GOLD AND STOCK MARKETS VOLATILITY: AN EMPIRICAL RELATIONSHIP

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ABSTRACT

The development of an economy is very much related to stock markets. In a global scenario, the world economies are related to each other, hence economies throughout the world are related to domestic and international factors. Various micro and macro fundamentals make the stock markets very much sensitive. In India gold is considered an attractive investment avenue and it has been found that when markets are volatile in nature the investors prefer to shift their investment in assets like gold. GARCH (1,1) and E-GARCH (1,1) models are used to explore the volatility of stock prices. GARCH models can be applied when data is stationary, there is no heteroskedasticity in the residuals and serial correlation is in the data series. Before the application of GARCH models, the data series are converted to stationarity. Augmented Dickey-Fuller (ADF) and Phillip Perron (PP) tests are applied to check the stationarity of both the series. The volatility study will be beneficial for policymakers and investors for future reference. The study is limited to secondary data as there are many other factors that impact the stock market volatility in India.

KEYWORDS
Volatility, Stock Markets, Sensex, Gold Prices

INTRODUCTION

Fundamentals of the economy and future prospectus expectations make the stock market volatility very much sensitive. The financial markets achieve the objective of efficient transfer of resources to the persons who need them from the persons who have idle resources. The channel of allocation of savings to investments is provided through financial markets. The word volatility is similar to risk. High volatility means high risk. It is a measure of how far the current price of an asset deviates from its past prices. Volatility is an important tool to measure how far there is a deviation in the current prices of an asset as compared to past average prices. Sometimes business investment decisions are also affected by stock market volatility which may hamper economic performance. Regulatory and structural changes may be required due to extreme cases of volatility and it may interrupt the smooth functioning of the financial system. A large number of factors and events impact the stock market volatility. The portfolio of an investor is designed keeping in mind the volatility due to various factors and their possible impact on the portfolio. Stock markets fluctuate with the fluctuations in the financial markets. So understanding of fluctuations in the market in the form of volatility due to various crucial events and factors is very much essential for an investor to gain maximum earnings from the investments. The focus of the present study is on gold prices and

its impact on stock market volatility in India. Traditionally gold is a very conservative investment option and relatively scarce in nature. Gold is traded like other commodities on a dollar-dominated basis. During times of crisis, the capital outflow may be out of emerging economies. Hence International gold prices and other factors make the gold prices volatile in nature. Macroeconomic variables and stock market volatility is in focus in many empirical studies. Due to heavy demand in the country gold prices are continuously increasing as a result of an increase in international gold prices and appreciation of the dollar against rupee. Gold is emerging as an alternative investment option for the last many years. As a result of the heavy demand of gold in the domestic market gold prices in India are continuously increasing. During the period of high inflation or political uncertainties and crisis situations gold is in a position to maintain liquidity and can maintain a balanced portfolio. The problem under study as stated in the title of study "Gold and Stock Market Volatility: An Empirical Relationship" is related to the impact of gold prices on stock market volatility in India. From the review of the literature, it was found that there is a yawning gap of the specific relationship between gold prices and stock market volatility in India. Although, a large number of studies have been conducted to explore the linkage between various macroeconomic variables and stock market volatility.

LITERATURE REVIEW

Mukhuti, Somnath, Amalendu Bhunia (2013) investigated the reaction of the Indian stock market index on Indian gold price or the relationship between Indian gold price and Indian stock market index. Bivariate and multivariate cointegration tests were used in the analysis. It was found by the results of the bivariate cointegration test that there is no cointegration relationship between the gold price and the stock market indices. But the results of the multivariate cointegration test show that there is a presence of a steady cointegration relationship between the gold price and stock market indices in India.

Bhunia, Amalendu, Sanjib Pakira (2014) investigated in the study the impact of exchange rates and gold prices on Sensex in India. Unit root test, Johansen cointegration test, and Granger causality test have been used in the study. It was indicated by the Johansen cointegration test that there exists a long-term relationship among the selected variables. It was shown by Granger Causality test result that there must be either bidirectional or no causality among the variables.

Srinivasan P (2014) in the paper investigated gold price, stock price and exchange rate causal nexus in India through the Granger Causality test and the Autoregressive Distributed Lag (ARDL). It was revealed by the analysis that the gold price and stock price tend to have a long-run relationship with the exchange rate in India. No evidence of stable long-run cointegration relationship among stock price and gold

price in India was found. It was indicated that in the short run there exists no causality runs from gold price to stock price or vice versa. It was concluded that stock price forecasting in India is not contained in domestic gold price significant information.

Banumathy, Karunanithy, Ramachandran Azhagaiah (2014) examined in the study that whether there exists a causal link between BSE Sensex and gold price. Granger Causality test has been employed to provide evidence on the existence of a causal relationship between the variables. Existence of causal relationship between

Variables were found as shown by the results of Johansen's cointegration that there is cointegration between the two variables. A causal relationship exists which is running from SENSEX to GOLD however there is no such relationship that exists from GOLD to SENSEX. It was concluded by the study that between stock price and gold price a unidirectional relationship exists.

Afsal, E.M., Mohammad Imdadul Haque (2016) explored in the research paper that in the Saudi Arabian context the gold market price movements are considered to detect non-linear dependencies with the stock market. In this study generalized autoregressive conditional heteroskedasticity (GARCH) class the univariate and multivariate models are employed. To detect the persistence level of volatility the work uses GARCH (1,1) specification, further to study leverage effect a series of models are used. It was proved that a dynamic relationship between gold and the stock market do not exist.

Patience Hlupo (2017) investigated the association between gold prices and equities on the Zimbabwe Stock Exchange (ZSE). To determine the nature and direction of the relationship Correlation analysis, regression analysis, and granger causality tests were conducted. Between gold prices and stocks of gold mining firms on the ZSE, a weak short-run unidirectional relationship was found.

NEED OF THE PRESENT STUDY

In the financial research, the study of stock market volatility is considered to be a dynamic area. Gold has been a very conservative investment instrument and considered an attractive investment in India. When the investors are in a panic due to stock market volatility and avoid investment in risky assets like stocks they invest in less risky assets such as gold. Like all other commodities gold is traded virtually on a dollar-dominated basis. In volatile times for Indian investors gold is an attractive investment avenue.

OBJECTIVES OF THE STUDY

The main purpose of the study is to analyse that whether gold prices impact the stock volatility or not. The overall problem can be split into the following objective:

To study volatility in Indian stock market i.e. BSE Sensitive Index (SENSEX) due to gold prices.

HYPOTHESIS OF THE STUDY

The following hypothesis has been framed for the study:

H01: There is no significant impact of gold prices on stock market volatility in India.

Ha1: There is a significant impact of gold prices on stock market volatility in India.

Model Selection: Assumptions followed for the best model:

1.) Null Hypothesis: There is no serial correlation in the residuals or error term Alternative Hypothesis: There is a serial correlation.

2.) Null Hypothesis: There is no Arch effect.

Alternative hypothesis: There is an Arch effect.

For the best model status, the Null hypothesis is desirable

ARCH effect: If P-value is more than 5%.We cannot reject the null hypothesis i.e we accept the null hypothesis i.e. there is no Arch effect.

DATA

The study is essentially analytical research in nature to know the impact of gold prices on the Stock market volatility in India i.e. BSE Sensex. The present study comprises of gold prices and their impact upon stock market volatility. Volatility is essential for the stock markets as it keeps an eye on the nerve of the market. The stock market can fluctuate due to any information. Although the impact of negative information is more on the market as compared to positive information and these pieces of information make the stock markets volatile in nature. The research paper analyses the stock market volatility and Gold price volatility linkage. BSE Sensex closing prices is dependent variable under observation which is used as a proxy for stock prices and Gold prices are used on the other side as an independent variable. The data under observation is in between 1st January 2000 to 31st December 2017. Stock prices daily closing data is collected from the official website of Mumbai Stock exchange and Gold prices daily data is collected from the World Gold Council official website.

RESEARCH METHODOLOGY

Unit root test, Correlogram test, ARCH test, univariate models of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) class like GARCH (1, 1), E-GARCH (1, 1) are used to evaluate the volatility. For high order, serial correlation autocorrelation and partial autocorrelation functions of residuals are displayed along with Ljung –Box Q- Statistics for high order serial correlation. If in the residuals there is no serial correlation, partial autocorrelations and autocorrelations

at all lags must be zero and with large p values, Q statistics must be insignificant. Before applying Generalized Autoregressive Conditional Heteroscedasticity (GARCH) methodology residuals must be examined for evidence of heteroscedasticity. Presence of heteroscedasticity in residuals in Sensex Lagrange Multiplier (LM) test for ARCH effects is applied.

GARCH (1,1) MODEL

Simplest GARCH (1,1) specification is as follows:

$$y_t = x_t'\theta + \epsilon_t \quad \textbf{(eqn. 1)}$$

$$\sigma_t^2 = \omega + \alpha\epsilon^2_{t-1} + \beta\sigma^2_{t-1} \quad \textbf{(eqn. 2)}$$

Eqn 1 is mean equation, which is written as exogenous variables function with an error term. Since one period ahead forecast variance is σ_t^2 which is based on past information, called conditional variance .Eqn 2 is conditional variance equation which is a function of three terms:

- ω is a constant term
- Previous period volatility news ,measured as log of squared residual from mean equation: ϵ^2_{t-1} (ARCH term)
- Forecast variance of last period: σ^2_{t-1} (GARCH term).

E-GARCH (1,1) MODEL

Nelson (1991) proposed E-GARCH or Exponential GARCH model. Conditional variance specification is:

(E- GARCH) model:

$$\log\sigma^2{}_t = \omega_t + \sum_{k=1}^{\infty} \beta k g(Z_{t-k}) \quad \textbf{(eqn. 3)}$$

Where ωt, βk are deterministic coefficients and

$$g(Z't) = \theta Z_t + \gamma(IZ_tI - EIZ_tI) \quad \textbf{(eqn. 3a)}$$

It can be directly seen that

$$E[g(Z_t)] = 0 \quad \textbf{(eqn. 3b)}$$

Log of conditional variance is in the left-hand side. It means that rather than quadratic, leverage effect is exponential and conditional variance forecasts are guaranteed to be non-negative. Least square model basic version assumes that expected value of error terms when squared is the same at any given point. This assumption is known as homoscedasticity and is centre point of ARCH and GARCH models. The focus of ARCH technique given by Engle (1982) is on modelling of

conditional variance and conditional heteroskedasticity. Lagged conditional variance terms as autoregressive is included in the generalized ARCH model (Bollerslev, 1986). It contains the mean equation and variance equation. Exponential GARCH (E-GARCH) Model proposed by Nelson (1991) is an important model to find volatility as well as asymmetry information analysis. Asymmetric /leverage effect means whether bad news negative shock is more pronounced than good news positive shock for stock markets or vice-versa. Volatility modelling techniques traditionally were based on assumption of homoscedasticity and not in a position to capture the changing variance i.e. heteroskedasticity in the returns. So there was a need to capture financial time series features. To capture the features of financial time series nonlinear models such as ARCH/GARCH were developed.

Calculation of Stock Market Return: The returns are calculated and a logarithmic difference of two periods is taken as follows:

$$(\boldsymbol{InPt - InPt-1})*100$$

Where Rt is the return in the period t, daily closing prices of the index at time t and t-1 are Pt and Pt-1 respectively.

DESCRIPTIVE STATISTICS

A descriptive statistics summary for daily returns series of BSE Sensex Index for the period of eighteen years from January 2000 to December 2017 is presented in table 1.The values of mean, maximum, minimum, standard deviation, skewness, kurtosis and Jarque-bera test are included in the descriptive statistics. The mean of the BSE Sensex Index return is 0.000413 and for Gold Prices mean value is 0.000420

The standard deviation of BSE Sensex return series is 0.014849 and for gold prices, the standard deviation is 0.011171. Both series have negative skewness which is an indication of the long left tail for these series. The kurtosis for both the series is more than 3 and was found to be positive which means highly leptokurtic distribution compared to normal distribution for both variables.

Table 1: Analysis of Descriptives

(Period: 1st January 2000 to 31st December 2017)

Variable	Sensex	Gold Price
Mean	0.000413	0.000420
Median	0.000949	0.000324
Maximum	0.159900	0.071273
Minimum	-0.11809	-0.09495
Std. Dev.	0.014849	0.011171
Skewness	-0.20392	-0.18451
Kurtosis	10.61301	8.643642
Jarque-Bera	10823.22	5956.221

UNIT ROOT TEST

Whether the time series data possess a unit root or the time series variable is non stationary it is confirmed by the unit root test in statistics. In the empirical research to test the unit root in a time series data is a standard practice. For standard economic theory stationarity is required. ADF and PP unit root test are employed to check the stationarity of both time series. In the level series ADF and PP statistics had the presence of unit root in Sensex as Mackinnon's value did not exceed the critical values at 1%, 5% and 10% level. Hence null hypothesis of unit root was accepted. Which means that price series were non stationary. Hence series were transformed to first difference to make it stationary. Table 2 showed that the null hypothesis of unit root was rejected as reported by ADF and PP test statistic at first difference. The computed absolute values for index were higher than Mackinnon's critical values at 1%,5% and 10% level for ADF and PP test.Hence first difference of Index series were stationary.Since the data is stationary. Hence GARCH (1,1) and E-GARCH(1,1) models can be applied.

Table 2: Analysis of Unit Root Test (Daily Observations)

(Period: 1st January 2000 to 31st December 2017)

	ADF		PP	
	With Intercept	**With Trend & intercept**	**With Intercept**	**With Trend & intercept**
Sensex	62.06619	62.06261	62.13442	62.13122
Gold	41.62545	41.62672	68.08892	68.09065
Critical Values				
1 % level of Significance	3.431673	3.960153	3.431673	3.960153
5 % level of Significance	2.862010	3.410841	2.862010	3.410841
10 % level of Significance	2.567063	3.127219	2.567063	3.127219

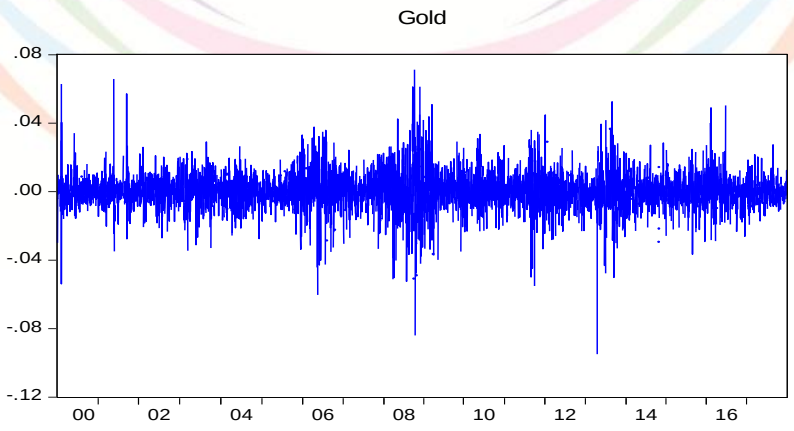

Figure 1: Gold prices time series daily observations
(Period: 1st Jan 2000 to 31st Dec 2017)

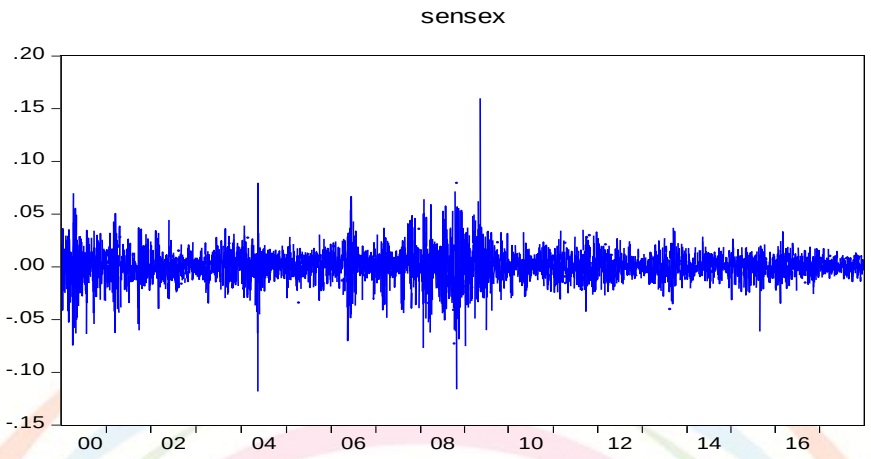

Figure 2: Sensex Return Series daily observations
(Period: 1st Jan 2000 to 31st Dec 2017)

ANALYSIS OF GARCH MODELS

ARCH and GARCH models are the main methodologies applied to model the stock market volatility in financial time series. GARCH term means the previous day's volatility. In the GARCH (1,1) model there is one ARCH term and one GARCH term.GARCH model has two parts, one is the mean equation and another is the variance equation. Firstly mean equation is developed then variance equation is developed. ARCH and GARCH both are the internal shocks of volatility or family shocks influencing BSE Sensex. The symmetric GARCH has the main drawback that conditional variance is unable to respond asymmetrically to rise and fall in the stock returns. To capture the symmetric effect GARCH (1,1) model is used, whereas for asymmetric effect or leverage effect E-GARCH(1,1) model is employed. Logic behind leverage effect or asymmetric is that stock return distribution is highly asymmetric. Volatility in prices increases as a result of bad news as compared to good news. Results of GARCH (1,1) and E-GARCH (1,1) models of Sensex return for the period of eighteen years from 1st Jan 2000 to 31st Dec 2017 are presented in Table 3 The results contain ARCH coefficient, GARCH coefficient, and E-GARCH coefficient. ARCH and GARCH indicate that lagged conditional variance and lagged squared disturbance impact on conditional variance that means volatility news from previous periods explain current volatility. In the estimated variance equation of the GARCH (1,1) model to check for any remaining autocorrelations in standardized and squared standardized residuals Ljung-Box test was used. If the variance equation was specified correctly Q (12) and Q2(12) statistics should not be significant. The Lagrange Multiplier (ARCH-LM) test was used to test the presence of remaining ARCH effects in the standardized residuals. Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) show that asymmetric effect (leverage) was

captured by parameters of E-GARCH (1,1) which exhibit that negative shocks have a significant impact on conditional variance (volatility). 0

Table 3: Analysis of GARCH (1,1) Model for SENSEX Returns

(Period: 1st Jan 2000 to 31st December 2017)

	GARCH (1,1)		E GARCH (1,1)	
Mean Equation				
Φ_1	0.000	0.000	0.000	0.001
Variance Equation				
ω	0.000	0.000	-0.349	0.000
α	0.096	0.000	0.195	0.000
β	0.893	0.000	0.977	0.000
γ				
δ			-0.075	0.000
Gold	0.000	0.000	2.169	0.000
AIC	-5.955		-5.970	
SIC	-5.948		-5.962	
RESIDUAL TESTS				
Q (12) Stats	46.573 (0.052)		45.974(0.0170)	
Q^2(12) Stats	20.506(0.058)		16.247(0.180)	
ARCH LM TESTS				
Lag 5	-0.008 0.572)		-0.004((0.751)	
Lag 10	0.015 (0.302)		0.0365(0.014)	

The variance equation in the table above shows constant (ω), ARCH term (α) and GARCH term (β) for the GARCH (1,1) model which were significant. ARCH is significant.GARCH is also significant. Gold Price or outside shock is also significant. In GARCH (1,1) the sum of two estimated ARCH and GARCH coefficients (persistence coefficients) was close to one. It was estimated by the asymmetric E-GARCH (1,1) model that the leverage (asymmetric) effect captured by parameter estimate δ coefficient was statistically significant with a negative sign.

CONCLUSION

The research paper investigated the impact of Gold prices on stock market volatility.The daily data for the period 1st January 2000 to 31st December 2017 is used in the study which is collected from the official website of the Bombay Stock Exchange and official website of World Gold Council. The values of mean, maximum, minimum, standard deviation, skewness, kurtosis, and jarque-bera test were included in the descriptive statistics. Unit root test, Correlogram test, ARCH test, univariate models of Generalized Autoregressive Conditional Heteroskedasticity

(GARCH) class like GARCH (1, 1), E-GARCH (1, 1) were used to evaluate the volatility. Augmented Dickey-Fuller (ADF) test and Phillip Perron (PP) test result show that the series is stationary and integrated of order one. In the estimated variance equation of the GARCH (1,1) model to check for any remaining autocorrelations in standardized and squared standardized residuals Ljung-Box test was used. The variance equation was specified correctly and Q (12) and Q2(12) statistics were not significant. The Lagrange Multiplier (ARCH-LM) test was used to test the presence of remaining ARCH effects in the standardized residuals. Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) showed that in the variance equation constant (ω), ARCH term (α) and GARCH term (β) for GARCH (1,1) model were significant. ARCH was significant.GARCH was also significant. Gold Price or outside shock was significant. Asymmetric effect (leverage) was captured by parameters of E-GARCH (1,1) which exhibit that negative shocks have a significant impact on conditional variance (volatility).

REFERENCES

Afsal, E.M., Mohammad Imdadul Haque (2016) "Market Interactions in Gold and Stock Markets: Evidences from Saudi Arabia". International Journal of Economics and Financial Issues, 6(3), 1025-1034

Patience Hupo (2017) "The Relationship between Gold Prices and Equity Market Performance: Evidence from the Zimbabwe Stock Exchange". Proceedings of The IRES International Conference, Harare, Zimbabwe.

Narang, S.P, Raman Preet Singh, "Causal Relationship between Gold Price and Sensex: A Study in Indian Context". Vivekananda Journal of Research, PP 33-37.

Bhuniai, Amalendu, Sanjib Pakira (2014) "Investigating The Impact of Gold Price and Exchange Rates on Sensex: An Evidence of India", European Journal of Accounting Finance and Business, Volume 2(1)

Srinivasan P (2014), "Gold Price, Stock Price and Exchange rate Nexus: The Case of India", The Romanian Economic Journal, XVII (52).PP 77-94

Banumathy, Karunanithy, Ramachandran Azhagaiah (2014)"Causal Relationship between Stock Price and Gold Price in India: A Granger Causality Test Approach" International Journal of Research in Management, Science & Technology Vol. 2, No. 2

Mukhuti, Amalendu Bhunia (2013), "Is it true that Indian gold price influenced by Indian stock market reaction",Journal of Business Management and Economics,Vol. 4(8),pp 181-186.

Karunanithy, Banumathy, Ramachandran Azhagaiah (2014) "Causal Relationship between Stock Price and Gold Price in India: A Granger Causality Test Approach", IJRMST

Basic Econometrics,Damodar N Gujrati,Dawn C Porter,Sangeetha Ganasekar, McGraw Hill, N.Delhi (5th Ed.),pp 70

Bollerslev, Tim (1986). "Generalized Autoregressive Conditional Heteroskedasticity," Journal of Econometrics, 31, 307–327.

Dickey, D.A. and W.A. Fuller (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," Journal of the American Statistical Association, 74, 427–431

Engle, Robert F. (1982). "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflation," Econometrica, 50, 987–1008.

Engle, Robert F. (1982). "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflation," Econometrica, 50, 987–1008.

MacKinnon, James G. (1991). "Critical Values for Cointegration Tests," Chapter 13 in R. F. Engle and C. W. J. Granger (eds.), Long-run Economic Relationships: Readings in Cointegration, Oxford: Oxford University Press.

Nelson, Daniel B. (1991). "Conditional Heteroskedasticity in Asset Returns: A New Approach," Econometrica, 59, 347–370.

Phillips, P.C.B. and P. Perron (1988). "Testing for a Unit Root in Time Series Regression," Biometrika, 75, 335–346.

Taylor, S. (1986). Modeling Financial Time Series, New York: John Wiley & Sons.