GOLD & STOCK RELATION: INVESTORS' REACTION DURING COVID-19 OUTBREAK

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Abstract

This research tries to examine the association between stock and gold during COVID-19 pandemic along with investors' investment preference during COVID-19 lockdown by considering three macroeconomic variables (BSE, NSE & Gold) with their daily data over a period from 30th January 2019 to 31st July 2020 under VAR environment. The time series data are normally distributed and stationary after first difference with same order of integration without co-integrated equations with optimum lag length one. The long run equilibrium relationship is absent during COVID-19 outbreak but short run association is found when lagged gold price influences gold itself. Furthermore, two-way Granger responses exist between BSE and NSE only. The investors prefer stock investment as compared to gold during COVID-19 lockdown. Finally, the VAR models are valid and stable based on various residuals tests.

Keywords*: Co-integration, VAR, COVID-19, Gold, BSE, NSE*

JEL classification: *C12, C15, C32*

1. Introduction

It is true that water is life. Life without water is impossible. But in economic sense, it has almost no value. Oppositely, the yellow metal (gold) that has no need in livelihood as compared to water but its monetary value has already been touched the sky during this COVID-19 pandemic. So, a stable and healthy financial system depends on economic development of a country. If an economy has efficient and well functioning financial systems then the nation

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can flourish and may improve the standard of living of its countrymen. It is pointed out by Tripathy (2016) that the economic activity and its involvement with the real sector shows considerable significance. According to Smith (2011), during the time of market crisis, stock market generally comes down but the gold's at the same time price reacts oppositely. Currently, the investors are more tending to keep a portion of their investments in the form of gold with the expectation of higher prices and that can also hedge against inflationary situation. Sometimes, when an economy goes through political uncertainty, economic boom, emergency, war or when dollars weakens etc. then the investors have a tendency to buy gold as a store of value for economic safety and to protect their portfolios from uncertain economic shocks as a tool of diversification (Kiohos & Sariannidis, 2010). In India, due to its high domestic demand, the gold price is sharply increasing because of its high security, liquidity, risk diversification tool, a safe haven investment and an asset of last resort (Gaur & Bansal, 2010). According to the Webster's dictionary "haven" means an avenue of confidence that offers hopes and conditions (Baur & Lucey, 2006). In India, the capital market is not the first preference of investment till date because the investors believe that yellow metal is a secure and attractive investment tool for the Indian investors (Narang & Singh, 2012) and it depends on individual sentiment on gold holding and the habit of gold investment in Indian culture is well established from the ancient age as it is preserved by the Indians for a long time without loss of its value. It also acts as a hedge against loss of wealth in time of market failure (Mishra & Mishra, 2010; Paul, 2012). The rising demand is not only depend on its usage and speculation only but also influenced by other factors in Indian economy. The earlier studies show that there is a linkage between gold's demand and other investment opportunities. Generally, the market fickleness creates panic to the investors' mind to take rational decisions. So, deep uncertainty in stock market may be the reason for high demand of yellow metal (Bhuyan & Dash, 2018). During this COVID-19 pandemic the world economy is in a turbulence situation. There is a deep uncertainty when the world economy will come out from this crisis period. The stock markets around the globe have lost investors' faith due to COVID-19 pandemic shock. The global stock markets are under in volatile situations and very difficult to predict the movement of stock prices during this pandemic situation. Oppositely, it is found that the gold price is moving in upward direction sharply and touched a record high during this pandemic situation. The investors shift their investments from stock markets to gold because for safety, liquidity and it helps to hedge against this pandemic shock. Nationwide

lockdown makes the economic activities more disruptive but on the other hand this lockdown helps to control the spreading of this deadly corona virus into population. During this uncertain pandemic situation whether lockdown and investors preferences on gold influence the gold prices to move high? Some are arguing that gold prices are a good proxy for other macroeconomic variables. So it is a preferred indicator of global economic performances. Some analysts opined that gold is a leading indicator that can combat against inflationary situation and many of them recommend that gold may be used as a toll of diversification. Thus, gold is recognized as a regularly traded instrument and which has a close linkage with the capital market from the investors' standpoint. On the other hand, if price of gold increases then it is matter of concern about market break down in near future that leads to financial stability implications from the view point of policy makers. Hence, gold is an important topic of research in the field of financial economics nowadays (Tripathy, 2016).
Finally, the study is designed as follows: in section 2 literature survey is described. Section 3 deals with objective. Hypothesis is given in section 4. Section 5 describes data and study period. Section 6 provides methodology. Section 7 analyses the result. Conclusion and recommendation are given in section 8.

2. Literature Review

The relationship between socio-economic variables under the VAR environment is discussed very little. The economic impact due to COVID-19 pandemic is a recent phenomenon. The life and livelihood are now uncertain due to COVID-19. The human civilization is stood at risk for survival. The whole world is jointly working when we will get released from this deadly virus. Research in various fields is conducting around the globe for the way out. Few papers have already been published and considered for developing this research. The researchers around the globe are working on this issue critically and trying to establish the relationship between the socio-economic variables.

Truly, Granger is the first who introduces the idea of co-integration in 1981 and then the idea is further widen by Engle and Granger (1987); Eagle and Yoo (1987, 1991); Phillips and Ouliaris (1990); Stock and Watson (1988); Phillips (1991); Johansen and Juselious (1990); and finally Johansen (1988, 1991, 1994) and thereafter many empirical studies are conducted by the researchers around the globe. In 1986, Roll and Ross inspect the underlying association among the stock market and macroeconomic variables during the

period from 1953 to 1983 and observe that capital market is considerably influenced by the macroeconomic shocks (see Kim 2003).

It is evident from the above studies that the association among the capital market performance and macroeconomic factors are well established. But the literature on socio-economic variables with pandemic effect is very scanty around the globe. In this situation, this study tries to inspect the long and short run symmetry relationships among the socio-economic factors in Indian context under the VAR environment and along with the analysing of how a positive innovation or shock (impulse) can changes the behaviour of the socio-economic variables under the VAR framework and here is the identity of this study being considered.

In 2001, Smith Graham examines the association between gold price and stock price indices in USA. Therefore, he considers daily prices over a period between 1991 and 2001 by considering 4 gold prices and 6 stock indices. He observes that short-run association between gold return and stock return is insignificantly negative. But gold prices and stock prices are integrated at same order but they are not co-integrated. However, he observes that short-run uni-directional causality runs from stock to gold. Similarly, Baur & Lucey (2006) seek to examine two issues (a) whether gold may be used as a hedge against stocks and /or bonds and (b) whether gold is a secure investment when market falls. Therefore, they consider time series data over ten years' periods from 30th November 1995 to 30th November 2005. So, to examine the above two objectives they use various volatility forecasting measures like DCC, GARCH etc. They observe that gold may act as a hedge against stocks and may be considered a trustful investment avenue against stocks during trading days after an extreme stock market crash. In 2010, Kiohos and Sariannidis seek to inspect the short term consequence of energy prices and financial markets on gold by considering US market over a period from 1st January 1999 to 31st August 2009 using daily data and thus they apply GARCH type models. They opine that gold market may act as a mobilization aspect of evade against various portfolios. They also observe that US dollar exchange rate significantly influences gold markets' volatility and observe presence of volatility persistence. Finally, they suggest that yellow metal may be used as a protected investment tool during market volatility (see Baur and Lucey, 2006). In the same light, Mishra et. al., (2010) examine the co-integration and causal relationship between the gold and capital market during a period between 1991 and 2009 by considering daily data and thus they conduct Johansen test of co-integration along with Granger causality analysis. According to the Johansen co-integration test there are two

co-integrated equations with same order. Finally, the Granger causality test discovers two-way short-run association among gold prices and BSE. In 2011 Toraman et. al. seek to examine the probable macro-economic aspects that affect the gold prices in USA. To examine the above objective they consider oil prices, USA's exchange rate, inflation, real interest and gold over a period from June, 1992 to March, 2010. Therefore, they apply MGARCH and CCC models. The study shows that ARCH effect exists on some variables but few variables follow non-stationarity. Finally, they observe that gold prices and exchange rate are inversely correlated but oil prices and gold prices are positively associated. In 2012, Narang and Singh look at the underlying relationship among gold and BSE by considering daily data over a period from 2002 to 2012 by applying co-integration and causality test and they observe absence of co-integration relationship among the variables and also absence of causality association between gold and BSE at any direction. Similarly, in 2012, Omag examines the association between gold prices and some macro-economic factors over a period range between January 2002 and December 2011 by considering daily data in Turkey. Thus, he applies multiple regression technique to examine the above objectives. He observes a positive connection between gold prices and exchange rate and also favourable relationship is found between ISE and exchange rate. Finally, he opines that gold may be considered as an alternative as compared to other investment avenues. Likewise, in 2013, Baig et. al., tries to inspect the causal association between gold prices and macro-economic variables over a period from 2000 to 2010 by applying co-integration and causality techniques by considering monthly data in Pakistan. They find absence of significant correlation between the macro-economic variables. They observe that the data are free from unit root problem after their first difference and also co-integrated at same order but there is no existence of co-integrated equation and thus long-run equilibrium relationship is absent. Moreover, they also exhibit absence of short-run Granger causality relationship. In 2013, Mukhuti et. al., investigates the association between Indian stock market and gold rate over a study period from 1991 to 2012 by considering daily data. Therefore, they use bi-variate and multivariate Johansen co-integration approach to study the above objective. First, they observe that the data are stationary at 1st difference (see, Baig et. al., 2013) and integrated at same order. Then, they observe that there is absence of co-integrated relationship at any significance level (see, Baig et. al., 2013) based on bi-variate co-integration test but multivariate co-integration test signifies existence of long-run stable association between stock markets and gold rates (see, Mishra et. al., 2010). In 2013, Sindhu tries to scrutinize the impact of

macro-economic variables on gold rates over a period from November 2006 to December 2011 by taking into consideration the daily prices in India. The study applies simple correlation and regression analysis technique to examine the research questions. Finally, the study shows that gold prices and exchange rates are inversely related but energy prices positively influence gold prices. Moreover, inflation rates and gold prices are positively correlated but gold and repo rates are independent. Similarly Contuk et. al. in 2013, examines the effect of variations in gold rates on ISE100 index over a period from 2009 to 2012 by considering daily data in Turkey and thus they apply GARCH type models to investigate the effect. They observe that the time series data are suffered from ARCH effect and thus they apply GARCH models. Finally, they observe that gold and stock values are affected by their own shocks and shocks by each other. On the other hand, Tripathi et. al., (2014) seeks to examine the cause and effect association between gold rate and global macro-economic variables by considering nine years monthly time series data in India. To examine the above objectives, they apply various statistical and econometrics measures. They observe presence of co-integrated equations that means existence of long-run equilibrium association among the co-integrated variables. They also observe that short-run causality runs from gold to exchange rate and energy price. Again in 2015, Khan inspects the impact of crude oil and gold prices on economic development in Pakistan over a period from 1997 to 2014 by using monthly time series data. Thus, he applies OLS regression analysis and observes that Karachi stock exchange and economic growth are negatively associated with gold rates. According to the regression analysis, it is found that economic growth has strong relationship with stock market and gold prices in Pakistan. In the same fashion, Gokmenogln et. al., (2015) investigates the impact of gold price, its volatility, energy price and its volatility on S&P 500 index by taking into account daily data from 2013 to 2014 by applying ARDL and error correction mechanism. They report that long-run equilibrium association exists between the macro-economic variables. They also observe short run bi-directional causality between energy price volatility and stock market. Similarly, in 2015, Akgulet et. al., tries to examine the non-linear association between gold and S&P 500 index over a period from 1986 to 2013 by considering daily data. Thus, they apply Markov-Switching Bayesian VAR measures to examine the above research questions. They consider gold prices and stock market as the endogenous variables and energy price as the exogenous variable. First, they confirm the number of regime (3 regimes) by applying LR test statistic and then employed to estimate the MS-BVAR model. Finally, they

observe that energy prices affect the gold prices and stock prices and the effects are varied according to the regimes. According to impulse response function, the effect is diverse. In 2015, Tiwari and Gupta try to inspect the causal association between gold prices and capital market in India during a period from July 2005 to August 2014 with daily time series data. They apply unit root and Granger causality tests to examine their objectives. They observe that data are stationary after first difference and observe evidence of short run causal association between them (see. Narang 2012 & Baig 2013). A popular study by Tripathi in 2016, who examines co-integrated association among gold and stock prices in Indian context by considering daily data over a period from July 1990 to April 2016. She applies various statistical tests to examine the above objective. She finds that the data are stationary after first difference with same order of co-integration. According to Johansen co-integration test the prices of gold and stock is related towards long run but absence of short run equilibrium connection. She also observes that stock price can be used to forecast gold price. Similarly, in 2016, Raza et. al., investigates various asymmetric impact of gold and energy prices on stock market by considering top ten emerging economies around the globe over a period from January 2008 to June 2015 of the daily time series data. They apply ARDL approach to study this relationship. They find that the markets are optimistically associated with gold and energy prices except China but long run asymmetric equilibrium relationship exists among the macro-economic variables based on bound testing approach. They observe that energy prices negatively impact on all the stock markets. Finally, they argue that emerging markets are more prone to negative shocks. In 2017, Kaur and Kaur examine the consequence of gold on Indian stock market by taking monthly data over a period from April 2007 to March 2016. They apply various statistical measures like J-B statistic, unit root test, correlation and regression and observe that gold price and BSE are positively correlated. Moreover, gold price can influence stock price significantly. In the same year (2017), Hlupo investigates the association among gold rate and stock market in Zimbabwe by considering daily data. Therefore, the study uses various statistical and econometric tools like ADF test, multivariate regression technique and Granger causality to explore. He finds that the daily time series data are stationary at first difference with positive correlation between gold prices and mining. He also observes absence of causality between the macro-economic variables which is also supported by the regression result. Similarly, in 2017, Seifoddini et. al., conducts a comparative study by taking into account gold and stock market in the developed (US) and developing (Iran) markets over a period from December

2013 to December 2016 by considering daily time series data on gold spot prices and stock prices. To examine the above objective they apply Threshold regime switching model. Finally, they observe that stock prices and gold prices don't follow any specific regimes but this association may changes in short as well as long terms between the two economies. In 2017, Mittal examines whether the gold price is affected by macro-economic conditions. Therefore, he examines various macro-economic variables like gold supply, mine production, net central bank sales, interest rates, recycled gold, demand of gold, inflation, US dollar, economic strength, world instability, jewellery market and other investment alternatives to examine the above issues. Finally, he observes that all those macro-economic factors directly or indirectly influence gold prices. In the same year (2017), Shobha seeks to look at whether gold is a safer and attractive investment avenue to the investors based on its risk and return as compared to the stock and bond. The study considers daily statistics of gold, bond and Nifty 50 index during the period ranges between 2012 and 2017 by applying volatility forecasting modelling. She observes that volatility of risk is lower than the stock and bond. The study also says about gold is a good investment avenue for the educated people as compared to others. Similarly, in 2017, Seshiah et. al., seeks to inspect the influence of energy prices, exchange rate, trade deficit and fiscal deficit on gold prices over a period from 1994-1995 to 2014-2015 with monthly observations in India. They apply various statistical and econometrical tools and techniques. They observe that the time series data are stationary after first difference with same order of integration. According to the Johansen co-integration test there are two co-integrated equations and the variables have long run relationships. They also observe two way cause and effect association between trade and fiscal deficit in addition to trade deficit and exchange rate. Similarly, uni-directional short run causality exists between gold and exchange rate; gold and fiscal deficit; trade deficit and gold; and also trade deficit and energy prices. In 2018, Balaji and Mahalingam seek to examine the impact of macro-economic factors on gold rates in India by considering secondary data. Thus, they use various statistical tools like correlation, regression and coefficient of variation to explore carious influences of the macro-economic variables. They observe that gold prices are more volatile as compared to other variables. They also find that gold price is strongly correlated with BSE, NSE, energy price, euro, Yen and foreign institutional investment. According to the regression result they point out that BSE, NSE and crude oil prices can influence the gold prices. Similarly, in 2018, Bhuyan and Dash examine the association between gold prices and NSE over a period from

January 2001 to December 2017 by considering monthly time series data. They apply co-integration and causality tests in the study. They observe that the time series data are stationary after first difference with co-integrated equations that means presence of long-run equilibrium association between them. But, they observe absence of short run association among them. Once again in 2018, Ameer et. al., examines the relationship among the gold and stock prices in Germany during 2004 to 2016 by considering monthly data obtained from Bloomberg data base. They consider Frankfrut stock exchange and divide the entire time period in three parts (pre, post and during recession). Therefore, they use co-integration and causality tests developed by Johansen and Granger respectively. They show that the correlation between gold and stock is positive and some time it is negative across the sub periods. They observe long run equilibrium association among the variables but there is absence of short run causal association among the variables. Similarly, in 2018, Moreman and Bonga seek to observe the relation between gold and oil price shocks on South African stock market and its component indices over a period from 3rd January 2006 to 31st December 2015 by considering daily data. To examine this issue, they use GARCH and asymmetric dynamic conditional correlation (ADCC) approaches. They also examine the extent of optimal portfolio weight, hedge ratio and hedge usefulness. They observe significant instability spill over between the gold and stock market and also energy price and stock market. In the same year in 2018, Mukhuti tries to examine the impact of volatility of domestic gold prices on stock prices in India over a period from 2008 to 2018. Thus, he applies correlation, regression and Granger causality test and observes positive correlation between BSE and NSE with the gold prices but there is no significant impact on gold prices as presented by the regression equation. Finally, Granger causality shows bi-directional relationship between gold prices and BSE's return and also NSE's return. Similarly, in 2018, Sharma et. al., seek to examine the determinants of gold prices over a period from 1991 to 2000 in India. Thus, they consider many macro-economic variables to examine this. Therefore, he applies simple and multiple regression techniques and also applies various statistical tests. They observe that the macro-economic factors have positive influence on gold. But, individual impact of inflation and interest rates on gold prices is negative and insignificant. In 2019, Sun tries to examine the association between the macro-economic variables in China over a period from 2008 to 2016 by taking into account the daily data collected from various secondary sources. Thus, he considers energy, gold, stock and exchange rates in China and applies correlation measure which is based on Vine Coupla

technique. He observes that energy market captures the dominant position in other markets.

In the developed countries a lot of research works have shown the relationship between gold and the macro-economic variables. However, there is few research works are conducted in the developing countries like India. But, in pandemic situation, study on gold is scanty. The present study tries to address this research gap and add value to the existing literature. There is lot of evidences on financial disaster but global economic slowdown due to COVID-19 is totally new in financial literature. More specifically, the study highlights to examine the equilibrium association between stock and gold prices both in short and long horizons and also focuses on investors' fondness between gold and stock during CVID-19 in India.

3. Objective of the study

Particularly, the study is designed to attain the underlying objectives:

i. To examine the long-run equilibrium association
ii. To establish the short-run causal association and direction
iii. To establish whether gold is more preferable by the investors as compared to stock during COVID-19 lockdown

4. Data & Study Period

The study considers daily time series statistics over a time from 30th January 2019 to 31st July 2020. The daily closing value of BSE and NSE are obtained from their official websites. The daily gold prices of ten grams (22 carat) in Indian rupee is collected from multi commodity exchange and cross checked with prices provided by world gold council.

5. Hypothesis formulation

The study is designed to inspect the underlying relationship among the gold and stock prices by using dummy variable under VAR environment during COVID-19 pandemic and thus the following hypotheses are formulated:

Hypothesis 1:
H_0: Time series data are non-stationary
H_1: Time series data are stationary
Hypothesis 2:
H_0: Absence of long run equilibrium association among the variables
H_1: Presence of long run equilibrium association among them
Hypothesis 3:

H_0: Absence of short run causal association among the variables
H_1: existence of short run causal association among them
Hypothesis 4:
H_0: Investors don't like to prefer gold investment during COVID-19 lockdown
H_1: Investors like to prefer stock investment during COVID-19 lockdown

6. Methodology

The study considers the closing prices of the selected macroeconomic variables and converts them into logarithm forms of time series. It is assumed that time series data is normally distributed. The study uses Jarque-Bera (1981) test statistics to examine normality of the time series data based on sample skewness and kurtosis and thus, the following testable hypothesis is formulated as under:
H_0: the distribution is normal
H_a: the distribution is not normal
The J-B test statistic can be defined as below:

$$JB = (n-k)\left(\frac{s^2}{6} + \frac{(k-3)^2}{24}\right) \quad (1)$$

Where, s and measures sample skewness and kurtosis respectively, n represents number of observation. It is assumed that the distribution follows normal if the value of skewness and kurtosis is 0 and 3 respectively and vice-versa. The outcome of normality is presented in table 1. It is observed that the skewness and kurtosis of the time series data is less than 0 and 3 respectively that means data are normally distributed. Here, the probabilities values of the JB statistics are higher than 5% level in all cases indicating acceptance of the null hypotheses.

Table 1 Test of normality

Variable	Observation	Skewness	Kurtosis	JB	*P*-value
logBSE	125	-0.050278	2.109197	4.185631	0.123339
logNSE	125	-0.096592	2.110137	4.318628	0.115404
logGold	162	-0.074307	2.303051	3.427811	0.180161

The non-stationarity is one of the significant problem when deals with time series data in modelling economic relationship. In case of non-stationary data, OLS regression procedures produce incorrect estimates of the parameters (spurious regression). So, non-stationarity must be tested and corrected when dealing with time series econometric modelling. The study uses Augmented

Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to ensure non-stationarity. Therefore, the study considers the following random walk model

$$Y_t = \alpha + \rho Y_{t-1} + e_t \quad (2)$$

Where, Y_t is a series of observation at time t. It is evident that when $|\rho|=1$ then Y_t faces unit root problem (non-stationary) and then the variances grow exponentially as t increases (Dickey & Fuller 1979). After taking first difference, the series looks like $\Delta Y_t = Y_t - Y_{t-1} = e_t$ that becomes stationary (white noise) and then regression is run by taking ΔY_t on ΔX_t instead of Y_t on X_t. Dickey and Fuller extend the test procedure by inserting an extra lagged term of the endogenous variable in the right hand side for the elimination of autocorrelation problem. The optimum lag length may be determined by using various criterions (AIC, SBIC & HQIC). The ADF test may be written as under:

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + e_t \quad (3)$$

Similarly, Phillips and Perron (1988) widen a simplification of the ADF test technique and consider the following equation:

$$\Delta Y_t = \alpha + \delta Y_{t-1} + e_t \quad (4)$$

Here, the PP test makes a rectification to the t statistic of the coefficient δ from the AR(1) process to explain the serial correlation in e_t. So, PP test is the modification of the ADF test that takes into consideration the less restrictive nature of the error structure.

The outcome of the unit root test is presented in table 2. It is found that in level form the time series data are non-stationary (unit root) based on both the test statistics. But the time series become stationary when first difference is taken.

Table 2 Unit root test

Var.	ADF				Phillips-Perron				Order of Integration
	Level		1st Difference		Level		1st Difference		
	t-stat.	Prob.	t-stat.	Prob.	t-stat.	Prob.	t-stat.	Prob.	
logBSE	-1.645	0.4566	-12.863*	0.000	-1.612	0.473	-12.726*	0.0000	I(1)
logNSE	-1.609	0.4749	-12.900*	0.000	-1.592	0.483	-12.752*	0.0000	I(1)
logGold	-0.085	0.9480	-12.683*	0.000	-0.162	0.939	-12.696*	0.0000	I(1)

Significant at 5 percent level.
Note: Author's own calculation

Order of integration is one of the important criteria for co-integration analysis. According to the Ganger theorem if Y_t and X_t are I(d) then presence of linear combination may be found between them of order "b", where $b < d$ that confirms I(1) but the linear combination of them must be I(0) and thus,

spurious regression can be eliminated. Here, the series are stationary at their first differences with order of integration is I(1).

Then choosing of optimum lag length is another important criterion for co-integration and VAR modelling. It is assumed that the lag length will be optimum when the loss function will be minimized and thus, the study uses AIC, SBIC and HQIC criterions.

Table 3 highlights the result of choosing optimum lag criterion. The optimum lag is found one based on SBIC and HQIC but AIC indicates four. The study uses, one lag because out of three criterions, two criterions indicate to choose one lag for co-integration and VAR modelling.

Table 3 Selection of optimum lag length

Lag order	AIC	SBIC	HQIC
0	-18.15645	-18.08562	-18.12769
1	-25.23725	-24.95395*	-2.12223*
2	-25.16149	-24.66572	-24.96021
3	-25.14268	-24.43443	-24.85514
4	-25.36830*	-24.44757	-24.99449

**Indicates lag order selection, AIC: Akaike Information Criterion; SBIC: Schwarz Bayesian Information Criterion & HQIC: Hannan Quinn Information criterion*
Note: Author's own calculation

After satisfying the preconditions of VAR modelling, now co-integration relationship can be examined among the macro-economic variables. Granger (1981) is the pioneer to introduce co-integration and thereafter it is extended by Engle and Granger (1987), Engle and Yoo (1987), Phillips and Ouliaris (1990), Stock and Watson (1988), Phillips (1986 & 1987), Johansen and Juselious (1990) and Johansen (1988, 1991 & 1995). According to Harris (1995), co-integration means presence of stable relationship in the long-run from which an economic system converges in due course. In accordance with, Asteriou (2007) observes that in bi-variate regression model, there may be facts of more than one co-integrating vector with many equilibrium relationships and thus, Johansen (1991) propose maximum-likelihood co-integration technique under VAR environment as below:

$$Z_t = n + k_1 \Delta z_{t-1} + \ldots\ldots\ldots + k_p \Delta z_{t-p} + \Pi z_{t-p} + e_t \qquad (5)$$

Where, Z_t is a k vector of non-stationary series of order I(1), n is a k vector of parameters to be estimated and e_t is a k vector of innovations. Hence, the above

VAR(p) model may be expressed in a Vector Error Correction Model (VECM) as below:

$$\Delta Z_t = n + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \Pi Z_{t-1} + e_i \quad (6)$$

Where, $\Pi = \sum_{i=1}^{p} k_{i-1}$ and $\Gamma i = -\sum_{j=i+1}^{p} k_j$

Where, matrix Π represents long-run relationships (p*p matrixes of parameters) and matrix Γ_i provides short run coefficients to be estimated (p*p matrixes of coefficients). Although, Π can be decomposed as follows:

$$\Pi = \alpha\beta;$$

Where, α denotes adjustment speed and β represents long-run matrix of coefficients which is equivalent to the error correction term.

Johansen test is divided into two parts that uses maximum likelihood statistics namely trace test and maximum Eigen value test.

The trace test can be represented as under:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \bar{\lambda}_i) \quad (7)$$

Here, T stands for number of observations, $\hat{\lambda}$ is the eigen value and n is the number of separate series to be analysed. The hypothesis can be formulated as under:

H_0: Number of co-integrating vector is ≤ r (r = 0, 1, or 2)

H_a: Number of co-integrating vector is r

Likewise, the max eigen value test can be written as under:

$$\lambda_{\max} = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (8)$$

The testable hypothesis can be formulated as below:

H_0: Number of co-integrating vector is r

H_a: Number of co-integrating vector is r + 1

Where, the null hypothesis r = 0 is tested against r = 1 and also tested against r = 2.

Sims (1980) says that, if simultaneity exists among variables then distinction between dependent and independent variables is worthless that means they are considered as endogenous and therefore, each equation has the same set of regressors for developing VAR model. It is found from the beginning that the

variables are first differenced stationary with order of integration is I(1) with optimum lag length one. The outcome of Johansen co-integration test is presented in table 4. It is found from the table that the trace statistic and max eigen statistic are insignificant based on both tests as the probabilities values are higher than five percent significance level that means absence of co-integrating equations or long-term equilibrium association among gold and stock prices during COVID-19 pandemic in India and therefore null hypothesis is accepted here and so, we can proceed for VAR modelling for examining short-run relationship.

Table 4 Johansen Co-integration test

Hypothesized no. of CEs	Eigen value	Rank test (Trace)			Rank test (Max-Eigen value)		
		Trace Stat.	Critical Value (0.05)	P-value**	Max-Eigen Stat.	Critical Value (0.05)	P-value**
None	0.1050	21.3021	29.7970	0.3391	13.319	21.1316	0.4233
At most 1	0.0598	7.98273	15.4947	0.4673	7.4053	14.2646	0.4424
At most 2	0.0048	0.57739	3.84146	0.4473	0.5773	3.84146	0.4473

***Trace & Max-Eigen value tests indicate no co-integrating equations at 5% significance level; *denotes rejection of the hypothesis at 5 percent level; **denotes MacKinnon-Haug-Michelis p-values**
Note: Author's own calculation

Co-integration shows absence of co-integrating equations among gold and stock prices during COVID pandemic and thus unrestricted VAR modelling may be developed to check short run association among the variables.

It is presumed that the macro-economic variables are independent under VAR framework and presence of simultaneity of relationship between them. The study considers three (BSE, NSE and Gold) macroeconomic variables and simultaneously dummy variable is used in the VAR equation to examine the investors' preferences towards gold and stock investment during COVID-19 lockdown. Dummy variable generally takes two numerical values 1 and 0. It can be shown as below:

D = 1, when investors prefer to invest in gold during COVID-19 lock-down
D = 0, otherwise

The above situation can be specified under the VAR environment as under:

$$\Delta \log Gold_t = \alpha_1 + \sum_{j=1}^{p} \beta_j \Delta \log Gold_{t-j} + \sum_{j=1}^{p} \gamma_j \Delta \log BSE_{t-j} + \sum_{j=1}^{p} \lambda \Delta \log NSE_{t-j} + \delta Dummy_t + e_{1t} \quad (9)$$

$$\Delta \log BSE_t = \alpha_2 + \sum_{j=1}^{p} \beta_j \Delta \log BSE_{t-j} + \sum_{j=1}^{p} \gamma_j \Delta \log NSE_{t-j} + \sum_{j=1}^{p} \lambda \Delta \log Gold_{t-j} + \delta Dummy_t + e_{2t} \quad (10)$$

$$\Delta \log NSE_t = \alpha_3 + \sum_{j=1}^{p} \beta_j \Delta \log NSE_{t-j} + \sum_{j=1}^{p} \gamma_j \Delta \log BSE_{t-j} + \sum_{j=1}^{p} \lambda \Delta \log Gold_{t-j} + \delta Dummy_t + e_{3t} \quad (11)$$

Here, it is presumed that each equation in the VAR system contains p lag of the macroeconomic variables (VAR(p))with an error term of shocks or pulses.
To estimate the VAR model, stationary must be checked and observe that the variables are stationarity after differencing i.e. I(1) and the optimum lag length is established one based on SBIC and HQIC criterion.
Now, we can estimate the VAR(1) model as below:

$$\Delta \log \hat{G}old_t = \hat{\alpha}_1 + \hat{\beta}_1 \Delta \log Gold_{t-1} + \hat{\lambda}_1 \Delta \log BSE_{t-1} + \hat{\gamma}_1 \Delta \log NSE_{t-1} + \delta Dummy_t + e_{1t} \quad (12)$$

$$\Delta \log \hat{B}SE_t = \hat{\alpha}_2 + \hat{\beta}_2 \Delta \log BSE_{t-1} + \hat{\lambda}_2 \Delta \log Gold_{t-1} + \hat{\gamma}_2 \Delta \log NSE_{t-1} + \delta Dummy_t + e_{2t} \quad (13)$$

$$\Delta \log \hat{N}SE_t = \hat{\alpha}_3 + \hat{\beta}_3 \Delta \log NSE_{t-1} + \hat{\lambda}_3 \Delta \log BSE_{t-1} + \hat{\gamma}_3 \Delta \log Gold_{t-1} + \delta Dummy_t + e_{3t} \quad (14)$$

Where, α indicates constant term. β, λ and γ are the slope coefficients to be estimated. δ is the slope coefficient of the dummy variable that measures investors' preference towards gold investment during COVID-19 lockdown only when it is positive and statistically significant or vice-versa. Δ is the difference operator.
The study also conducts causality test to find out the trend of causality among the variables under VAR environment.

The goodness or suitability of the VAR model is checked by using some well known statistical measures like serial correlation, heteroskedasticity and normality by considering the residuals.

Finally, the CUSUSM test is applied for parameter stabilization by considering the recursive residuals:

$$\theta_t = \sum_{j=k+1}^{T} \frac{\theta_t}{\hat{\sigma}_t}, \qquad \mathrm{j} = \mathrm{k}+1, \ldots\ldots\ldots, \mathrm{T} \quad \textbf{(15)}$$

with, $\hat{\sigma}^2 = \dfrac{\sum_{j=k+1}^{T} (\theta_t - \bar{\theta})^2}{T-K-1}$ and $\bar{\theta} = \dfrac{\sum_{j=k+1}^{T} w_t}{T-k}$

Where, θ denotes the recursive residuals. σ denotes standard error of the regression fitted to T sample points and k is the number of coefficients to be estimated.

7. Result & Analysis

The estimated short-run coefficients of the VAR models (Equation 12, 13 & 14) are presented in table 5. It is observed from the table (Equation 12) that the slope coefficients of BSE and NSE are statistically insignificant to influence the gold price during Corona virus outbreak in the short run. But the one period lag slope coefficient of gold is statistically significant and influences its own price significantly during COVID-19. Similarly, the slope coefficients for equations 13 and 14 are found to be insignificant meaning that the exogenous variables in the VAR equations have failed to influence the endogenous variables during the crisis period respectively. Although, the constant terms of all the VAR models are statistically significant. But, the slope coefficients of the dummy variables under the VAR models are insignificant that means that the investors don't like to prefer gold investment during the time of COVID-19 lockdown in India or oppositely the investors like to invest in stock markets (BSE and NSE) during the specified period of COVID-19 lockdown. The macro-economic time series data are good fit into the VAR models as shown by the R^2 values and the models are free from autocorrelation problems as suggested by the Durbin-Watson test statistics.

Table 5 Estimation of coefficient under VAR

Dep. Var.	**Const.**	**Coefficients**				**R^2**	**D-W**
		$\beta_1 logGold_{t-1}$	**$\lambda_1 logBse_{t-1}$**	**$\gamma_1 logNse_{t-1}$**	**$\delta_1 Dummy_{t-1}$**		
$\Delta logGold_t$	0.853** (2.702)	0.9113** (9.5287)	-0.1034 (-0.1424)	0.0630 (0.0850)	-0.0021 (-0.5424)	0.953	2.049
$\Delta logBSE_t$	1.687** (2.472)	**$\beta_2 logBse_{t-1}$**	**$\lambda_2 logGold_{t-1}$**	**$\gamma_2 logNse_{t-1}$**	**$\delta_2 Dummy_{t-1}$**	0.949	1.949
		2.4094 (1.5517)	-0.2579 (-1.2626)	-1.6868 (-1.0641)	0.0065 (0.7735)		
$\Delta logNSE_t$	3.593** (2.380)	**$\beta_2 logNse_{t-1}$**	**$\lambda_2 logBse_{t-1}$**	**$\gamma_2 logGold_{t-1}$**	**$\delta_3 Dummy_{t-1}$**	0.952	1.946
		-0.8169 (-0.5258)	1.5451 (1.0153)	-0.2606 (-1.3019)	0.0066 (0.7026)		

*****significant at 5 percent level***
Note: Author's own calculation

The direction of Granger causality is presented in table 6. Two-way or bi-directional causality is found between Bombay Stock Exchange and National

Stock Exchange during COVID-19. But in other cases the evidences of direction of causalities are absent.

Table 6 Granger causality test

Null Hypothesis (H_0)	F-Statistic	Prob.	Decision
BSE doesn't Granger cause Gold	0.0211	0.8847	Don't Reject H_0
Gold doesn't Granger cause BSE	0.4745	0.4922	Don't Reject H_0
NSE doesn't Granger cause Gold	0.0421	0.8376	Don't Reject H_0
Gold doesn't Granger cause NSE	0.5575	0.4567	Don't Reject H_0
Dummy Variable doesn't Granger cause Gold	2.3870	0.1250	Don't Reject H_0
Gold doesn't Granger cause Dummy Variable	0.3044	0.5821	Don't Reject H_0
NSE doesn't Granger cause BSE	4.8399**	0.0297	Reject H_0
BSE doesn't Granger cause NSE	4.6157**	0.0337	Reject H_0
Dummy Variable doesn't Granger cause BSE	2.3659	0.1266	Don't Reject H_0
BSE doesn't Granger cause Dummy Variable	2.0845	0.1514	Don't Reject H_0
Dummy Variable doesn't Granger cause NSE	2.6654	0.1051	Don't Reject H_0
NSE doesn't Granger cause Dummy Variable	2.0026	0.1596	Don't Reject H_0

*****significant at 5 percent level***
Note: Author's own calculation

The validity of the VAR model is checked and the outcomes are presented in table 7. It is found that the observed R^2 values of the residuals of all the VAR models based on Breusch-Godfrey test are statistically insignificant that means absence of autocorrelation problem in the VAR models which is desirable. The heteroskedasticity test tells about rejection of null hypothesis in all the cases which is not enviable. Although, the J-B statistic of the residual is insignificant meaning that rejection of null hypothesis regarding normality which is acceptable. Finally, it may be concluded that the VAR models are valid based on two criterions out of three.

Table 7 Test for checking validity of the VAR

Dependent Variable	B-G LM test		B-P-G Het. Test		Normality Test	
	Obs* R^2	Prob.	Obs* R^2	Prob.	J-B Stat.	Prob.
Residuals of $\Delta logGold_t$	0.8788	0.2872	32.108	0.0001	1.8325	0.3216
Residuals of $\Delta logBSE_t$	0.8931	0.3446	36.569	0.0000	2.5127	0.2784
Residuals of $\Delta lognNSE_t$	0.9713	0.3243	95.766	0.0000	2.1247	0.4578

Note: Author's own calculation

The parameter stabilization of the VAR models is checked by applying CUSUM test and the graphs are presented in three figures. It is found that the cumulative sums of scaled recursive residuals in all the cases are inside in five percent critical lines that indicate parameter stability and absence of structural break which is acceptable.

Figure: 1 - Gold
Stability diagnostic

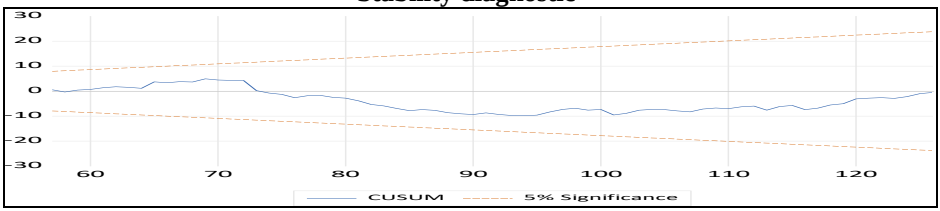


Figure: 2 – BSE

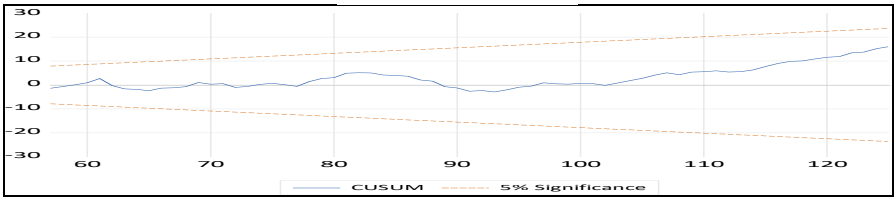
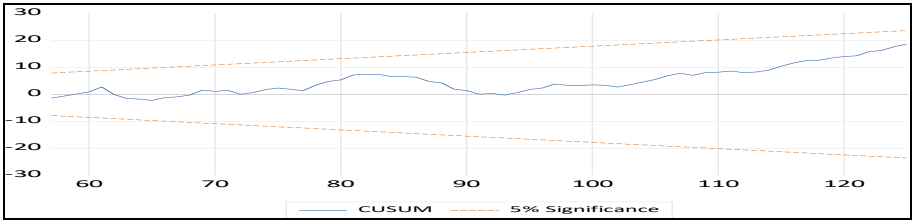


Figure: 3 - NSE



8. Conclusion

This study seeks to look at the association between stock and gold investment during COVID-19 pandemic in India. Here, the macroeconomic variables are integrated of order I(1) with optimum lag length of one without any co-integrated equations and also absence of long run equilibrium

relationship among them during COVID-19 pandemic. In the short-run it is observed that only one period lagged gold price significantly influence the gold price under VAR model (Equation 12). During COVID-19 lockdown, the investors like to prefer to make investment in stock as compared to gold as suggested by the dummy variable coefficients. The bi-directional causality is seen between BSE and NSE only. Various residuals tests enlighten about VAR model validity and stability.

The VAR modelling may be applied extensively in the emerging and underdeveloped countries for better understanding of the macroeconomic variables. Furthermore, this study may be helpful to the researchers, social thinkers, investors, investment managers and policy makers to rethink again about the association between stock and gold by contributing more knowledge in this field.

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