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Long-Run and Short-Run Causality between Stock Price and Gold Price: Evidence of VECM Analysis from India

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ABSTRACT:
The prime objective of the study is to identify the long-run and short-run relationship between Indian stock price viz., BSE SENSEX (hereafter named as BSE) and gold price (GOLD) in India. The daily closing price data were collected for the period of ten years ranging from 1st April 2004 to 31st March 2014 with 2490 observations. The study employed two models: Model one used GOLD as dependent variable and BSE as independent variable and the other model is vice versa. First, the stationarity of the data is checked through Augmented Dickey Fuller test, and then Johansen cointegration test and Vector error correction model (VECM) are employed for analysis. Using Augmented Dickey Fuller test, it was found that the series are not stationary at level, but the same becomes stationary at first differencing. The results of Johansen cointegration test revealed that Indian stock market (SENSEX) is significantly and positively cointegrated with the gold price (GOLD) which leads the way to run the VECM. The results from the VECM (in model one) provides evidence for the existence of long-run relationship between BSE and GOLD, while there is no short-run causal relationship running from BSE and GOLD. On the other hand, there is no long-run as well as short-run relationship between the two variables (in model two).

Keywords: *ARCH test, BSE Sensex, Co-integration, Gold price, Unit root test, Vector error correction, Wald Test*

JEL Classifications: C32, G10 and C58

INTRODUCTION

Identifying the relationship between stock price and gold price has been the subject matter of much scholastic debate over many years because gold is considered to be one of the most precious elements from ancient times. But, now-a-days many people prefer to invest in gold. There are many studies undertaken on investigating the relationship between gold price and stock price in many countries. For instance, the works of Sujit and Kumar (2011), Narang and Singh (2012), Ray (2013), Tanzeem and Aravanan (2014) reported that there existed a causal relationship between gold price and the stock price.

Testing and detecting the cointegrating relationship between variables does not provide sufficient information. Many researchers for instance Basher and Sadorsky (2006); Sujit and Kumar (2011) studied the cointegrating relationship between different variables using Johansen cointegration test. Raza Collins et al. (2013) examined the long-run relationship

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between GOLD and Karachi stock exchange (KSE) and Bombay stock exchange (BSE) from 2005 to 2011 and found an evidence for the significant long-run relationship between GOLD and KSE, whereas there was no long-run relationship between GOLD and BSE. Bhunia and Das (2012) examined the presence of long-run equilibrium relation between gold price and stock market returns in India.

Literature Review

Joshi (2013) studied the relationship between export and GDP using vector error correction model (VECM) and found an evidence for the presence of short-run causality between export and GDP. Singh and Kaur (2013) studied the relationship between foreign direct investments (FDI) and current account (CU) and capital account (CA) for the period from 1991 to 2012. Using the Johansen cointegration test, the study found that FDI - CU and FDI - CA are cointegrated in the long-run. Maysami and Koh (2000) examined the long-term equilibrium relationship between Singapore, US, and Japan stock indices and selected macro-economic variables. Using VECM, the study concluded that the Singapore stock market is significantly and positively cointegrated with the stock markets of Japan and the US.

Kapusuzoglu (2011) examined long-run and short-run dynamics between National 100, National 50 and National 30 Index of Istanbul Stock Exchange (ISE) and international Brent oil price and found that there was a long-run relationship between each of the three variables. Besides, Anoruo and Mustafa (2007) and Miller and Ratti (2009) investigated the long-run relationship between oil prices and international stock market returns and found a long-run relationship between the variables; the stock exchange had responded negatively to the increase in oil price in the long-term.

Many studies have been undertaken on the relationship between oil prices and stock prices however only few studies have concentrated on analyzing the relationship between gold and stock price in emerging economic financial market. In India, no study has specifically investigated the relationship between gold and stock prices. Hence, the present study not only identifies the cointegration between BSE and GOLD, but also specifically identifies the long-run and short-run relationship between the two variables using Vector Error Correction (VEC) Model.

Many studies have been carried out to test the relationship between various economic and stock price with the help of econometric tools. Nevertheless, only limited researches have been conducted to explore the relationship between gold price and stock price. In particular, there is no empirical evidence regarding the relationship between gold price and stock price by utilizing the vector error correction model (VECM). Hence, the present study attempts to analyze the long-run and short-run relationship between Indian stock price (BSE) and gold price (GOLD) with the help of VECM.

Conceptual Background

Gold is a brilliant yellow precious metal that is resistant to air and water erosion. Prior to 1962, India was the world's largest gold market and the main trading centre was Bombay. In 1962, the government enacted the Gold Control Act, which prohibited the citizens of India from holding pure gold bars and coins due to loss of reserves during the Indo-China war. It was declared that the old holdings in pure gold had to be compulsorily converted into jewelry. Pure gold bars and coins were to be dealt in only by licensed dealers.

A large unofficial market sprung up which dealt in cash only as a consequence of the legislation it was adversely affected the official gold market, paving way for smuggling and black marketing, which comprises many jewelers and bullion traders. As a result, the Indian government pledged 40 tons of gold from their gold reserves with the Bank of England. The government abolished the 1962 Gold Control Act in 1992 and liberalized the import of gold in India for a duty payment of ₹250 per 10 grams. The government made up for the foreign exchange problem allowing free imports and earning the taxes. This step expanded the gold market and it also waved off the unofficial trade i.e. smuggling and black marketing. This makes India the most price-sensitive market for gold in the world.

World's largest gold producing country is South Africa with 394 tons in 2001. However, world's largest gold consuming country is India with an annual demand of 843.2 tons comprising

26.2% of total world demands. World's gold demand is constantly increasing and it is nearing record levels at 4000 tons per year while the mine production is constant at 2250 tons per annum. (Source: World Gold Council). The gold price is moving upwards due to the reduction in production level as compared to the demand. It has been estimated that the total world gold production would decline about 30% over the next seven years as the new discoveries in the major gold producing countries have become difficult, expensive and time consuming, according to the studies done by The World Bank and Beacon Group.

Historical experiences show that the trend of gold prices is always higher during the period of stock market slump. A common perception about gold is that it can act as a safe haven in the event of a severe stock market downturn. As the gold price rises, Indian investors tend to invest less in stocks, causing stock prices to fall (Bhunia and Mukhuti, 2013, Yahyazadehfar and Babaie, 2012). India's passion for gold is not new. However, what has happened over the last few years is that rising gold import has coincided with a rise in its price and a weakening of the rupee value against the dollar. Since the need and importance of gold has not been reduced in the past few years, the present study attempted to examine the relationship between gold price and the Indian stock prices.

Objectives of the Study

The primary objective of the study is to analyze the long-run and short-run causality between BSE SENSEX stock price (BSE) and gold price (GOLD).

More Specifically

1. To investigate the long-run relationship between GOLD and BSE.
2. To identify the short-run relationship between GOLD and BSE.

Hypotheses Developed for the Study

H_0^{1a}: There is no long-run causality between GOLD and BSE.

H_0^{1b}: There is no short-run causality between GOLD and BSE.

H_0^{2a}: There is no long-run causality between BSE and GOLD.

H_0^{2b}: There is no short-run causality between BSE and GOLD.

RESEARCH METHOD

Source of Data and Period of the Study

The study used secondary data to examine the relationship between stock price and gold price, the daily closing price of both the variables for 10 years period from 1st April 2004 to 31st March 2014. The study used BSE (Sensex) share price indices as proxy for Indian stock prices. The data of stock price of BSE Sensex are collected from BSE's official website (www.bseindia.com) and the Indian gold prices are collected from the Multi Commodity Exchange website (www.mcxindia.com).

Research Methods Used for the Analysis

The econometric tools viz., Augmented Dickey Fuller (ADF) test, Johansen cointegration test, Vector error correction models (VECM) and Wald test are used for analysis. First, ADF test is used to examine the stationarity of the two variables. Second, the Johansen cointegration test is used to identify the existence and the number of cointegrating vectors. Finally, with the presence of the cointegrating vectors, the VECM is applied to identify the existence of long-run relationship and Wald test is employed to identify the short-run relationship between the two variables used in the study viz., BSE and GOLD.

Unit Root Test

The study is fully based on time series data and hence there arises a need to check for the stationarity in the series. Augmented Dickey Fuller test is used to identify the stationarity in the series of data.

H_0: Data are not stationary (Unit root exists)

H_1: Data are stationary (Unit root does not exist)

If **ADF** statistics exceed critical value, the H_0 can be rejected. Hence the H_1 is accepted which means the data are stationary.

Johansen Cointegration Test

When the variables are integrated with same order, the Johansen test of cointegration can be applied. The Johansen (1988) approach

determines the number of cointegrated vectors for any given number of non-stationary variables of same order. Johansen uses two statistics for testing the cointegration viz., λ_{trace} and λ_{max} statistics, which are as follows:

$$\lambda_{trace\ (r)} = -T \sum_{i=r+1} \log(1 - \lambda)$$

$$\lambda_{trace\ (r,r+1)} = T \log(1 - \lambda_{r+1})$$

Where,

r = number of separate series
T = number of usable observations
λ = estimated eigen values

H_0: There is no cointegration between GOLD and BSE (r=0)
H_1: There is cointegration between GOLD and BSE (r>0)

The H_0 reveals that the number of distinct cointegrating vector is less than or equal to *r* against a general alternative that it is > *r*. If the test statistics computed is greater than the table value, reject the H_0 that there are *r* cointegrating vectors. The presence of a cointegrating relation forms the basis of the vector error specification.

Vector Error Correction Model

Vector error correction (VEC) model is a restricted VAR (vector autoregression) designed for use with nonstationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge their cointegrating relationships while allowing for short-run adjustment dynamics (Engle and Granger, 1987). The cointegration term is known as the *error correction* term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

If the variables are cointegrated of the same order, then valid error correction model exists between the two variables. The determination of cointegration relationship (cointegrated vector) that shows the presence of long-term relationship between variables, causality relationships must be analyzed with error correction model.
The corresponding *VEC* model is:

$$\Delta y_{1,t} = \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{1,t}$$

$$\Delta y_{2,t} = \alpha_2 (y_{2,t-1} - \beta y_{1,t-1}) + \varepsilon_{2,t}$$

In this (simple) model, the only right-hand side variable is the error correction term. In long-run equilibrium, this term is equal to zero. However, if y_1 and y_2 deviate from the long-run equilibrium, the error correction term will not be equal to zero and each variable adjusts to partially restore the equilibrium relation. The coefficient measures the speed of adjustment of the *i*th endogenous variable towards the equilibrium.

Wald Test

The short-run causality is also tested using Wald test. The Wald test computes a test statistic based on the unrestricted regression. The Wald statistic measures how close the unrestricted estimates come to satisfy the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfy the restrictions. Figure 1 shows the steps through which the present paper has been structured.

RESULTS AND DISCUSSION

The study employed the unit root test to determine the stationarity of the variables viz., BSE and GOLD. For the two variables, the H_0 of unit root is tested using ADF test and the results are presented in table 1. From the table it is inferred that the test statistics suggest the presence of unit root in the level, which implies that the two series are non-stationarity and has unit root, i.e. integrated to order zero. More specifically, the H_0 of unit root cannot be rejected as the ADF test statistics does not exceed the critical value at each of the level i.e. 1%, 5%, and 10%.

On the other hand, while first differencing, both the variables yield apparent lack of a unit root, which implies that the two series are stationary and are integrated to order one. The

results shown in table 1 at first difference series reject the H_0 of unit root as ADF statistics exceed the critical value at all levels i.e. at 1%, 5% as well as for 10%. Hence, the result of ADF test for BSE and GOLD is not stationary I(0) 'at level' but the same becomes stationary at the position I(1) 'at first difference'.

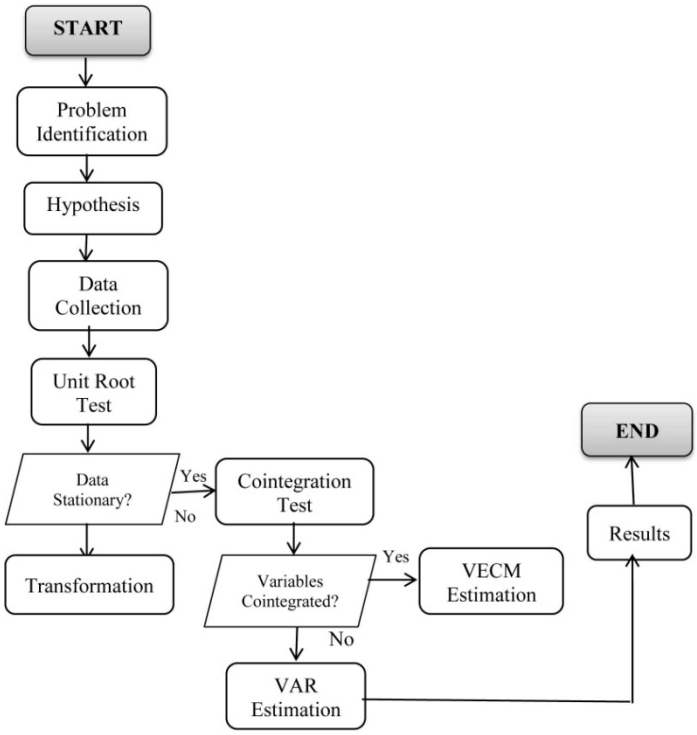

Figure 1: Research framework

Table 1: Results of unit root test

Variable	ADF Statistics (At Level)	ADF Statistics (1st Difference)
BSE	-1.37 (0.59)	-46.30* (0.00)
GOLD	-1.30 (0.06)	-19.86* (0.00)
Critical Values		
1%	-3.43	-3.43
5%	-2.86	-2.86
10%	-2.56	-2.56

Source: Computed results based on secondary data compiled from BSE and MCX websites.
*Figures in parentheses indicate p values. *Significant at 1% level.*

Table 2: Results of Johansen cointegration test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigen value**	**λ_{trace} Statistics**	**Critical value 5%**	**Probability**
None	0.0160	41.8783**	15.4947	0.0000
Atmost 1	0.0006	1.7042	3.8414	0.1917
Unrestricted Cointegration Rank Test (Maximum Eigen value)				
Hypothesized No. of CE(s)	**Eigen value**	**λ_{max} Statistics**	**Critical value 5%**	**Probability**
None	0.0160	40.1741**	14.2644	0.0000
Atmost 1	0.0006	1.7042	3.8414	0.1917

Source: Computed results based on secondary data compiled from BSE and MCX websites.
Trace test indicates 1 cointegrating eqn(s) at 0.05 level;
Max-eigenvalue test indicates no cointegration at 0.05 level.
**Significant at 1% level.

Johansen method is used in order to determine the number of cointegrating vectors; it provides two different likelihood ratio tests viz., the *trace test* and the *maximum eigenvalue test* and the results are shown in table 2. It is inferred that the λ_{trace} Statistics value as well as the λ_{max} Statistics value is greater than the critical value (None), which established a long-run cointegration relationship in the model. The p values for both statistics are significant at 1% level. Therefore, as per the statistics, H_0 'there is no cointegration' between the variables is rejected at 1% level of significance, which implies that there is one cointegrating vector between two variables.

Model 1:

The VECM equation for the dependent variable GOLD is as follows:

$$\begin{aligned} D(GOLD) = C(1) & \\ & * (GOLD(-1) \\ & - 61.1517223991 \\ & * BSE(-1) \\ & + 241008.768301) + C(2) \\ & * D\big(GOLD(-1)\big) + C(3) \\ & * D\big(GOLD(-2)\big) + C(4) \\ & * D\big(BSE(-1)\big) + C(5) \\ & * D\big(BSE(-2)\big) + C(6) \end{aligned}$$

GOLD = Dependent variable
BSE = Independent variable
C (1) = Coefficient of cointegrating equation (long-term causality)
C (2), C (3), C (4) and C (5) = Coefficient of cointegrating equation (short-term causality)
C (6) = Constant / intercept

From the VECM equation, the C(1) is the coefficient of cointegrating equation (GOLD(-1) - 61.1517223991*BSE(-1) + 241008.768301) from which the residual is taken for developing the error correction (EC) term and from the EC term the long-run causality is developed. The results of EC model is presented in table 3. C (1) is the residual at one period lag of cointegrating vector between GOLD and BSE. The ER term is negative (-0.11) and is highly significant at 1%, which implies that BSE has long-run causality on GOLD. In other words, BSE causes GOLD in long-run. Since the ER term from the VECM is significant with negative sign, the H_0^{1a} "there is no long-run causality between GOLD and BSE" is rejected. The result thus shows that there exists a long-run causality between BSE to GOLD.

On the other hand, from the VECM the short-run causality from BSE to GOLD is examined using the coefficient C (4) and C (5) as they are the coefficients of BSE. To identify the short-run causality from BSE to GOLD the study used chi-square value of Wald test. If the coefficients C (4) and C (5) jointly influence the GOLD, then there exists a short-run causality from BSE to GOLD. The results of Wald test is presented in table 4. It is inferred that the H_0 i.e C (4) = C (5) = 0 of lag two cannot jointly influence the GOLD. It is inferred that H_0 cannot be rejected, since the χ^2 is 24.70% which is >5%. Hence, the H_0^{1b} "there is no short-run causality

between GOLD and BSE" is accepted, which implies that C(4) and C(5) jointly impacts to zero. In other words, all the BSE having two lag cannot cause GOLD, and therefore it is concluded that there is no short-run causality running from BSE to GOLD.

Hence, from the model one, the study found that there is a long-run causality running from BSE to GOLD since EC term is significant negatively, whereas there is no short-run causality running from BSE to GOLD since χ^2 value (1.206) is not significant. Therefore, H_0^{1a} is rejected and H_0^{1b} is accepted.

Model 2:

The VECM equation for the dependent variable BSE is as follows:

$$\begin{aligned} D(BSE) = C(1) * (&BSE(-1) \\ &- 0.0163527691579 \\ &* GOLD(-1) \\ &- 3941.16075305) + C(2) \\ &* D\big(BSE(-1)\big) + C(3) \\ &* D\big(BSE(-2)\big) + C(4) \\ &* D\big(GOLD(-1)\big) + C(5) \\ &* D\big(GOLD(-2)\big) + C(6) \end{aligned}$$

GOLD = Independent variable
BSE = Dependent variable
C (1) = Coefficient of cointegrating equation (long-term causality)
C (2), C (3), C (4) and C (5) = Coefficient of cointegrating equation (short-term causality)
C (6) = Constant / intercept

From the table 5 it is inferred that there is no long-run causality between BSE and GOLD. Since the value of coefficient is positive and not significant it reveals that GOLD has no long-run causality on BSE. On the other hand, the Wald statistics indicates the short-run causal effects between these two variables; the Wald statistics (0.65) is statistically insignificant, which indicates that there is no short-run causal relationship running from GOLD to BSE. Hence, from the model two, the study found that there is no long-run and short-run causality between these two selected variables. In other words, the GOLD has no influence on the dependent variable called BSE in the long-run and short-run. Therefore, H_0^{2a} as well as H_0^{2b} are accepted, implying that "there is no long-run causality as well as short-run causality between BSE and GOLD".

Table 3: Results of vector error correction model

Variables	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.1133	0.0121	-9.3586	0.0000
C(2)	-0.3915	0.0206	-18.9471	0.0000
C(3)	-0.2000	0.0196	-10.1646	0.0000
C(4)	-23.523	23.0107	-1.0222	0.3067
C(5)	-7.5561	23.0184	-0.3282	0.7427
C(6)	578.1889	5052.9860	0.1144	0.9089

Source: Computed results based on secondary data compiled from BSE and MCX websites.

Table 4: Results of Wald test

Wald Test statistic	Value	Df	Prob.
F Statistics	0.6032	2,24	0.5471
Chi-square	1.2065	2	0.5470
Null Hypothesis Summary:C(4)=C(5)=0			
Normalized Restriction (=0)		Value	Std. Err.
C(4)		-23.5233	23.0107
C(5)		-7.5561	23.0184

Source: Computed results based on secondary data compiled from BSE and MCX websites.

Table 5: Results of vector error correction model and Wald test

Variables	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	8.91E-05	0.0006	0.1371	0.8914
C(2)	0.0759	0.0201	3.7643	0.0000
C(3)	-0.0143	0.0201	-0.7122	0.4764
C(4)	1.21E-05	1.81E-05	0.6684	0.5039
C(5)	-4.96E-06	1.73E-05	-0.2876	0.7736
C(6)	6.2421	4.4305	1.4089	0.1590
Wald Test statistic H_0: *C(4)=C(5)=0*		**Value**	**Df**	**Prob.**
F Statistics		0.4176	2,24	0.6587
Chi-square		1.8352	2	0.6586

Source: Computed results based on secondary data compiled from BSE and MCX websites.

Table 6: Results of normality test

Statistics	Model 1	Model 2
Mean	6.67E-12	-5.14E-16
Median	-13594.26	5.2616
Maximum	2408716	2078.395
Minimum	-1656358	-1366.06
Standard Deviation	251522.9	220.5377
Skewness	1.101581	0.14626
Kurtosis	15.93098	8.8586
Jarque-Bera	17830.16 (0.0000)	3565.647 (0.0000)
N	2487	2487

Source: Computed results based on secondary data compiled from BSE and MCX websites.

Model Selection and Diagnostic Check

The two models used in the study are subject to diagnostic check to assess whether the model was correctly specified. The selection criterion among the two models was based on three methods. Firstly, the residual of the model should be normally distributed, and secondly, the model should be able to capture the autoregressive conditional heteroscedasticity (ARCH) effect and thirdly, the model should not have any serial correlation.

First, the residuals are tested for normal distribution. The results from the table 6 show that the residuals for both the models applied are not normally distributed, since the probability of Jarque-Bera statistics is less than 5% and therefore, the H_0 "residuals are normally distributed" is rejected. However, many researchers (for instance, Hoxha, 2010) say that the model can be accepted even though the residuals are not normally distributed.

Table 7: Results of heteroskedasticity test

ARCH Test	Model 1	Model 2
Obs*R^2	65.4362	74.3548
Prob. Chi-square	0.0000	0.0000

Source: Computed results based on secondary data compiled from BSE and MCX websites.

Table 8: Results of serial correlation

Breusch-Godfrey Test	Model 1	Model 2
Obs*R^2	98.3877	1.0721
Prob. Chi-square	1.0000	1.0000

Source: Computed results based on secondary data compiled from BSE and MCX websites.

Secondly, the H_0 "there is no ARCH effect" is tested and the result from the table 7 shows that the value of test statistics (Obs*R^2) is less than 0.05. Hence, the H_0 is rejected implying that both the models have ARCH effect. Finally, "there is no serial correlation effect" is tested for both the models and the probability value of observed R^2 >5% for both the models and hence the H_0 is accepted, indicating that there is no serial correlation effect among the selected variables (table 8).

Overall, both the models used showed uniformity of inference for all the three diagnostic check viz., normality, ARCH effect and serial correlation. Both the models have no serial correlation, whereas there is some additional ARCH effect in the residuals.

Major Findings of the Study

1. From the model one, i.e if GOLD is considered as the dependent variable, the study found existence of long-run causality from BSE to GOLD, whereas there is no short-run causality running from the variable.
2. From the model two, i.e if BSE is considered as the dependent variable, the study found non-existence of long-run and short-run causality running from GOLD to BSE.

CONCLUSION

The present study investigated the long-run and short-run relationship between Indian stock price (BSE SENSEX) and gold price (GOLD) using VECM model. The study considered the daily closing price of BSE Sensex and gold price for the past 10 years from 1st April 2004 to 31st March 2014. The present study arrived at several inferences about the long-run and short-run relationship between these two selected variables viz., BSE and GOLD using ADF test, Johansen cointegration test, VECM and Wald test. The study also found that BSE and GOLD are cointegrated (model one) in long-run but not in short-run. From the model two of VECM, i.e. considering BSE as dependent variable, the study found that that there is no long-run and short-run causality running from GOLD to BSE.

Scope for Further Studies

With the help of the closing price of 10 years ranging from 1st April 2004 to 31st March 2014, the present paper showed that there is a long-run causality between BSE and GOLD, but the Wald test did not predict any short-run causality between the two variables. The study could have been improved with additional test on different frequencies of data viz., weekly, monthly and quarterly. Further, the study is limited to a single commodity as gold, therefore the study could be extended taking in to consideration of other precious metals viz., platinum and other commodities.

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