent than other possible options for testing the presence of cointegration, such as Johansen and Juselius (1990) and Engle and Granger (1987) cointegration approach. As a result, this method is used to determine whether or not certain exogenous and endogenous variables are cointegrated.

For examining cointegration, this test uses the Wald or joint F statistic, which compares the null hypothesis (H0) of no cointegration to the alternative hypothesis (H1) of cointegration among chosen variables. The lower and upper (I0& I1) critical boundaries are compared to the F statistic. If the estimated value of the F statistic is greater than I1, cointegration is present. If the F statistic is somewhere between I0 and I1, then the test result is inconclusive. In contrast, if the F statistic is less than that of I0, no cointegration is indicated Azam et al. (2019).

3.3.4. long-run and short-run coefficients estimation

Next we estimate the short-run and long run model parameters. Eq. (3) shows the long run functional form of the model used in the study.

$$\Delta GP_t = \sigma_0 + \sum_{i=1}^{l} \sigma_1 GP_{t-1} + \sum_{i=1}^{m} \sigma_2 GPV_{t-i} + \sum_{i=1}^{o} \sigma_3 OPV_{t-i} + \sum_{i=1}^{q} \sigma_4 SPV_{t-i} + \sum_{i=1}^{p} \sigma_0 CD_{t-i} + \varepsilon_t \quad (3b)$$

The short run model is estimated by using model described by Equation (4) below, once we done the long-run estimations.

$$\Delta GP_t = \varphi_0 + \sum_{i=1}^{l} \varphi_1 \Delta GP_{t-1} + \sum_{i=1}^{m} \varphi_2 \Delta GPV_{t-i} + \sum_{i=1}^{o} \varphi_3 \Delta OPV_{t-i} + \sum_{i=1}^{q} \varphi_4 \Delta SPV_{t-i} + \sum_{i=1}^{p} \varphi_5 \Delta CD_{t-i} + \varphi_5 ECT + \varepsilon_t \quad (4)$$

Where, the short-run and long-run values are σ_1 and φ_1, respectively. ECT represents the error correction term, that must be negative and significant, as well as it shows the speed with which the system adjusts to equilibrium. As a result, its coefficient must be less than one Azam et al. (2019). In addition to ARDL approach, NARDL approach has also been employed in the study for robustness analysis because it compensates for both short- and long-run asymmetries and beats the threshold cointegration estimation.

4. Results and discussion

4.1. Descriptive statistics

The basic data characteristics such as mean, standard deviation and data range (minimum and maximum values are given in Table 1. Gold prices have the highest mean value but volatility in gold prices has the lowest mean value among all series. The maximum value and minimum value of Gold prices are also the highest one among all of the variables with highest variability about the mean, but volatility in gold prices has the lowest maximum and minimum values and has the lowest variability about mean among all the series.

4.2. Correlation matrix

Table 2 below gives the correlation among the variables. The findings of the correlation estimation indicate a negative correlation between gold price, volatility in oil price, volatility in gold prices and silver price.

To begin our empirical analysis, it is necessary to check the order of integration of the series. For the application of ARDL bound testing, it is important to confirm that series should be stationary either at level or at the first difference, because F Statistic would no longer be suitable if either of the series is integrated of order 2i.e., I(2). For this purpose, Andrews, (1981) test for stationarity has been applied in the current study. Table 3 below reports us the findings of this test.

Table 3 shows the results of the ADF test at the level and at the first difference (by using intercept as well as intercept and trend in the empirical estimation). Table 1 reveals that gold prices (GP), gold price

Table 1
Descriptive analysis.

Variables/series	Mean	Min	Max	Std Dev.	J-B Stats
GPV	16.76	11.07	48.98	4.899	22.034***
OPV	52.50	31.3	325.15	32.26	13.944***
SPV	39.84	19.38	100.66	12.666	16.542***
GP	1807	1474	2067.2	100.6	22.404***

Where *** = P < 0.05.

Table 2
Correlation matrix.

	GP	GPV	OPV	SPV
GP	1.00			
GPV	−0.587	1.00		
OPV	−0.059	0.126	1.00	
SPV	−0.084	0.046	0.058	1.00

Table 3
Test for Unit root by applying ADF.

Unit root (level)	Intercept	Intercept and Trend	Decision
GP	−2.732***	−3.334***	I(0)
GPV	−1.561	−3.564***	I(0)
OPV	−2.018	−2.301	I(1)
SPV	−1.245	−1.379	I(1)
CD	−4.448*	4.094*	I(0)
Unit root (first difference)			
GP	−4.534*	−4.500*	I(0)
GPV	−7.781	−3.819	I(0)
OPV	- 2.751***	- 2.601	I(1)
SPV	−7.905	−4.294	I(1)
CD	10.860*	−10.287*	I(0)

*, ** and *** shows 1 percent, 5 percent and 10 percent level of significance respectively.

volatility and number of deaths due to corona (CD) are level stationary. Conclusively, oil price volatility (OPV) and silver price volatility (SPV) are stationary at the first difference. Thus we can assert that all of the series are integrated at different orders, which encourages the use of the ARDL bound testing approach for coefficient estimation testing and cointegration.

4.3. Optimal ARDL model selection

It is necessary to select the optimal ARDL model before we proceed toward estimating long run and short run coefficient estimation. Because the ARDL model incorporates lagged values of both endogenous and exogenous variables, it is critical to choose the best ARDL model that minimizes RSS (residual sum of squares). The AIC is used to select the best model. Table 4 summarizes the model selection process. ARDL has been chosen as the best ARDL (1,1,1,2) model based on AIC. All of the model fitness requirements are met with this model since it was chosen because of the smallest residual sum of squares .

4.4. ARDL bound test

After determining an optimal model using the AIC lag length selection criterion, the very next step is to see if the research variables are cointegrated Pesaran et al. (2001).The F-statistic calculated is higher than the I1 bound at all acceptable significance levels, confirming the presence of cointegration among research variables. As a result, it is established that selected variables are cointegrated (see Table 5).

Table 4
ARDL optimal model.

Dependent variable Gold prices (GP), selected model: ARDL(1,1,1,2)				
Variables	Coefficients	Std.error	t-values	Prob value
GP(-1)	0.170	0.218	−2.160	0.731
GVP	−0.138	0.139	−3.467	0.000
GVP(-1)	−0.054	0.581	−4.086	0.004
OPV	−0.001	0.056	−3.541	0.006
OPV(-1)	−0.590	0.765	−2.758	0.039
SPV	−0.231	0.004	−4.171	0.001
SPV(-1)	−0.149	0.001	−3.760	0.000
CD	−0.006	0.231	−2.473	0.005
CD(-1)	−0.008	0.498	−4.324	0.048
CD(-2)	−1.543	0.601	−4.297	0.027
CONS	3.561	1.006	−2.781	0.512
R2	0.845 Hannan- Quinn criterion 0.367			
Adj. R2	0.839 DW (Durbin Watson stat) 2.222			
AIC Criterion	0.389 F-stat 29.751			
Schwarz Criterion	0.779 p (F-stat) 0.000			

4.5. Long run estimation

The long-run regression coefficients show how the dependent variable (GP) responds to changes in the regressors. The dynamic ARDL model can then be used to predict long term relationships between variables. Table 6 shows the estimates for long-run coefficients.

According to the finding of our long run estimation, the gold volatility is found to enhance gold prices. For each percent increase in the gold price volatility, the price of gold rises by 0.5percents. In contrast, silver price volatility is found to diminish the gold prices. For a percent increase in silver price volatility, gold prices decline by 1.3 percents. Considering the impact of COVID-19 on the gold prices, the findings indicate that there is a long run positive impact of both corona virus numbers of deaths on gold prices. If the number of deaths due to this pandemic increases by one percent, the price of gold increases by 0.05 percent. And last, the findings indicated that oil price volatility has significantly positive impact on the gold prices. Gold prices increase by 0.05 percent due to one percent increase in number of deaths due to COVID-19.

4.6. Short-run ARDL results

The speed of adjustment towards long run equilibrium is shown in Table 7 by the ECT values. The ECT meets all three criteria because it is statistically significant with a negative and less than one coefficient. The coefficient has a very high value of −0.729, indicating that the speed of adjustment towards equilibrium is 72.9 percent. The negative sign implies that the model will eventually reach equilibrium in the long run. At the 5% significance level, all of the short-run coefficients are significant.

From the findings of short run estimation, it can be inferred that like in the long run, all variables are found to significantly impact the gold prices in the short run as well. Volatility in the gold prices decreases the gold prices in the short run. These findings are consistent with the notion that a rise in gold market volatility should, by definition, lower gold prices. However, over longer time period, investors may gain confidence in gold as a safe asset class, causing gold prices to rise because of rise in the volatility of its price. Our finding supports the finding of Tanin et al. (2021) from the existing literature. Similar to long run, the price volatility of silver and oil (contrast to long run) diminishes the gold prices. And last, an increase in the number of deaths due to corona pandemic exerts positive impact on gold prices supported by the findings of Ali et al. (2020), Yousef and Shehadeh (2020) and Atri et al. (2021) confirming the property of gold as a safe haven in the short run also.

4.7. NARDL long run and short run estimations

NARDL approach has been applied for robustness and short run and long run NARDL results are given in Table 8.

Long-term NARDL analysis yields comparable results to the ARDL

Table 5
ARDL bound test.

Test- statistics	Value	K
F-stat	19.876	3
Critical value bounds		
Significance	I0	I1
10%	2.92	3.56
5%	4.34	4.63
2.5%	3.59	3.99
1%	3.34	5.71

Table 6
Long-run ARDL estimates.

Dependent variable (Gold price)	Coefficients	Prob-value
GPV	0.548	0.000
OPV	0.497	0.042
SPV	−1.327	0.000
CD	0.059	0.012
Cons	1.529	0.000

Table 7
Short Run ARDL estimates.

variables	Coefficient	t-stat	Prob value
Error correction term (ECM)	−0.729***	−2.183	0.009
D(GPV)	0.567	−2.478	0.045
D(OPV)	0.125	−3.532	0.000
D(SPV)	−1.989	−3.786	0.017
D(CD)	0.279	4.612	0.029
D(CD-1)	0.334	4.446	0.004
Cons	1.000	0.125	0.001

Table 8
NARDL long run and Short run Results.

Long Run Estimation			
Variables	Coefficient		P-value
GPV	−3.033		0.009
SPV	−1.223		0.090
OPV	−1.246		0.010
CD	1.602		0.018
Short Run Estimation			
dGP(-1)	−0.127		0.008
dGPV(-1)+	−0.811		0.006
dGPV(-1)-	−0.334		0.045
dSPV(-1)$^{-}$	−0.110		0.084
DSPV(-1)+	−1.534		0.008
dOPV(-1)$^{-}$	−0.929		0.098
dOPV(-1)+	−0.836		0.045
dCD(-1)$^{-}$	0.214		0.087
dCD(-1)$^{+}$	1.340		0.034
dCD(-2)-	0.767		0.056
dCD(-2)+	0.294		0.067
Cons	1.000		0.009
Diagnostics		Statistics	p-value
LM test	0.3535		0.380
Heterosckedasticity test	0.5778		0.455
Normality test	0.432		0.545

bound test. Gold price volatility, silver price volatility and oil price volatility have significant and negative impact on gold prices, but number of deaths due to Corona cause gold prices to rise. Moving towards short run dynamics of NARDL estimation, it is found that the results are similar to those in the long run. i.e., gold price volatility, oil price volatility and silver price volatility adversely affect stock prices whereas number of deaths due to corona virus has positive effect on gold prices.

4.8. Discussion

The findings of the study clearly provide the evidences for gold as a safe haven in COVID 19 pandemic. consistent with the findings of Mensi et al. (2017), Beckmann et al. (2019), Harris and Shen (2017), Q. Ji et al. (2020), the current findings prove that rise in volatility in gold and silver prices incentivizes the investors to purchase gold as a significant hedging instrument Singhal et al. (2019). In other words, irrespective of the market used to value assets, whether gold or silver, the assessment of uncertainties is critical. This finding is consistent with asset pricing theories such as the Capital Asset Pricing Model and Arbitrage Pricing Theory, both of these theories point to the necessity to account for one type of risk or the other in asset valuation, and because the pandemic is linked to global uncertainty, it can pose a systemic risk to financial markets. Thus our finding supports the fact that silver and gold are sometimes compared to identical, and they may have similar sensitivity to variations in volatility. however, the findings of Troster et al. (2019) contrasts us as they found no causality between gold and silver market volatilities, but it is consistent with the finding of Tanin et al. (2021) who observed that an increase in silver price volatility diminished the gold prices.

The finding that number of deaths due to COVID raises gold prices is indeed plausible as during health crises of the COVID-19 period, investors seek refuge in a safe haven, and gold is a popular choice. We argue that gold is the safer commodity and acts as a stabilizing force for the financial system in times of crisis. Our results corroborate the study by Baur and McDermott (2010) in terms of gold as safe haven, (Ali et al., 2020), Yousef and Shehadeh (2020) and Atri et al. (2021) who argued that gold is a safe haven particularly in the period of COVID-19.And last, the findings indicated that oil price volatility has significantly positive impact on the gold prices suggesting that gold is a safe haven for the investors in times of COVID pandemic, a finding consistent with Dutta et al. (2020), but in contrast with Dutta (2018) who did not find any significant impact of oil price volatility on prices of gold. A possible intuition behind this phenomenon underlines the fact that rise in oil prices lead to inflationary pressures which raises concerns among investors to switch toward some risk adverse asset and for this gold is a suitable option for them.

5. Conclusion

The outbreak of the worldwide COVID-19 pandemic has caused a downturn in commodity markets due to lower global demand. The threat of a worldwide economic slowdown has triggered potential downside risks in many commodities markets. As a result, investors who own the assets are vulnerable to price fluctuations. Therefore, recognizing an alternative instrument to hedge these risks is critical. Therefore, the current study is one of the first efforts toward establishing a link between gold price volatility, oil price volatility, and silver rice volatility, number of deaths due toCOVID-19 pandemic and gold prices during this deadly pandemic. For the purpose of empirical estimation, the study employed ARDL bound testing approach and non linear ARDL to analyze the time series daily data spanning over 30 Jan 2020 to 16 Dec 2021. The findings of long term estimation indicate that gold price volatility and oil price volatility have positive impact on gold prices, while silver price volatility has negative impact on gold prices. In the short run, gold price volatility has negative impact on gold prices, but deaths due to COVID-19 is found to have positive impact on gold prices both in the long-run and in the short run.

5.1. Policy recommendations

The findings of this study can assist policymakers in controlling this hazardous condition. This study has the ability to give the society with clear, evidence-based options, especially when it comes to investment decisions. According to our findings, despite the COVID 19, gold continues to hold its value as a "safe haven" asset in situations of health crisis. We suggest that investors should seek gold as a safe haven in times of crisis because it performs positively and therefore is a secure investment in uncertain and turbulent times. The choice to invest in gold in the long run may provide opportunities for investors to buy this precious metal as a safe-haven asset, however, in order to gain the rewards of such an investment in the short run, investors must behave wisely and attentively. In other words, gold can indeed be regarded a safe haven in the short run to some extent. This research will assist not only international investors and benefactors, but also policymakers and eager researchers who want to make the best investment choices possible in both

peaceful and difficult conditions.

5.2. Limitations of the study

The mere focus of present study is the estimation of gold as a safe haven during COVID-19 pandemic. However, other commodities, such as U.S. Treasury securities (like US T-bonds) crypto-currencies (like bitcoin), may also serve as safe haven in the short term particularly in the current era of COVID-19 crisis and this area needs exploration. The ARDL bound testing model is used in current study. However, future studies should consider different methodologies (such as the NARDL approach) and should apply more than one estimation methodology to compare the results to have more comprehensive and better estimation.

Author statement

We have revised manuscript titled **Do oil, gold and metallic price volatilities prove gold as a safe haven during COVID-19 pandemic? Novel evidence from COVID-19 data** There is no author's conflict among authors in this research. The plagiarism of this manuscript is not greater than 13%. So, this will be a good edition in existing literature.

Data availability

Data will be made available on request.

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