Impact of Global Financial Crisis and Implied Volatility in the Equity Market on Gold Futures Traded on Multi Commodity Exchange, India

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Abstract

Gold is one of the most highly traded commodities in the Indian Commodity Market. It can be traded either in the spot market or the futures market, options contracts are not permitted in the Indian commodity market. In this study, the price behaviour of Gold futures traded on Multi Commodity Exchange are analysed from the year 2007 to year 2013. The issue of the introduction of option contracts on Gold in the Indian commodity market has been addressed through: (a) Presence of short term persistence in return volatility (b) Impact of recent Global Financial Crisis on daily return volatility (c) Impact of implied volatility of equity market on return and weekly return volatility. The study indicates the presence of short term persistence in return volatility of gold as well as the influence of the recent Global financial crisis on return volatility of the metal. It is also observed that that the implied volatility of equity market affects the weekly returns as well as weekly return volatility of a futures contract of Gold.

Keywords: Crisis, Futures, Gold, VIX, Options

JEL Codes: Q02, L61, G01

1 Introduction

Over the years, India has continued to play a significant role in the global production chain of precious metals including gold and silver. The Forwards Market Commission initiated trading in gold and silver futures on Indian Commodity exchanges in 2003-04. In 2012-13, Gold was traded at Multi Commodity Exchange (MCX) and Indian Commodity Exchange (ICEX). Various contracts were traded on the commodity exchanges including Gold (1kg), Gold (100 gms), Gold Mini (10gms), Gold Guinea (8 gms), and Gold Petal (1gm).

Currently, option contracts on commodities are not available for trading in the Indian commodity market. In this study, the price behaviour of Gold futures traded on Multi Commodity Exchange are analysed from the year 2007 to year 2013. The issue of the introduction of option contracts on Gold in the Indian commodity market has been addressed through: (a) Presence of short term persistence in return volatility (b) Impact of recent Global Financial Crisis on daily return volatility (c) Impact of implied volatility of equity market, measured by India VIX[1] on weekly return and weekly return volatility.

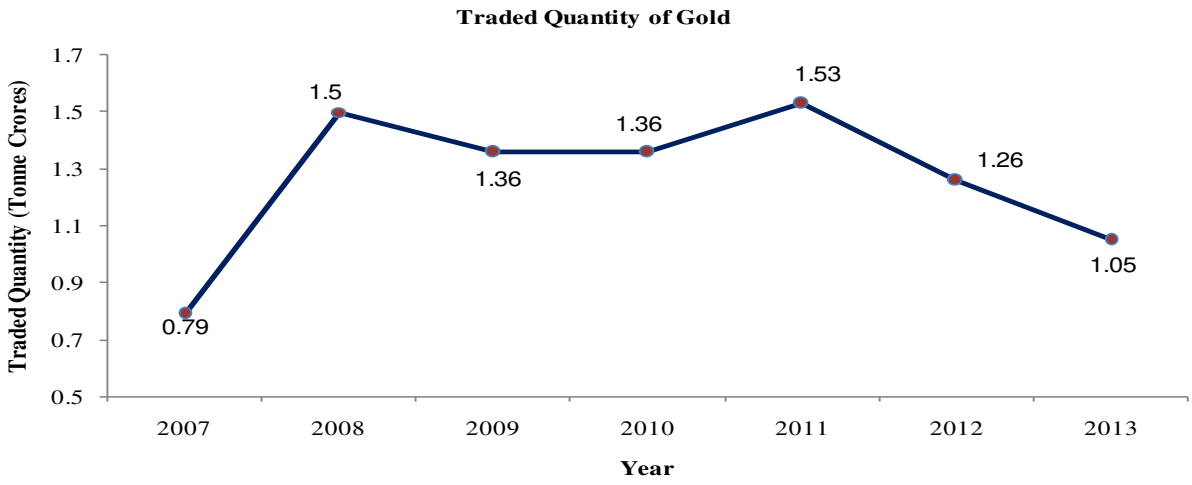
The number of traded contracts (in lots) (in crores) traded on MCX annually from the year 2007 to 2013 are plotted in a graph (refer to Figure 1). It is clear from the figure that gold futures have been extensively traded on MCX in the above mentioned period.

Source: MCX

Figure 1: Traded contracts (in lots) (Crores)

Figure 2 describes the traded quantity of Gold traded in Crores tonnes on MCX from 2007 to 2013.

[1] India VIX is a volatility index based on NIFTY Index options. It is a measure of the expectation of market volatility over the near term. VIX is a trademark of Chicago Board Options Exchange (CBOE); NSE has been granted a license by Incorporated (CBOE) and Standard & Poor's, with permission from CBOE, to use such mark in the name of the India VIX.



Source: MCX

Figure 2: Traded quantity (Crore tonnes)

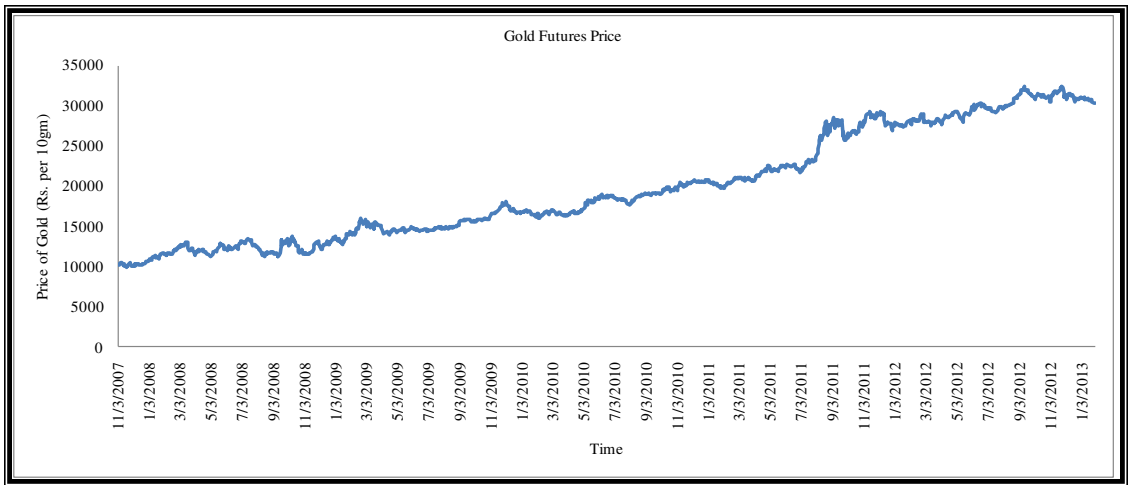
Table 1 gives the total value (Rs. Crores) of Gold traded on MCX from 2007 to 2013.

Table 1: Value of Gold traded on MCX (2007 - 2013)

Year	Total Value (in Rs. Crores)
2007	747860.92
2008	1840543.86
2009	2077976.08
2010	2484778.53
2011	3842725.33
2012	3743090.10
2013	3035596.70

Source: MCX

Figure 3 depicts the movements of futures prices of gold from November 2007 to January 2013.



Source: Authors Work; Compiled from Bloomberg

Figure 3: Price behaviour of Gold

Prices continued to stay in the range of Rs. 10,000-12000 per 10gm until the second half of March 2008 for near month contracts slated for delivery in April 2008 touching Rs. 13090 per 10gm due to lower interest rates, which had lead to a decline in price of a dollar accompanied by a rise in crude oil prices. Soon after March 19, 2008, gold futures prices began to decline averaging at Rs.12100 per 10gm. With the oil price hike in July 2008, gold market faced a spike, when it peaked at Rs. 13482 per 10gm on July 14, 2008. This was followed by a fluctuation in price, in the range of Rs.11259 and Rs. 13774 per 10gm till December 2008. Gold prices rose to around Rs. 15979 per 10gm in February 2009, gold was reported to be in the over bought zone during the period. This was followed by an upward journey and prices continued to remain in the range of Rs. 14000-15500 per 10gm until November-December 2009, when it peaked at Rs. 18109 per 10gm (December 2, 2009), as the dollar weakened and demand for the metal from central bankers rose. A sharp spike in gold prices was observed towards the end of 2010, when gold prices reached a peak of Rs. 20526 per 10gm (November 2010) due to the fall of dollar versus a basket of major currencies, boosting interest in the metal as a haven from currency market volatility followed by an average of Rs. 20934 per 10gm in the period from January 2011-May 2011. In May 2011, gold prices increased to Rs. 22626 per 10gm due to rising inflation and interest rates along with rise in crude oil prices. This was followed by a fluctuation in gold prices in the period from May to July 2011 with the price reaching a level of Rs. 28904 per 10gm in August 2011.Prices continued to remain in the range of Rs. 27000 to Rs. 29000 per 10gm till June 2012, and gold prices crossed the Rs. 30,000 per 10gm mark in June 2012 followed by an upward journey till November 2012(Rs. 32229 on November 27, 2012).

After a discussion of Gold prices, the next section reviews the studies pertaining to price and return volatility of Gold as well as the impact of implied volatility of equity markets on commodities.

2 Literature Review

High frequency futures price data of Gold, Silver and Copper is used by Khalifa et al. (2011) to estimate measures of volatility – absolute returns, bi-power volatility, realised volatility, integrated volatility using Fourier transformation. The authors evaluate predictive performance of GARCH (1,1) model using the four measures of volatility. They conclude from the comparison of measures of volatility that Gold has highest forecast error. Empirical research has been extensively conducted for studying volatility of prices of precious metals using asymmetric Power GARCH (Tully and Lucey (2007). Akgiray et al (1991) assess the time series properties of spot prices of gold and silver by using the GARCH model. The authors split the data into similar economic periods for the analysis. The study indicates that a GARCH (1,1) model assuming a power exponential distribution is an effective model to study volatility of prices of precious metals.

Literature suggests that extensions of GARCH model can be used to model volatility of precious metals as well as non-ferrous metals. Cochran et al. (2011) study the threshold effects in returns of metals, i.e., Aluminium, Copper, Gold, Silver and Platinum employing the difference in yield between 10-year treasury bonds and 90-day treasury bills as the threshold variables. They conclude that DT-FIGARCH (1, δ, 1) model captures the non-linearity of metal returns and their volatilities. They provide evidence to support the argument that the short memory of component of the volatility process of Copper, Platinum and Silver returns is unaffected by a change in regime, whereas long memory parameters are dependent on the regime.

Hammoudeh and Yuan (2008) examine futures prices of oil, Gold, Silver and Copper and utilise the GARCH, EGARCH, CGARCH model to study the impact of the Crude Oil shock and interest rate on metal returns and volatilities. They conclude that conditional volatility is more persistent for Gold and Silver than for Copper, and Crude Oil volatility is found to have a negative impact on metal volatility.

Arouri et al. (2012) investigate the long memory properties in terms of returns and volatilities of precious metals, namely: Gold, Silver, Platinum and Palladium, and document evidence that there is long range dependence in the daily conditional return and volatility processes for the precious metals. They conclude that Platinum is not an appropriate hedging instrument during the periods of crisis and consider Gold to serve as a better instrument. The authors ascertain that FIGARCH model is most effective in terms of predictive power for volatility and returns. Ismail et al. (2012) assess the impact of the crisis on volatility of Gold, Silver, Bronze and Platinum using the GARCH model and suggest investment in Gold and Platinum are safer in comparison to Silver and Bronze.

With respect to the Indian Commodity market, Gold has been studied extensively by various authors, and one such study is by Saravanan and Deo (2010) which looks into the gold futures price as well as the spot price of gold traded on NCDEX. The paper concludes that futures market leads the spot market even though it is observed from Granger causality that there exists bidirectional causality. Secondly, the authors argue that the date of expiration of gold futures contract does not influence the volatility of spot prices of gold, which has been attributed to the lower trading volume on the date of expiry of the contract.

A study on mini gold futures traded on MCX for the period from 1 January 2005 to 31 December 2008 by Devaradhen et al. (2010) uses Cointegration – VECM (Vector Error Correction Mechanism), to assess the relationship between spot price and futures price series. The results of the cointegration technique indicate the presence of a long run equilibrium relationship between the two price series and a unidirectional causality moving from mini gold futures to spot market. Jayagurunathan et al. (2010) employ Johanssen Cointegration technique and VECM model to examine the relationship between near month futures contract prices and spot market prices of gold traded on the Multi Commodity Exchange during the period from 2 May 2005 to 30 July 2009. The authors conclude that there exists a long term relationship between the two series of prices while the spot market leads the futures market proving that the information efficiency of spot contracts is higher.

By employing the Vector Error Correction Models, Pavabutr and Chaihetphon (2010) show that the futures price of standard and mini contracts of gold leads the spot price of the contracts in the long run as well as the short run. The study also finds that even though the trading volume of mini gold futures contracts is low, it is able to influence the spot price of gold significantly.

Srinivasan and Ibrahim (2012) analyse the futures and spot price of gold in order to examine the price discovery process and the spillover of volatility. The study uses VECM and the bivariate ECM-EGARCH(1,1) model. The study concludes that a univariate relationship exists from the price of gold spot contracts to gold futures contracts and spillover of volatility from spot to futures market are found to be stronger than spillover of volatility from futures market to spot market.

Another study which employs cointegration technique to examine the long run relationship and the short run relationship between gold spot prices and gold futures price is by Sharma and Agnihotri (2011). The study uses price series of spot contracts and futures contract of gold traded on MCX and NCDEX. The study finds that MCX gold futures market is efficient with respect to shorter periods (ranging from 1 week, 2 months and 3 months). Whereas, in case of contracts traded on NCDEX, the authors indicate that the gold market is found to be efficient only in the short run.

A study on the efficiency of futures market of Gold, Crude Oil, and Guar Seed is performed by Goyari and Jena (2010) using Engle Granger Cointegration test. The authors on the basis of the Engle Granger Cointegration test claim that there exists a cointegration in the long term between the spot and futures price of the three commodities respectively. For the purpose of forecasting of futures prices, the study employs linear ARIMA, random walk models and VAR model and the results of the forecasting values indicate an upward trend in the prices over the period from 2009 to 2010.

Yuvaraj (2012) tests the efficient market hypothesis for four commodities (precious metals, i. e., Gold, Silver, Crude Oil and Natural Gas) and the study finds that past prices cannot be utilised to predict the futures price of commodities. It concludes that the commodity market is in the weak form of efficiency. Granger causality is employed by Sahoo and Kumar (2009) to observe the efficiency of commodity futures in five commodities (Gold, Copper, Crude Oil, Soya Oil, and Chana). The authors find that there is a feedback effect from price of futures contract to the price of spot contract for the commodities respectively. They also conclude that the futures market does not necessarily lead to inflation in price of commodities by using Granger causality tests between trading volume and the spot price of Gold, Copper, Soya Oil and Chana respectively.

Most of the studies pertaining to the Indian commodity market have not analysed the impact of the financial crisis and impact of implied volatility in equity market on the gold returns and volatility, the current study tries to fill this gap. This needs to be looked to examine the need of introducing options for which the underlying asset will be gold to be traded in the Indian commodity derivatives market.

3 Data and Methodology

The study comprises three parts. The first and second part of the study use daily futures prices (near month futures contract) of Gold traded on MCX for the period between November 3, 2007 and January 30, 2013. The closing prices of near month futures contracts are extracted as they are generally the most liquid contracts. The third part of the study deals with weekly price series of Gold futures traded on Multi Commodity Exchange (MCX), and employs India VIX closing value data[2]. The data for India VIX is available from November 5, 2007.

[3] India VIX closing values daily data is available from 1 November 2007 onwards. India VIX is reported throughout the week except Saturday and Sunday, while price data for commodities is reported on all days of the week excluding Sunday. To maintain symmetry, weekly data for both price of commodities and India VIX is employed.

The data for commodity prices has been extracted from Bloomberg, and Multi Commodity Exchange, while India VIX closing value data has been compiled from National Stock Exchange of India (NSE) website and Bloomberg. Table 2 presents the summary statistics for Gold futures prices daily series for the period of study.

Table 2: Descriptive Statistics for Daily Price Series of Gold (in Rs/10gm)

Statistic	Futures Price
Mean	19751.10
Mode	14895
Median	18364
Standard Dev	6702.03
Minimum	9924
Maximum	32359
Skewness	0.41
Kurtosis	-1.20
StDev/Mean	0.34

Source: Authors Work

The above table clearly shows that the prices of Gold futures varied over the period of study were varied from as low as Rs. 9924 per 10gm to Rs. 32359 per 10gm. Table 3 presents the summary statistics for India VIX for the period of study.

Table 3: Summary Statistics of Weekly India VIX

Statistic	India VIX
Mean	28.57
Median	25.95
Maximum	85.13
Minimum	13.04
Std. Dev.	11.16
Skewness	1.43
Kurtosis	5.89

3.1 Short Term Persistence in Volatility of Gold

The first part of the study involves computing the daily return series of Gold futures prices. Return is calculated as the log difference in price. After the calculation of daily return series, the Jarque Bera test for normality is performed, followed by Augmented Dickey Fuller Test and Phillips-Perron Test for

stationarity. To check whether there exists short term persistence in volatility, we use a ARMA GARCH model in Model I (Equation 1 and Equation 2)[3].

Model I	
$\sum_{i=1}\delta_i r_{t-i} + \sum_{j=1}\delta_j \varepsilon_{t-j} + \varepsilon_t$;	$\varepsilon_t \sim N(0, \sigma_t^2)$ (Equation 1)
Variance equation: $\sigma_t^2 = s_0 + s_1(\varepsilon_{t-1})^2 + s_2\sigma_{t-1}^2$	(Equation 2)

Where r_t represents the return of Gold futures at time t; j_0 represents the constant term; δ_i is the ith autoregressive coefficient; δ_j is the jth moving average coefficient; ε_t represents the error term; σ_t^2 is the conditional variance term; s_0 is the constant term in the variance equation (Equation 2); ε_{t-1}^2 is news about the volatility from previous period (ARCH term); s_1 is the coefficient of ARCH term; σ_{t-1}^2 accounts for the previous period's forecast variance (GARCH term); s_2 is the coefficient of GARCH term.

3.2 Impact of Global Financial Crisis on return volatility of Gold

To understand whether the financial crisis which began on 1 September 2008 (when the effects of the crisis started to show up) had an impact on the daily historical volatility of Gold futures traded on MCX, a modified ARMA GARCH model (Model – ARII) is employed. The mean equation remains the same (Equation 1 as in Model-ARI), whereas a dummy variable (D_t) is added to the variance equation (Equation 3) to study the impact of crisis on the volatility of Gold futures via modified ARMA GARCH model.

Model II	
$\sum_{i=1}\delta_i r_{t-i} + \sum_{j=1}\delta_j \varepsilon_{t-j} + \varepsilon_t$;	$\varepsilon_t \sim N(0, \sigma_t^2)$ (Equation 1)
Variance equation: $\sigma t^2 = s_0 + s_1(\varepsilon_{t-1})^2 + s_2\sigma_{t-1}^2 + s_3 Dt$	(Equation 3)

Where r_t represents the return of Gold futures at time t; δ_i is the ith autoregressive coefficient; δ_j is the jth moving average coefficient; ε_t represents the error term; σ_t^2 is the conditional variance term; s_0 is the constant term in the variance equation (Equation 3) ; ε_{t-1}^2 is news about the volatility from previous period (ARCH term); s_1 is the coefficient of ARCH term; σ_{t-1}^2 accounts for the previous period's forecast variance (GARCH term); s_2 is the coefficient of GARCH term; D_t accounts for the dummy variable (D_t=0 before 1 September 2008 and D_t=1 after 1 September 2008); s_3 is the coefficient of the dummy variable D_t.

[3] ARMA GARCH (1,1) is run as it was found to be the most suitable model; To check whether or not GARCH models can employed for the daily return series, ARCH-LM tests were performed using the daily return series.

Table 4: Summary Statistics of Weekly Returns of Gold Futures Price

Statistic	Weekly Gold Futures Price
Mean	0.0040
Median	0.0029
Maximum	0.1192
Minimum	-0.0889
Std. Dev.	0.0262
Skewness	0.4858
Kurtosis	6.2137
ADF(4)^	-8.0885**
ADF(t,4) ^	-8.0972**
PP(0) ^	-16.4896**
PP(4) ^	-16.5149**

^Critical value at 5% level for ADF(4), PP(0) and PP(4) is -2.86 and for ADF(t,4) it is -3.41; ** indicates significance at 5% level

From Table 4, it is revealed that the average weekly return on gold futures for the period of study is positive, 0.0040. The value of kurtosis for the series is higher than 3, indicating a heavy tailed leptokurtic distribution. On running the stationarity tests, Augmented Dickey Fuller Test and Phillips Perron test for the weekly return series, it is observed that the weekly return series of futures prices is stationary.

3.3 Impact of implied return volatility of equity market on returns and return volatility of Gold Futures

Weekly data for Gold returns is used to analyse whether returns and conditional volatility of Gold traded were affected by implied volatility in equity market (measured by India VIX).

Variants of ARMA GARCH modified model are employed to model this relationship. This part of the study uses three specifications (Model III, Model IV, and Model V) in modified ARMA GARCH model. The first specification (Model-III) includes India contemporaneous VIX variable in the mean equation, as well as AR and MA parameters (Equation 4) while there is no alteration in variance equation of basic ARMA GARCH model (same variance equation as Model I – Equation 2). This specification is used to study the impact of implied volatility in equity market on return of Gold. The second specification (Model IV) includes AR, MA parameters in the mean equation and India contemporaneous VIX variable in the variance equation (Equation 5) of the basic ARMA GARCH model. This specification is used to study the impact of implied volatility in equity market on volatility of Gold futures. The third

specification tries to study the effect of volatility in the equity market on Gold simultaneously; this includes Indian contemporaneous VIX variable both in the mean equation as well as the variance equation. The mean equation also includes the ARMA parameters.

3.3.1 The impact of implied volatility in equity market on return of Gold

Model III

$\sum_{i=1}\delta_i r_{t-i} + \sum_{j=1}\delta_j \varepsilon_{t-j} + \varepsilon_t$; $\varepsilon_t \sim N(0, \sigma_t^2)$ (Equation 4)

Variance equation: $\sigma_t^2 = s_0 + s_1(\varepsilon_{t-1})^2 + s_2\sigma_{t-1}^2$ (Equation 2)

Where r_t represents the return of commodity futures at time t; j_0 represents the constant term; IN_VIX_t represents contemporaneous VIX; j_1 is the coefficient of IN_VIX_t; δ_i is the ith autoregressive coefficient; δ_j is the jth moving average coefficient; ε_t represents the error term; σ_t^2 is the conditional variance term; s_0 is the constant term in the variance equation (Equation 2); ε_{t-1}^2 is news about the volatility from previous period (ARCH term); s_1 is the coefficient of ARCH term; σ_{t-1}^2 accounts for the previous period's forecast variance (GARCH term); s_2 is the coefficient of GARCH term.

3.3.2 The impact of implied volatility in equity market on return volatility of Gold futures

Model IV

$\sum_{i=1}\delta_i r_{t-i} + \sum_{j=1}\delta_j \varepsilon_{t-j} + \varepsilon_t$; $\varepsilon_t \sim N(0, \sigma_t^2)$ (Equation 1)

Variance equation: $\sigma_t^2 = s_0 + s_1(\varepsilon_{t-1})^2 + s_2\sigma_{t-1}^2 + s_4(IN\_VIX)_t$ (Equation 5)

Where r_t represents the return of Gold futures at time t; j_0 represents the constant term; δ_i is the ith autoregressive coefficient; δ_j is the jth moving average coefficient; ε_t represents the error term; σ_t^2 is the conditional variance term; s_0 is the constant term in the variance equation; ε_{t-1}^2 is news about the volatility from previous period (ARCH term); s_1 is the coefficient of ARCH term; σ_{t-1}^2 accounts for the previous period's forecast variance (GARCH term); s_2 is the coefficient of GARCH term. IN_VIX_t represents contemporaneous VIX; s_4 is the coefficient of IN_VIX_t (Equation 5).

3.3.3 The impact of implied volatility in equity market on return of Gold and return volatility of Gold futures (simultaneously)

Model V

$\square_{=1}\square\delta_i r_{t-i} + \square_{=1}\square\delta_j\varepsilon_{t-j} + \varepsilon_t$; $\varepsilon_t \sim N(0, \sigma_t^2)$ (Equation 4)

Variance equation: $\sigma_t^2 = s_0 + s_1(\varepsilon_{t-1})^2 + s_2\sigma_{t-1}^2 + s_4(IN\_VIX)_t$ (Equation 5)

Where r_t represents the return of Gold futures at time t; j_0 represents the constant term; IN_VIX_t represents contemporaneous VIX; j_1 is the coefficient of IN_VIX_t; δ_i is the ith autoregressive coefficient; δ_j is the jth moving average coefficient; ε_t represents the error term; σ_t^2 is the conditional variance term; s_0 is the constant term in the variance equation; $(\varepsilon_{t-1})^2$ is news about the volatility from previous period (ARCH term); s_1 is the coefficient of ARCH term; σ_{t-1}^2 accounts for the previous period's forecast variance (GARCH term); s_2 is the coefficient of GARCH term. IN_VIX_t represents contemporaneous VIX; s_4 is the coefficient of IN_VIX_t (Equation 5).

We calculate AIC values using different orders of ARMA in modified ARMA GARCH model. On the basis of the lowest AIC values, we estimate the parameters for the five models explained in detail above.

4 Empirical Results

4.1 Short Term Persistence in Volatility of Gold

The AIC values for ARMA parameters in Equation 1 (Model I) are reported for Gold in Table 5.

Table 5: AIC values for ARMA parameters in Equation 1 (Model I) for Gold

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-6.53709	-6.53646	-6.53535	-6.53607	-6.53497	-6.53371
AR(1)	-6.53644	-6.53527	-6.54575	-6.53514	-6.53401	-6.53487
AR(2)	-6.5354	-6.54593	-6.54561	-6.54568	-6.5383	-6.53839
AR(3)	-6.5359	-6.53503	-6.54342	-6.54669	-6.54471	-6.54362
AR(4)	-6.53494	-6.53382	-6.53833	-6.54547	-6.54678	-6.54868
AR(5)	-6.53368	-6.53269	-6.53799	-6.54336	-6.54473	-6.54271

On the basis of the lowest AIC values, we estimate the parameters for Model I (Equation 1 and Equation 2). The results for Model I for Gold are reported in Table 6.

Table 6: Results of Model I (Equation 1 and Equation 2)

Return on	Mean Equation			Variance Equation			Log Likelihood
	Mean Constant (j_0)	AR term	MA term	Variance Constant (s_0)	Coefficient of Error (ARCH effect) (s_1)	Coefficient of Variance (GARCH effect) (s_2)	

Gold Futures	**0.0004 (0.0191)**	(4,5)		**1.68E-07 (0.0000)**	**0.0509 (0.0000)**	**0.9406 (0.0000)**	5229.023
		-0.9351 (0.0000)	0.0495 (0.0753)				

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

Under the specification of ARMA GARCH model (Model-I) the mean equation (Equation 1) contains both autoregressive (AR) and moving average (MA) parameters. From Table 6, it can be seen that for Gold, AR parameter is significant whereas MA parameter is insignificant.

Coefficients of ARCH (s_1) and GARCH (s_2) of Gold is positive and significant, indicating the presence of short term persistence in volatility. Economically speaking, this indicates that the shocks caused to the conditional volatility of Gold futures persist for a long time. The presence of persistence in volatility of metals can be considered useful for risk management (optimal hedging strategies) as well as pricing of derivative contracts in the precious metal.

4.2 Impact of Global Financial Crisis on return volatility of commodities

The AIC values for ARMA parameters in Equation 1 (Model II) are reported for Gold in Table 7.

Table 7: AIC values for ARMA parameters in Equation 1 (Model II)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-6.5456	-6.54497	-6.54383	-6.54448	-6.54336	-6.54211
AR(1)	-6.54495	-6.54378	-6.55294	-6.54356	-6.54246	-6.5413
AR(2)	-6.54387	-6.55294	-6.54976	-6.55114	-6.55053	-6.54933
AR(3)	-6.54432	-6.54344	-6.55366	-6.5557	-6.55311	-6.55336
AR(4)	-6.54332	-6.54227	-6.55053	-6.55301	-6.55065	-6.5519
AR(5)	-6.54207	-6.54113	-6.54928	-6.55464	-6.55047	-6.54981

On the basis of the lowest AIC values, we estimate the parameters for Model II (Equation 1 and Equation 3). The results for Model II for Gold are reported in Table 8.

Table 8: Results of Model II (Equation 1 and Equation 3)

Return on	Mean Equation			Variance Equation				Log Likelihood
	Mean Constant (j_0)	AR term	MA term	Variance Constant (s_0)	Coefficient of Dummy (s_3)	Coefficient of Error (ARCH effect) (s_1)	Coefficient of Variance (GARCH effect) (s_2)	

Gold Futures	**0.0006 (0.0000)**	(3,3)		**4.13E-06 (0.0000)**	**-3.15E-06 (0.0001)**	**0.0445 (0.0000)**	**0.9408 (0.0000)**	5232.616
		0.7976 (0.0000)	**-0.8404 (0.0000)**					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

In the specification related to financial crisis (Model II), the variance equation (Equation 3) contains an additional variable, the dummy variable (D_t) besides ARCH and GARCH terms. The AR and MA terms in the mean equation (Equation 1) are found to be significant.

From the coefficient of (s_3) in the variance equation it is observed that the financial crisis affects return volatility of futures on Gold, the coefficient of the dummy variable is found to have a negative sign which indicates that the volatility responds in the opposite direction of crisis, indicating that volatility has declined after September 2008. The ARCH and GARCH terms are significant for the return series. Thus, it can be advanced that there is presence of short term persistence in volatility in the chosen period of study.

4.3 Impact of implied return volatility of equity market on returns and return volatility of Gold Futures

4.3.1 The impact of implied volatility in equity market on return of Gold

The AIC values for ARMA parameters in Equation 4 (Model III) are reported for Gold in Table 9.

Table 9: AIC values for ARMA parameters in Equation 4 (Model III) for Gold

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-4.75555	-4.749	-4.74156	-4.74304	-4.73553	-4.74554
AR(1)	-4.74899	-4.74769	-4.74014	-4.73668	-4.79586	-4.82271
AR(2)	-4.74148	-4.80619	-4.75613	-4.79936	-4.79252	-4.7987
AR(3)	-4.73943	-4.73292	-4.79873	-4.80421	-4.79696	-4.78152
AR(4)	-4.7324	-4.79872	-4.78758	-4.79685	-4.78691	-4.7842
AR(5)	-4.73233	-4.80097	-4.7943	-4.78642	-4.78896	**-4.8268**

On the basis of the lowest AIC values, we estimate the parameters for Model III (Equation 4 and Equation 2). The results for Model III for Gold are reported in Table 10.

Table 10: Results of Model III (Equation 4 and Equation 2)

Return on	Mean Equation				Variance Equation			Log Likelihood
	Mean Constant	AR term	MA term	Coefficient of India VIX (j_1)	Variance Constant	Coefficient of Error (ARCH	Coefficient of Variance (GARCH	

	(j_0)				(s_0)	effect) (s_1)	effect) (s_2)	
Gold Futures	**0.0049 (0.0000)**	(5,5)		**1.0792 (0.0002)**	2.15E-05 (0.0979)	**0.1813 (0.0035)**	**0.7827 (0.0000)**	654.5508
		0.326 (0.1248)	**-0.5313 (0.0219)**					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

Under the specification of modified ARMA GARCH model (Model-III) the mean equation (Equation 4) includes a variable named India contemporaneous VIX apart from the constant term, AR and MA terms. In Table 10 we report the results of Model III for Gold. The AR parameter is insignificant while MA term is found to be significant. For the return series of Gold futures, the coefficient of India contemporaneous VIX (j_1) in the mean equation is found to be significant. Thus, it can be inferred that weekly returns of Gold futures are influenced by implied volatility of equity market. In the variance equation (Equation 2 of Model-III), the ARCH effects and GARCH effects are exhibited by the commodity futures return series.

4.3.2 The impact of implied volatility in equity market on return volatility of Gold futures

The AIC values for ARMA parameters in Equation 1 (Model IV) are reported for Gold in Table 11.

Table 11: AIC values for ARMA parameters in Equation 1 (Model IV)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-4.75615	-4.74935	-4.74181	-4.74353	-4.736	-4.74698
AR(1)	-4.74937	-4.74861	-4.74113	-4.73727	-4.72979	-4.80668
AR(2)	-4.74182	-4.74107	-4.75806	-4.80303	-4.79636	-4.80391
AR(3)	-4.73989	-4.7333	-4.8029	**-4.80921**	-4.80202	-4.79697
AR(4)	-4.73284	-4.72588	-4.75852	-4.80187	-4.77893	-4.79158
AR(5)	-4.7327	-4.80477	-4.79862	-4.79927	-4.78852	-4.78006

On the basis of the lowest AIC values, we estimate the parameters for Model IV (Equation 1 and Equation 5). The results for Model IV for Gold are reported in Table 12.

Table 12: Results of Model IV (Equation 1 and Equation 5)

Return on	Mean Equation			Variance Equation				Log Likelihood
	Mean Constant (j_0)	AR term	MA term	Variance Constant (s_0)	Coefficient of IN_VIX_t (s_4)	Coefficient of Error (ARCH effect) (s_1)	Coefficient of Variance (GARCH effect) (s_2)	
Gold	**0.0039 (0.0000)**	(3,3)		-7.56E-06 (0.8024)	**1.68E-06 (0.0000)**	**0.1818 (0.0032)**	**0.7518 (0.0000)**	648.2201

Futures		**0.6117 (0.0000)**	**-0.8292 (0.0000)**					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

In the second specification related to VIX (Model IV), only the variance equation (Equation 5) contains an additional variable, the India contemporaneous VIX variable besides ARCH and GARCH terms. It is reported in Table 12 that in the mean equation (Equation 1), the AR and MA parameters are found to be significant for the Gold return series. From the coefficient of India contemporaneous VIX (s_4) in the variance equation it is observed that implied volatility in equity market affects return volatility of futures on Gold. The ARCH term (s_1) and the GARCH term (s_2) are significant for Gold. Thus, for Gold futures it can be advanced that there is presence of short term persistence in volatility.

4.3.3 The impact of implied volatility in equity market on return of Gold and return volatility of Gold futures (simultaneously)

The AIC values for ARMA parameters in Equation 4 (Model V) are reported for Gold in Table 13.

Table 13: AIC values for ARMA parameters in Equation 4 (Model V) for Gold

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-4.75064	-4.744	-4.73651	-4.73873	-4.73123	-4.74147
AR(1)	-4.744	-4.74322	-4.7357	-4.73252	-4.72503	-4.79937
AR(2)	-4.73646	-4.73567	-4.7522	-4.79665	-4.7901	-4.79638
AR(3)	-4.73482	-4.72828	-4.79612	-4.80269	-4.79543	-4.79012
AR(4)	-4.72781	-4.72087	-4.78777	-4.78873	-4.75775	**-4.82353**
AR(5)	-4.72746	-4.79724	-4.79107	-4.79225	-4.80245	-4.81058

On the basis of the lowest AIC values, we estimate the parameters for Model V (Equation 1 and Equation 5). The results for Model V for Gold are reported in Table 14.

Table 14: Results of Model V (Equation 4 and Equation 5)

Return on	Mean Equation				Variance Equation				Log Likelihood
	Mean Constant (j_0)	Coefficient of IN_VIX_t (j_1)	AR term	MA term	Variance Constant (s_0)	Coefficient of IN_VIX_t (s_4)	Coefficient of Error (ARCH effect) (s_1)	Coefficient of Variance (GARCH effect) (s_2)	
Gold Futures	**0.0048 (0.0000)**	-3.17E-05 (0.3865)	(4,5)		5.51E-06 (0.8128)	7.43E-07 (0.5743)	**0.1767 (0.0063)**	**0.7788 (0.0000)**	654.1174
			0.3481 (0.3523)	-0.1458 (0.0687)					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

In the third specification of VIX both the mean equation (Equation 4) and the variance equation (Equation 5) contain an additional variable, the India contemporaneous VIX variable besides AR and MA term in the mean equation and ARCH and GARCH terms in the variance equation respectively. It is reported in Table 14 that in the mean equation (Equation.4), the AR and MA parameters are found to be insignificant for Gold futures. In the mean equation, the coefficient of India contemporaneous VIX is insignificant for Gold. Whereas in the variance equation, the coefficient of India contemporaneous VIX, which indicates the implied volatility in equity market does not affect return volatility of futures on Gold. The ARCH term (s_1) and GARCH term (s_2) are significant for Gold futures return series.

5 Conclusion

Results indicate that returns on future prices of Gold is linearly related and there is a presence of persistence in return volatility as estimated by ARMA GARCH model which shows that volatility needs to be considered useful for risk management as well as pricing of derivatives underlying the precious metal. The financial crisis has a significant impact on daily return volatility of Gold futures. The estimates of ARMA GARCH model on weekly returns indicate that the implied volatility of equity market influences weekly returns as well as weekly return volatility of a futures contract of Gold. Thus, the precious metal clearly could provide a diversification value in the portfolio of hedgers.

Though, the volatility in the commodity market is lower than volatility in the equity market, but the return volatility is found to be affected by the volatility of the equity market. The pricing of futures contract does not consider the volatility inherent in the commodity but the position (long/short) in the contract is determined on the basis of systematic risk inherent in the commodity. In the commodity futures market, the long/short position holders are obligated to buy/sell the underlying commodity at the time of maturity. In order to mitigate the risk of return volatility in the commodities, it is imperative to introduce option contracts in the Indian Commodity market. Option contracts are priced taking into consideration the price volatility of the underlying commodity. The amount of premium of call options and put options is determined on the basis of volatility inherent in the commodity. The introduction of commodity option contracts in the Indian commodity market, specifically in case of Gold, will facilitate the long/short position holder to do away with the obligation and provide an opportunity to buy/sell the commodity from the spot market.

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