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GOLD VS. INDIA VIX : A COMPARATIVE ASSESSMENT OF THEIR CAPACITY TO ACT AS A HEDGE AND/OR SAFE HAVEN AGAINST STOCKS, CRUDE AND RUPEE-DOLLAR RATE

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ABSTRACT

The present study is an attempt to compare two assets viz. Gold and INDIA VIX against three asset classes Nifty Index, Rupee-Dollar Exchange Rate, Crude so as to identify which of the two assets could be considered as the right prescription for an Indian investor as a hedge and which asset could prove as a safe haven or a rescue asset during adverse market conditions. The study considers daily closing prices of five variables for the period April 1, 2008 - March 31, 2019. The study employs both traditional tools like OLS Regression (with Dummy Variable) and also newer techniques like quantile regression to achieve the stated objective. Further both linear and non linear models have been constructed and study also includes a separate section for the period of Sub Prime Crisis to judge the behaviour of our variables during these times. The results of the study using OLS Model clearly showed that INDIA VIX does appear to perform its role as a safe haven asset in weak to moderate form against Nifty return while gold fails completely in this role. On the other hand , results from quantile regression do give a clue that gold might work as a safe haven against different asset classes, this however comes with a very low probability and the same is also true for INDIA VIX. The quantile regression however throws some evidence that gold might also act as a hedge against Nifty Return while INDIA VIX could be suitable hedge against crude. Further the results of variability in returns during the sub prime crisis was noticed in case of gold as the dummy for sub prime was found to be statistically significant.

Keywords: INDIA VIX, GOLD, Quantile Regression, Hedging, Safe-Haven.

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INTRODUCTION

A lot of changes have taken place in financial markets over the past few decades e.g. the markets have grown not only in terms of number of instruments traded , but also in terms of volumes , market capitalization, trading styles, clearing and settlement. This steep growth has also enhanced the risks in terms of increased volatility, spill-over of volatility and associated unexpected returns which are seen to increase manifold during a crisis period. During these uncertain times, one asset that has received the attention of a lot of investors is Gold. Traditionally investors have often used this asset to hedge inflation risk, however the volatile markets as they are today, require an asset which could work as a hedge and even a safe haven against other asset classes which the investors usually hold e.g. stocks, currency and bonds. This requires a thorough analysis of different assets using empirical data to confirm the possibility of an asset which could serve as a hedge and/or safe haven.

A formal examination of Gold in the capacity of a hedge asset was initiated by Capie et.al.(2005) and Lucey et.al.(2006) with a more comprehensive analysis being done by Baur & Lucey (2010). Baur & Lucey (2010) found that Gold could work satisfactorily as a safe haven asset against stocks, however the same was not true for bonds. The paper also gave a formal definition of the terms; hedging and safe haven. An asset qualifies to be a hedge if it was negatively correlated or even uncorrelated with another asset or portfolio of assets in all situations except extreme situations (e.g. market turmoil) and if an asset continues to be negatively correlated during these extreme situations then such an asset could be categorised as a safe haven. A study by Raza, N., et.al. (2019) compared hedging effectiveness of four different alternate asset classes including crude and gold on stock indices (including Islamic indices) and the results showed that both gold and crude could be a good hedge for Islamic indices. However in terms of risk reduction capability, gold scored over crude. In yet another study, Iqbal, J. (2017) investigated capacity of gold to act as a hedge or a safe haven against exchange rate and stock markets for

three economies ; India, Pakistan, and US. They used both Baur and Lucey's (2010) model & quantile regression approaches to test their hypothesis. Whereas Baur's Model showed that gold was not acting as a hedge in any of the three economies, quantile methodology results were quite different for the three countries. In case of Pakistan it was seen that gold was a strong hedge against stocks and was a safe haven when both gold and stocks were showing bearish trends. The same was also true for US markets, however for India; gold was not seen as a good hedge for stocks.

Since gold falls in the category of precious metals, some researchers like Draper et.al (2006); Hammoudeh, Malik, and Mc.Aleer (2011) have also extended their research to cover other precious metals like silver and platinum. Researchers like Conover et al. (2009) ; Riley (2010); Morales and Andreosso-O'Callaghan (2011) amongst others have proved that like gold, other precious metals do also enjoy hedging and safe haven characteristics and thus investors can reduce their portfolio risks with the inclusion of these precious metals in their portfolio. Other studies with almost similar results were undertaken by Jaffe (1989), Chua et al. (1990). Further researchers also found that precious metals too were also found to actually perform their best when the financial markets witnessed high volatility. What made an asset like gold extremely popular as compared to other precious metals was that it could act as a strong hedge during times of persistent volatility (today's high volatility persisting in near future also) which also yielded low returns *(high volatility-low return relation is called asymmetric relation between return-volatility see Christie (1982) and Campbell and Hentschel (1992))*.

On the other hand there have been very few studies which could dis-approve the hedging characteristics of gold and precious metals and one such study was carried out by Robiyanto, et al., (2017). In their paper, a comparative study of gold vs. other precious metals and crude pertaining to hedge and safe haven characteristics was carried out for South East Asian Stock markets. The results showed that whereas crude acted as a hedge, gold and other precious metals did not for most markets. As far as safe haven was concerned, crude did fulfil its role for most of the markets,

whereas precious metals including gold acted as safe havens only in one or two select markets. Thus except for these handful of studies, majority of studies do confirm to the hedging characteristics of gold.

An interesting study was carried out by Pullen, et al. (2014) where they made a comparative analysis of diversifier, hedging and safe haven characteristics of different types of gold classes viz. gold ETF, Pure bullion , gold stocks and gold funds . The research which covered daily data period from 1987–2010, found that whereas gold bullion was a hedger, while gold funds, ETF and stocks were mere diversifiers. As far as safe haven property was concerned only, gold bullion and ETFs were seen to display this property. Thus keeping in view the above discussion, the broad conclusion which can be drawn is that the gold acting as an instrument of hedge is now widely recognised and well understood by today's investing class and portfolio managers.

Now this being the case, an important question which arises is : Can we think of an alternate asset , beyond gold and other precious metals which could also be used as a hedge against the market conditions such as one with extreme volatility coupled with sustained low returns which has become quite common phenomenon nowadays in the financial markets? Researchers have attempted to find a solution to this by including other commodities including agricultural commodities, base metals and the all popular asset 'crude oil'. Some researchers like Wu, S. et al. (2019) have experimented with Bitcoin; Bitcoin has many features similar to gold and many argue that it was launched primarily for two reasons; first, as an investment avenue for those who lose trust in the main system and second, to overcome the uncertainty in the existing financial system (Bouri, Eet.al. 2017; Wang et al., 2018; Wu, S. et al. 2019). During European Debt crisis of 2010, the Crypto banking crisis of 2012 and the 2018 currency crisis of Turkey in 2018 a lot of investors did actually switch to Bitcoin to hedge their risks (Wu, S. et al. (2019).

A paper by Bouri, et al. (2019) focused on eight crypto currencies and undertook a tail analysis to check the effectiveness of safe haven and hedging characteristics of

these crypto currencies. The results showed a mixed interaction between equity indices and crypto-currencies with some crypto currencies performing their role as a safe haven with some success against US stocks, while others did not. These results would imply that those crypto currencies which were giving positive safe haven clues could be used by investors to take care of their downside risk. The researchers however have also advised a word of caution while using crypto currencies that such currencies are of recent origin, carry much higher risk, are subject to less regulations and large manipulations, besides they also carry little empirical research to support their roles. Now with this being the case, such an asset just cannot be compared with assets like gold which has been used by the investors as an alternate investment asset for centuries.

The above discussion clearly points out that none of the above mentioned assets could play a satisfactory role and be an ideal substitute for the 'yellow metal' as a hedging instrument. On the other hand there is one asset which although is again of recent origin but this asset has been an outcome of a strong research and is rather close to financial markets than most assets discussed above. This asset is Volatility Index or VIX*. VIX or the Implied Volatility Index is based upon stock / index options which simply reflect the consensus opinion of market traders about future volatility of the underlying asset over its remaining lifetime. VIX has also been recently experimented for its hedge and safe haven characteristics by the researchers and the results obtained has been quite encouraging.

In a study by Brière, et.al.(2010) the researchers actually found that if the exposure to volatility was for a long period then this exposure proved to be extremely useful during sustained market declines. Another study by Boscaljon, & Clark, (2013) used event study methodology and found that when VIX rose by 25 %, investors increased stake in gold and gold ETFs. Now although the above two studies did talk about exposure to volatility but the direct mention of the VIX as an instrument of hedge /

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* *VIX was first introduced by Chicago Board Options Exchange in 2003 and was later adopted globally by other financial markets*

safe haven was seen for the first time in the paper by Hood & Malik (2013) where they compared the performance of VIX with gold and concluded that VIX was actually superior to gold and other alternate assets when it comes to the hedging and safe haven characteristics of an asset. A study by Abid et.al. (2019) compared the ability of four assets viz. crude, gold, bonds & VIX forecast volatility in equity markets and found that by using VIX, equities showed inverted dynamics showing benefits due to diversification.

The concept of volatility index (VIX) which was initially employed in case of stock markets has now been extended to other financial markets like bonds, T Bills and even for gold. One interesting study worth mentioning is that by Sarwar (2017) who did a comparative assessment of different types of VIX indices of different alternate assets viz. stocks, gold, silver and T –Notes with the objective of understanding the flight-to-safety phenomenon. The results showed that with the increase in stock VIX, there is both contemporaneous and delayed rise in the expected volatilities of all the three instruments viz. VIX of gold, silver & T Bills. Further the explanatory power of Stock VIX to explain volatility in these assets rises during a financial crisis. Also according to the paper when volatility flows from Stock VIX to other assets' VIX, the correlations tend to be negative between stock returns and return on these other assets thereby making stock VIX as an ideal tool for risk diversification and management.

Taking clue from the above that VIX does have the desired potential to act as a hedge and serve as a safe haven asset , it was decided to carry out our own research work which would be taking the shape of a comparative assessment of gold and INDIA VIX as instruments of hedge and/or safe haven .Further to improve the accuracy of our results it was also decided to include quantile regression framework along with usual OLS as quantile is known to provide a superior picture than the OLS especially at tail levels which is important for safe haven characteristics of any asset during extreme market conditions. It is worthwhile noting that such extreme market conditions which were a rare phenomenon prior to 90s are now occurring at fairly fast pace. However during the 90's the world has witnessed two-three major financial crisis within a gap of a decade. The biggest problem with a major financial crisis is

that it not only binds together all the major stock markets of the world forcing them to move in tandem. This impacts the returns of competing asset classes like bonds, currencies and real estate. Thus when all existing investment avenues join the crisis it challenges the popular concepts of diversification and asset allocation. Taking a note of these changing conditions, it was thought of making a detailed study of the two financial instruments Gold vs. INDIA VIX and how their roles vary according to different market conditions.

Before we proceed into the detailed empirical analysis of Gold vs. INDIA VIX as instruments of hedging and safe heaven, there is a need to carefully examine the two terms; hedging and safe haven as the entire focus of the paper revolves around these two terms. As already discussed we first state the definition as given by Baur & Lucey (2010) and according to their paper, an asset would qualify to be a hedge, if it is negatively correlated or even uncorrelated with another asset or portfolio of assets during normal market conditions and again if an asset is negatively correlated during extreme situations (financial distress or a crisis) then such an asset could be categorised as a safe haven. Now if we closely examine the definition of the two terms, we find that for a hedge asset, the definition is silent about its behaviour during adverse market conditions i.e. such asset may even move in tandem with other assets during adverse situations and still qualify as a hedge. Similarly definition of a safe haven speaks nothing about its behaviour during normal market conditions. The study plans to address these issues in detail in upcoming sections.

The entire study has been structured as follows: Section 1 or the current section gives the introduction and also reviews the studies in the area of hedging and safe haven characteristics of different assets attempted by researchers. Section 2 discusses the data, its statistical properties and also tests for variable stationarity. Section 3 discusses in detail the methodology employed along with stating of various hypothesis to be tested. The empirical results of the study are discussed in Section 4 followed by Section 5 which concludes the study and also gives the policy recommendations. At the end we have two more sections, Section 6 and 7 for

references & appendices respectively.

DATA

The current study: 'Gold vs. India VIX : A Comparative Assessment of their capacity to act as a Hedge and/or Safe Haven against stocks, crude and rupee-dollar rate' has been undertaken with a specific motive; the motive being "To compare two assets viz. GOLD and INDIA VIX from different angles so as to identify which of the two assets could be considered as the right prescription for an Indian investor as a good hedge and also could come as a rescue asset especially during bad times". The present study therefore aims to consider all sorts of market scenarios viz. normal, favourable, stressed and crisis to capture the behaviour of these two competing alternate investment avenues against different financial asset classes held by a representative investor in his/her portfolio.

The study employs both traditional OLS (with Dummy) and quantile regression methodologies to study the aspects of hedge and safe haven and the period of study has been taken as April 1, 2008 - March 31, 2019 with daily closing prices being collected for five variables namely INDIA VIX, Nifty Index, Rupee-Dollar Exchange Rate, Crude and Gold; the source of data being www.investing.com. Further the model development has not been restricted to linear relation between the variables, but also tries to capture the non-linear trends. Also the closing prices of all the variables have been converted to closing returns by using the formula $(P_t - P_{t-1})/P_{t-1}$ where P_t and P_{t-1} are the closing prices for the variable for period 't' and 't-1' respectively.

Statistical Description

A statistical description of data for all the five variables namely return on gold, INDIA VIX , crude, foreign exchange and NSE Nifty is given in Table I below. The Table provides information about mean & median return, Standard Deviation, Skewness, Kurtosis and JB Statistics (for normality) for each of the five variables.

The table reveals that average daily return for the ten year period April 1, 2008 –March 31, 2019 for variable; return on INDIA VIX is the highest while it is lowest for crude. It is important to note that this average daily return on INDIA VIX is not only highest amongst all the five variables but there is also substantial difference of approximately eight times between INDIA VIX return and return on NSE Nifty which is at the second place. On the other hand, the standard deviation of INDIA VIX is also the highest amongst all the variables thereby making return on INDIA VIX as a high risk-high return candidate. Further it would be interesting to compare how INDIA VIX would fare vis. a vis. other variables as an investment candidate when we consider both risk and return dimensions together and the tool we would be using is coefficient of variation which is nothing but dispersion of data around the mean . Applying the formula: Coefficient of Variation (C.V) = σ / μ ; where 'σ' is Standard Deviation and 'μ' is the average daily return of the concerned variable. The C.V. results given in column 10 of Table 1 clearly reveal that by incorporating both risk and return , exchange rate becomes the best performing variable, INDIA VIX comes second while performance of gold is the worst amongst all the variables.

Table I also gives information about the distribution characteristics of our variables by comparing the same to the normal distribution. The distribution characteristics with respect to skewness reveal that all the distributions are fairly symmetric with the distribution of INDIA VIX being positively skewed. As far as kurtosis is concerned , all the five distributions are leptokurtic with fatter tails. Further none of the five distributions is normally distributed as given by JB Statistics , computations given inlast column of table 1; the formula for the same is $JB = \{S^2 + (K - 3)^2\}$, 'n' is the number of observations, 'S' is the Skewness and 'K' is the Kurtosis of time series variable.

Table I : Statistical Data Description of all the variables for the period Apr 1, 2009-March 31, 2019

VARIABLE	Observations	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Coeff. of Variation	Jarque-Bera
Return on Crude	2651	0.000111	0.000364	0.178329	-0.12648	0.024607	0.348447	8.115058	221.68	2943.657
Return on Exchange Rate	2651	0.000218	0.000	0.037626	-0.03488	0.005162	0.167378	8.512056	23.68	3368.408
VIX Return	2651	0.003336	-0.00522	1.155979	-0.29573	0.080797	2.261471	22.8836	24.22	45930.2
Nifty Return	2651	0.000411	0.00047	0.177441	-0.12203	0.013329	0.557398	20.00065	32.43	32062.17
Gold Return	2651	0.000267	0.00012	0.142283	-0.11399	0.015402	0.441666	17.63718	57.65	24056.17

Source : Author's Own Computations

Stationary Diagnostics

Every research which requires setting up a OLS regression model, the data needs to be checked for stationarity as model building must be carried out only on stationary data. To check for stationarity , in this paper we would be applying DF GLS test of stationarity of variables. We have avoided the popular ADF unit root test for stationarity due to its low power (power to reject null hypothesis) and invalid results which are quite common in case there is a break in time series . Since we have included the period of sub prime crisis, the chances of break being very high , therefore we decided to go for DF GLS test which has been proposed by Elliott, Rothenberg and Stock (ERS) (1996).

$$\Delta \ddot{Y}_{k,t} = a_{1,k}\ddot{Y}_{(t-1),k} + S_{j=1}^{m} b_j \Delta \ddot{Y}_{(t-j),k} + u_{t,k} \quad \text{.....eq.(i)}$$

Equation (i) given above is the DF-GLS equation for test of stationary of variables. $\ddot{Y}_t$ is the de-trended variable, k= 1,2…5 representing each of the five variables viz. return on gold, return on VIX, return on crude, return on nifty and return on foreign exchange. 't' is the time period , $D\ddot{Y}_t$ is the change in de-trended variable $\ddot{Y}_t$ in period 't', a_1 is the coefficient which would check for the stationary of our variables. $\Delta\ddot{Y}_{(t-j)}$ represents the augmentation term which take care of serial correlation in time series and these are summed up 'm' times till serial correlation is removed with 'j' being the lag term. Finally u_t is the error term. Further since we are working on de-trended data,

the regression excludes intercept and time variable.

RESEARCH METHODOLOGY

Contemporaneous and Lagged relation amongst the variables (Linear Model)

Under the linear model we develop a contemporaneous and lagged relation amongst the variables. The following equation has been estimated :-

$$\mathbf{r}_{k,t} = b_1 + S_{i=1}^{n}\, b_{2,i}\, \mathbf{r}_{k,t-i} + S_{i=0}^{n}\, b_{3,i}\, \mathbf{r}_{Crude,\, t-i} + S_{i=0}^{n}\, b_{4,i}\, \mathbf{r}_{Nifty,\, t-i} + S_{i=0}^{n}\, b_{5,i}\, \mathbf{r}_{\frac{Re}{\$},t-i} + b_6 \mathbf{D}_{1A,t}$$
$$+ b_7 \mathbf{D}_{1B,t} + b_8 \mathbf{D}_{1C,t\,t} + b_9 \mathbf{D}_{2A,t} + b_{10} \mathbf{D}_{2B,t} + b_{11} \mathbf{D}_{2C,t} + b_{12} \mathbf{D}_{3A,t} + b_{13} \mathbf{D}_{3B,t} + b_{14} \mathbf{D}_{3C,t}$$
$$+ u_{k,t} \qquad \text{.....eq. (ii)}$$

In equation (ii) above, 'r_k' is return on variable k , where 'k' is either gold or INDIA VIX which is taken to be Dependent Variable and regressed against its own lags $r_{k,t-i}$; 't' is the time period & 'i' is the lag. The number of lags('n') for the lagged endogenous variable are determined by using lag length determination criteria AIC. The model also has three independent variables; Return on Crude (r_{crude}) , Return on Nifty (r_{Nifty}) and Return on rupee-dollar exchange rate ($r_{\frac{Re}{\$}}$). The relation between dependent variable r_k and three independent variables is both contemporaneous and lagged i.e. lag 'i' = '0' (contemporaneous) and goes upto 'n'. Here too AIC determines the number of lags. We also have 3 x 3 = 9 Dummy Variables ; three dummies each for each of our three variables. In case of a dummy variable , the subscript '1' denotes crude, '2' denotes Nifty and '3' denotes exchange rate. Further again for Dummy there is yet another subscript; A, B & C; subscript 'A' is used for 1 %, 'B' for 5 % and 'C' for 10 % upper and lower range of observations . e.g. D_{1A} is a Dummy for crude which captures 1 % upper and lower observations for variable Crude. Here if the particular observation falls in top 1 % upper or lower range , it is taken as 1, else 0. It is to be noted that we first arrange the entire data relating to any particular independent variable in descending order (of returns) and capture the top 0.5 % and bottom 0.5 % observations for 1 % level. Similarly we have D_{2At} D_{3At} and so on making a total of nine dummy variables. Finally we have $u_{k,t}$ as the residual error term.

Strong, Weak and Moderate Dummy

As stated above we have taken three type of dummies for each independent variable viz. at 1 %, 5 % and 10 % (upper and lower range of the time series) . This distinction is done to identify the type of safe haven characteristics displayed by the concerned variable(asset). Further the type of safe haven characteristics of a variable(asset) also depends upon statistical significance and sign of the slope coefficient of the underlying dummies. While classifying the dummies, the following have been kept in the mind:-

(i) If all the three dummies for a variable say crude return (i.e. Dummy at 1%, 5% and 10 % levels) are statistically significant along with appropriate sign of the slope coefficient(s) which should ideally be negative, then we have a case of strong safe return of the asset crude.

(ii) If only two dummies i.e. dummy at 5 % & 10 % are statistically significant and also have correct sign, then it is a case of moderate safe haven.

(iii) If only one dummy at 10 % is significant, then it is a case of weak safe haven characteristic.

(iv) To qualify for safe haven characteristic , all preceding dummies must be significant for that asset e.g. Dummy for Crude at 1 % statistically significant would only be considered a safe haven for an asset if both 5 % and 10 % dummies for the crude are also statistically significant along with the correct sign of the slope coefficient.

Contemporaneous relation amongst the variables (Non-Linear Model)

Under this section, we establish a non-linear model(s) for our variable Return on Gold and Return on INDIA VIX under the following assumptions :-

(i) Price of a INDIA VIX or Gold (as may be the case) is a function of Nifty,

Crude and rupee-dollar foreign exchange returns.

(ii) The relation between the variables is taken to be contemporaneous only.

(iii) The feedback system does not work or the price of gold (or INDIA VIX) has no influence on the price of any other asset i.e. price of Nifty, Crude or rupee-dollar foreign exchange.

The following equation has been estimated :-

$$Ret_{k,t} = \beta_1 + \beta_2 \text{ Nifty Ret}^{(+)}_t + \beta_3 \text{ Nifty Ret}^{(-)}_t + \beta_4 \text{ Crude Ret}^{(+)}_t + \beta_5 \text{ Crude Ret}^{(-)}_t + \beta_6 \text{ Ret on Forex}^{(+)}_t + \beta_7 \text{ Ret on Forex}^{(-)}_t + \beta_8 D_{1A,t} + \beta_9 D_{1B,t} + \beta_{10} D_{1C,t} + \beta_{11} D_{2A,t} + \beta_{12} D_{2B,t} + \beta_{13} D_{2C,t} + \beta_{14} D_{3A,t} + \beta_{15} D_{3B,t} + \beta_{16} D_{3C,t} + u_t \quad \text{.....(iii)}$$

In equation (iii) given above

$$\text{Nifty Ret}^{(+)}_t = \begin{cases} \text{Nifty Ret}_t \text{ if Nifty Ret}_t > 0 \\ 0 \text{ if Nifty Ret}_t \le 0 \end{cases} \quad \& \quad \text{Nifty Ret}^{(-)}_t = \begin{cases} \text{Nifty Ret}_t \text{ if Nifty Ret}_t < 0 \\ 0 \text{ if Nifty Ret}_t \ge 0 \end{cases}$$

$$\text{Crude Ret}^{(+)}_t = \begin{cases} \text{Crude Ret}_t \text{ if Crude Ret}_t > 0 \\ 0 \text{ if Crude Ret}_t \le 0 \end{cases} \quad \& \text{Crude Ret}^{(-)}_t = \begin{cases} \text{Crude Ret}_t \text{ if Crude Ret}_t < 0 \\ 0 \text{ if Crude Ret}_t \ge 0 \end{cases}$$

$$\text{Ret on Forex.}^{(+)}_t = \begin{cases} \text{Ret on Forex}_t \text{ if Ret on Forex}_t > 0 \\ 0 \text{ if Ret on Forex}_t \le 0 \end{cases} \quad \& \quad \text{Ret on Forex.}^{(-)}_t = \begin{cases} \text{Ret on Forex}_t \text{ if Ret on Forex}_t < 0 \\ 0 \text{ if Ret on Forex}_t \ge 0 \end{cases}$$

D_{1A}, D_{1B}, D_{1C} are the dummy variables representing crude at 1%, 5% and 10 % of the upper and lower observations respectively. Similarly D_{2A}, D_{2B}, D_{2C} are dummies representing nifty at 1%, 5% and 10 % respectively and finally we have D_{3A}, D_{3B}, D_{3C} as dummies representing Foreign Exchange at 1%, 5% and 10 % respectively.

Equations under the Quantile Framework

Whereas the traditional OLS method tries of minimize the sum of the squared residuals in computation of the parameters, under the quantile framework we tend to minimize the sum of the absolute deviations . Thus we get :

Under OLS we have $\min_q \sum_{t=1}^{n} ((Y_t - X_t'q))^2$,

Under Quantile Regression we have $\arg \min_q \sum_{t=1}^{n} |(Y_t - X_t'q)|$

The number of quantiles included under the current study are seven and these include; 5th Quantile or $Q_{(0.05)}$, 10th Quantile or $Q_{(0.\ 10)}$, 25th Quantile or $Q_{(0.\ 25)}$, 50th Quantile -Median or $Q_{(0.\ 50)}$, 75th Quantile or $Q_{(0.\ 75)}$, 90th Quantile or $Q_{(0.\ 90)}$ and 95th Quantile or $Q_{(0.\ 95)}$. Again like the OLS model , here too we run both linear and non linear models after including same number of dummy variables as given earlier in eq.(iii) above i.e. three dummy variables each for each of the independent variables ; each independent variable representing 1 %, 5 % & 10 % upper and lower observations . The equations for the two models are given as under; linear (as eq. iv) and non-linear (as eq. v) :-

$$\mathbf{r}_{k,j,t} = f_{1,j} + \sum_{i=1}^{n} f_{2,j,i}\, \mathbf{r}_{k,j,t-i} + \sum_{i=0}^{n} f_{3,j,i}\, \mathbf{r}_{Crude,j,\,t-i} + \sum_{i=0}^{n} f_{4,j,i}\, \mathbf{r}_{Nifty,j,t-i} + \sum_{i=0}^{n} f_{5,j,i}\, \mathbf{r}_{\frac{Re}{\$},j,t-i} + f_{6,j}\, \mathbf{D}_{1A,j,t} + f_{7,j}\, \mathbf{D}_{1B,j,t} + f_{8,j}\, \mathbf{D}_{1C,j,t} + f_{9,j}\, \mathbf{D}_{2A,j,t} + f_{10,j}\, \mathbf{D}_{2B,j,t} + f_{11,j}\, \mathbf{D}_{2C,j,t} + f_{12,j}\, \mathbf{D}_{3A,j,t} + f_{13,j}\, \mathbf{D}_{3B,j,t} + f_{14,j}\, \mathbf{D}_{3C,j,t} + u_{j,t} \quad \text{..... (iv)}$$

$$\mathbf{r}_{k,j,t} = d_{1,j} + d_{2,j}\, \mathbf{r}_{nifty\ j,\,t}^{(+)} + d_{3,j}\, \mathbf{r}_{nifty\ j,\,t}^{(-)} + d_{4,j}\, \mathbf{r}_{crude\ j,\,t}^{(+)} + d_{5,j}\, \mathbf{r}_{crude\ j,\,t}^{(-)} + d_{6,j}\, \mathbf{r}_{forex\ j,\,t}^{(+)} + d_{7,j}\, \mathbf{r}_{forex\ j,\,t}^{(-)} + d_{8,j}\, \mathbf{D}_{1A,j,t} + d_{9,j}\, \mathbf{D}_{1B,j,t} + d_{10,j}\, \mathbf{D}_{1C,j,t} + d_{11,j}\, \mathbf{D}_{2A,j,t} + d_{12,j}\, \mathbf{D}_{2B,j,t} + d_{13,j}\, \mathbf{D}_{2C,j,t} + d_{14,j}\, \mathbf{D}_{3A,j,t} + d_{15,j}\, \mathbf{D}_{3B,j,t} + d_{16,j}\, \mathbf{D}_{3C,j,t} + v_{j,t} \quad \text{..... (v)}$$

For the two equations above, equation (iv) is linear while equation (v) is a non-linear model, For linear model (eq. iv) ;- $r_{k,j,t}$ is the return on dependent variable k, k =gold or INDIA VIX, 'j' is the j^{th} quantile , 't' being the time period of the study . 'i' is the i^{th} lag which goes from '0' contemporaneous till 'n' lags for three independent variables; r_{crude}, r_{nifty} and r_{forex} (Crude Return, Nifty return and Ret on Exch. Rate) and from '1' to 'n' lags for the variable 'k' (either Gold return or INDIA VIX return). The eq. (iv) also has nine dummies; Dummy with a subscript as '1' represents crude while subscript '2' represents nifty and subscript '3' as foreign exchange. Again subscript A would mean 1 %, 'B' 5 % and 'C' 10 % upper and lower range of observations. Finally we have the

residual error term as $u_{j,t}$.

For Non Linear model (eq v), the dependent variable continues to be the same i.e. $r_{k,j,t}$ $\delta_{1,j}$ is the intercept term, $\delta_{2,j}$ & $\delta_{3,j}$ are the coefficients of contemporaneous Nifty Ret $^{(+)}$ & Nifty Ret $^{(-)}$, $\delta_{4,j}$ & $\delta_{5,j}$ are the coefficients of contemporaneous Crude Ret $^{(+)}$ & Crude Ret $^{(-)}$ and finally $\delta_{6,j}$ & $\delta_{7,j}$ are the coefficients of contemporaneous Ret on Exch. Rate $^{(+)}$ & Ret on Exch. Rate $^{(-)}$,$v_{j,t}$ being the residual term. The eq. (v) also has same nine dummies as given for the linear model (iv) above.

The behaviour of Gold and INDIA VIX during sub prime crisis of 2008

This section of the study makes an attempt to find out whether any of the two variables i.e. gold or INDIA VIX could fulfill its role of a safe haven asset during period of Sub Prime Crisis which for the study has been taken as : April 1 2008-June 30, 2009 , when the world had witnessed extreme volatility in financial markets.

The applicable model for the Safe Haven of return on variable 'k' ('k' = gold or INDIA VIX) is given below as eq. (vi). Eq. (vi) is a simple OLS regression with independent variables being return on all the three assets. The period of subprime has been represented by a Dummy (D_1) which takes the value as '1' if the data belongs to the subprime period as stated above, else its value is '0'. Now if the Dummy for Sub Prime (D_1) is significant then we can say that the asset under consideration (Gold or INDIA VIX) acted in the capacity of a safe haven with respect to return during this period.

$$Ret_{k,t} = \lambda_1 + \lambda_2 D_{1,t} + \lambda_3 Nifty Ret_t + \lambda_4 Ret Crude_t + \lambda_5 Ret Forex_t + e_t \quad .....(vi)$$

Safe Haven characteristics of variable 'k' with respect to volatility of returns is given as equation (vii) . Assuming variable 'k' follows a simple GARCH(1,1) model and therefore to capture volatility we develop this equation where Dummy Variable (D_1)is included as a variance regressor as external estimator and if this dummy variable is found to be significant, then variable 'k' acts as a Safe Haven with respect to return

variability. The variance equation under eq. (vii) is a simple GARCH(1,1) having three components ; a Constant term, Square of the error term of previous period (called ARCH term) & last period's variance of the error term (called GARCH term).

$$Ret_{k,t} = \lambda_1 + \lambda_2 Nifty Ret_t + \lambda_3 Ret Crude_t + \lambda_4 Ret Forex_t + e_t \quad .....(vii)$$

$$e_t \sim iid.\ N(0, \sigma^2 e_t)$$

$$h_t = \alpha_1 + \alpha_2 u^2_{t-1} + \alpha_3 h_{t-1} + \alpha_4 D_{SP,t}$$

EMPIRICAL RESULTS OF THE STUDY

Under this section we give the empirical results of the study, and their implications, the tables for the same are given in the appendices section (Section 7). We would be discussing the results one by one as laid down in appendices. *Appendix I* gives the results of the stationary test of all our variables and we have applied DF-GLS Unit root test developed by Elliott, Rothenberg and Stock (1996) which has a higher power (does not accept the Null hypothesis when actually it is to be rejected) than ADF Unit Root test. The results of the test clearly reveal that absolute value of the computed 't' statistics for all our five variables (which are in the form of return) exceeds the absolute table value of 1.940944 (critical value at 5 % level) thereby all the five variables are rejecting the Null Hypothesis that return of variable has a unit root.

The next appendix; *Appendix II* which gives the results of relation between dependent variable as either Gold or INDIA VIX return and independent variables crude, foreign exchange and Nifty returns as a Linear Model*(Appendix II-A)* and as a Non Linear Model (*Appendix II-B*) . *Appendix II-A* regression includes contemporaneous and lagged relation between independent variables and dependent variable Gold or IVX. The regression also includes lagged dependent variable as explanatory variable. The first three columns of *Appendix II-A* show the coefficient and 'p' values of independent variables against Gold while the next three columns

show the relation against INDIA VIX.

To interpret the study results for the linear model (*Appendix II-A*) which shall be in terms of the concerned variable (Gold or INDIA VIX) acting as a hedge asset or a safe haven asset, the following **three conditions** need to be satisfied; fully or partially.

(1) For an asset to act as a complete hedge (for linear model) there must be (a) significant contemporaneous coefficient of the variable against which the hedge is being tested. (b) opposite sign of this contemporaneous coefficient (c) first lag of such a variable must also be significant and has the opposite sign.

(2) If only the first two conditions (a & b given above) are satisfied then the asset would only act as a partial hedge. On the other hand if only first condition is satisfied , then the relation is contemporaneous only.

(3) For the variable to act as a safe haven, its Dummy coefficient must be significant. Under the study, we have created three versions of Dummy viz. Dummy at 10 %, 5 % and 1% , these three versions represent the three types of safe haven. An asset serves as a strong safe haven if all the three versions of dummy viz. Dummy at 10 % , 5 % and 1 % are statistically significant, shall be a moderate safe haven asset if Dummy at 10 % and 5 % are statistically significant while shall be a low safe haven asset if Dummy at 10 % is significant. It is important to add that Dummy 10 % represents 5 % upper and 5 % lower extreme observations of a time series.

The interpretation of results for *Appendix II-A* on the on the basis of three conditions mentioned above is as under :

(1) Both the variables; Gold Return and Return on India VIX have contemporaneous relation with all the three independent variables viz. Return on Exchange rate , Return on Crude and Nifty Return.

(2) First Lag of crude is also significantly impacting Return on Gold, however the coefficient has a positive sign. Similarly first lag of Exchange Rate is significantly impacting India VIX, this too has a positive sign. Since these coefficients have a positive sign, the hedging capacity of the dependent variable i.e. gold and India VIX is ruled out in both the cases.

(3) The coefficient of Dummy for Nifty at 10 % is significant when the variable under consideration is India VIX, hence it qualifies to be a weak safe haven asset, rest of the dummies are not statistically significant.

The next appendix i.e. *Appendix II-B* is a non-linear model which shows the results of Contemporaneous relation between independent variables crude, foreign exchange and Nifty returns and dependent variable as either Gold or INDIA VIX return. Being a non linear relation each of the independent variables have been split into two parts viz. Return(+) and Return(-). For Non Linear Model, the following conditions must be satisfied for an asset (Gold or INDIA VIX) to act as a hedge/safe haven.

(1) (a) Return (+) must be significant and with opposite sign (i.e. negative sign) of the coefficient (b) Return(-) must be significant and with opposite sign of the coefficient (i.e. positive sign) (c) If both (a) and (b) conditions are fulfilled , then the asset is a complete hedge while if only one of the two exists, then asset is a partial hedge.

(2) The safe haven characteristics of an asset remain the same as for the Linear Model

The interpretation of the results for *Appendix II-B* on the on the basis of conditions mentioned above is as under :

(1) Variable Gold Return is having contemporaneous relation with (i) Return on Exchange rate (-) with coefficient having negative sign, (ii) Return on Crude(+) with coefficient having a positive sign and (iii) Nifty Return (+) with coefficient having a

negative sign . Since the coefficient must have the opposite sign to become a hedge we would say that Gold serves as a hedge only for Nifty Return (+). Another important aspect of these results is the direction of the relation i.e. since Nifty Return (-) is not significant while Nifty Return (+) is significant, we would have to be content with gold acting as a hedge only when Nifty return is rising (partial hedge) which actually does not amount to hedging during bad times.

(2) Variable INDIA VIX Return is having contemporaneous relation with (i) Return on Nifty (+) with coefficient having negative sign, (ii) Return on Nifty (-) with coefficient having a negative sign, (iii) Return on Exchange Rate(+) with coefficient having a positive sign, (iv) Return on Exchange Rate(-) with coefficient having a positive sign and (v) Return on Crude (-) with a coefficient having a negative sign . Now again since the coefficient must have the opposite sign to become a hedge we find that only Return on Nifty (+) & Return on Exchange Rate (-) qualify as a partial hedge asset .

(3) Only Dummy Variable for Nifty qualifies as a moderate safe haven asset as its slope coefficients are statistically significant at both 10 % and 5 % , rest of the dummies do not qualify as safe haven asset.

The next appendix *(Appendix –III)* gives the results of equations which have been developed under the Quantile Framework i.e.(eq. iv) and (eq. v). Appendix III gives the results of seven quantiles, 5^{th} Quantile or $Q_{(0.05)}$, 10^{th} Quantile or $Q_{(0.\ 10)}$, 25^{th} Quantile or $Q_{(0.25)}$, 50^{th} Quantile -Median or $Q_{(0.50)}$, 75^{th} Quantile or $Q_{(0.75)}$, 90^{th} Quantile or $Q_{(0.\ 90)}$ and 95^{th} Quantile or $Q_{(0.\ 95)}$. Further Appendix III includes *Appendix III-A* which pertains to the linear model under the quantile framework while *Appendix III-B* shows the Non-Linear quantile relationship.

The conditions which qualifies as asset to act as a hedge under quantile framework are as under :-

(1) For an asset to act as a complete hedge there must be (a) significant

contemporaneous coefficient of the variable against which the hedge is being tested. (b) opposite sign of this contemporaneous coefficient (c) the above two conditions must be fulfilled by majority of quantiles.

(2) If only the first two conditions (a & b given above) are satisfied then the asset would only act as a partial hedge. If only first condition is satisfied , then the relation is contemporaneous only.

The results of *Appendix III-A* (linear quantile model) reveal that coefficient of return on crude is significant at all the seven quantiles both with respect to Gold and INDIA VIX, however to act as a hedge the coefficient sign should be negative which is true for only in case of INDIA VIX and not gold. Thus INDIA VIX acts as a complete hedge against crude . On the other hand, Coefficient of foreign exchange is not only significant but also has negative sign against Gold in five out of seven quantiles showing that it acts as a partial hedge in these quantiles, however INDIA VIX does not act as a hedge against foreign exchange. Again similar result is seen in the case of return on Nifty where gold acts as a hedge in five out of seven quantiles while INDIA VIX acts as a hedge only in three out of seven quantiles.

With respect to safe haven, both Gold and INDIA VIX show evidence of a weak safe haven in three quantiles each against crude. Again Gold behaves a weak safe haven in two quantiles while India VIX for one quantile against foreign exchange. Finally for Nifty, gold acts as a strong safe haven for one quantile while INDIA VIX is moderate safe haven for one and weak for two quantiles.

The results of *Appendix III-B* (non-linear quantile model) pertaining to hedge capacity of Gold and INDIA VIX is as follows : (i) Three quantiles of Nifty (+) are significant with correct sign against INDIA VIX while only two Nifty(+) are significant with correct sign against Gold. (ii) Two quantiles of foreign exchange (+) are also significant with correct sign against gold but none against INDIA VIX. (iii) Four quantiles of Crude (-) are significant with correct sign against gold and three against INDIA VIX, but no quantile of Crude(+) is significant. Appendix III-B (non-

linear quantile model) also gives the safe haven characteristics of gold and INDIA VIX and it is seen that Gold acts as a weak safe haven against Nifty and Foreign Exchange in one and two quantiles respectively but no safe haven properties of India VIX is seen from the results. The results of Hedge and Safe Haven characteristics of Gold and INDIA VIX against all the three assets is summarized in Table 2 below.

The next appendix, *Appendix -IV* (A & B) depicts the results of behavior of gold and India VIX with respect to other assets during the subprime crisis of 2008. The period of sub prime has been taken as a period ; April 1 2008 - June 30, 2009. To incorporate this effect in our regression , a Dummy variable has been created which takes the value = '1' if the time period for the observation under consideration falls under the crisis period, else ='0'. Whereas Appendix IV(A) gives the results of dummy being included in the return equation, Appendix IV(B) includes the same dummy as a variance regressor . The results reveal that only when Dummy variable is considered as variance regressor (for variable gold only), it becomes statistically significant showing that return volatility of gold during the sub prime crisis was different that the return volatility during non sub prime crisis period. The return volatility of India VIX has not been computed as the index itself is a volatility index.

Table 2 : Summary Table for Empirical Results Gold & INDIA VIX as hedge and safe haven asset

Sr. No	Behavior of Gold / INDIA VIX	Return on Rupee-Dollar Exch. Rate		Return on Crude		Nifty Return	
		GOLD	INDIA VIX	GOLD	INDIA VIX	GOLD	INDIA VIX
1	*As a hedge asset (Linear Model) (Contemporary and Lagged Relation)*	Not a hedge, as only contemporaneous relation exists	Not a hedge, as only contemporaneous relation exists	Not a hedge, as only contemporaneous relation exists	Not a hedge, as only contemporaneous relation exists	Not a hedge, as only contemporaneous relation exists	Not a hedge, as only contemporaneous relation exists
2	*As a Safe Haven Linear Model*	Not a Safe Haven	Not a Safe Haven	Not a Safe Haven	Not a Safe Haven	Not a Safe Haven	Weak Safe Haven
3	*As a hedge asset (Non Linear Model)*	Not a Hedge	Against Return on Exchange Rate (-) as a partial hedge	Not a Hedge	Not a Hedge	Against Nifty Return (+) as a partial hedge	Against Nifty Return (+) as a partial hedge
4	*As a Safe Haven Non Linear Model Regression*	Not a Safe Haven	Not a Safe Haven	Not a Safe Haven	Not a Safe Haven	Not a Safe Haven	Dummy for Nifty acts as a moderate safe haven (slope coefficient is sig. both at 10 % and 5 %)
5	*As a hedge asset (Quantile Regression) Linear Model*	Partial Hedge	Not a hedge	Not a hedge	Complete Hedge	Complete Hedge	Partial Hedge
6	*As a Safe Haven (Quantile Regression) Linear Model*	Weak Safe Haven at two quantiles	Weak Safe Haven at one quantile	Weak Safe Haven at three quantiles	Weak Safe Haven at three quantiles	Strong Safe Haven at one quantile	Moderate Safe Haven at one quantile and weak safe haven at two quantiles
7	*As a hedge asset (Quantile Regression) Non Linear Model*	Against Return on Exchange Rate (+) as a partial hedge	Not a hedge	Against Return on Crude (-) as Partial Hedge	Against Return on Crude (-) as Partial Hedge	Against Nifty Return (+) as a partial hedge	Against Nifty Return (+) as a partial hedge
8.	*As a Safe Haven (Quantile Regression) Non Linear Model*	Weak Safe Haven at two quantiles	Not a Safe Haven	Not a Safe Haven	Not a Safe Haven	Weak Safe Haven at one quantile	Not a Safe Haven

CONCLUSION AND POLICY RECOMMENTATIONS

To conclude, the present study: 'Gold vs. INDIA VIX : A Comparative Assessment of their capacity to act as a Hedge and/or Safe Haven against stocks, crude and rupee-dollar rate' made a comparison of two alternate investment assets viz. Gold and INDIA VIX against three asset classes namely Nifty Index, Rupee-Dollar Exchange Rate, Crude so as to identify which of the two assets could be considered as the right prescription for an Indian investor when it comes to a good hedge asset and which asset could be suitable to be a safe haven or a rescue asset during adverse market conditions. To achieve this objective, the study employed both traditional tools like OLS Regression (with Dummy Variable) and also newer techniques like quantile regression which is known for its superior results especially during tough market conditions. The period of study was taken as April 1, 2008 - March 31, 2019 and daily closing prices of five variables namely INDIA VIX, Nifty Index, Rupee-Dollar Exchange Rate, Crude and Gold have been collected from www.investing.com for the present study. Further the model development included both linear and non-linear approaches to test relation between the variables. Also attempt was made to include the period of Sub Prime Crisis as a separate period to judge the behaviour of our variables during these times.

The results of the study appear to be quite dissimilar for OLS and Quantile Models and also for linear and non-linear models i.e. whereas the linear OLS model throws the evidence of INDIA VIX to be a weak safe haven against Nifty Return, on the other hand, quite surprisingly the other asset ; gold could not prove its ability against Nifty return. For OLS Non Linear Model , the weak safe haven evidence of India VIX as given in OLS linear model becomes even more stronger and gets converted to moderate safe haven against Nifty return while Gold again could not meet the requirements of safe haven even in case of nonlinear OLS Model. Thus according to OLS Models, INDIA VIX does appear to perform its role as a safe haven asset in weak to moderate form against Nifty return while gold fails completely in this role.

Coming to results of Quantile regression models , the results do give a clue that gold

might work as a safe haven against different asset classes, this however comes with a very low probability and the same is true for INDIA VIX. The quantile regression however throws some evidence that gold might also act as a hedge against Nifty Return while INDIA VIX could be suitable hedge against crude. In terms of results of a separate section which dealt with subprime crisis, the variability in returns was noticed in case of gold as the dummy for sub prime was found to be statistically significant.

There are a couple of policy recommendations which we wish to make on the basis of the above results. First since INDIA VIX is now a proven safe haven asset in weak to moderate capacity against stocks as per both linear and non linear models, it can be included in the portfolio for those investors intending risk minimization especially during the adverse market conditions. The quantum of investment in India VIX would depend upon the risk appetite of the investor. On the other hand if we go by quantile results, with gold proving to be hedge as well as weak safe haven makes gold as a strong candidate for Portfolio Diversification and Asset Allocation. In today's scenario , investing in different stock markets does not amount to diversification due to strong inter-linkages between different markets and gold therefore fulfills this void. Gold also passed the volatility test during the sub-prime crisis and therefore investors must keep this in mind and increase the stake gradually in gold as a built up against the extreme uncertainty which has become a recurring phenomenon in financial markets.

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APPENDICES

Appendix I : Testing of the Stationary of Variables : DF -GLS Unit root test			
Null Hypothesis	**Comp. 't' value**	**Elliott-Rothenberg DF-GLS Test critical value at 5 %**	**Result**
Return on Gold has a unit root	**-4.599371**	**-1.940944**	**Null Hypothesis is rejected**
Return on Crude has a unit root	**-2.305761**	**-1.940944**	**Null Hypothesis is rejected**
VIX Return has a unit root	**-5.803408**	**-1.940944**	**Null Hypothesis is rejected**
Return on Forex has a unit root	**-19.13102**	**-1.940944**	***Null Hypothesis is rejected***
Nifty Return has a unit root	**-46.67716**	**-1.940944**	**Null Hypothesis is rejected**

Appendix II A: Results of Contemporaneous and Lagged relation amongst the variables for Gold and India VIX : (Linear Model)					
Independent Variable	**Dep. Ret on Gold**	**Dep. Ret on Gold**	**Independent Variable**	**Dep. Ret on India VIX**	**Dep. Ret on India VIX**
	Coefficient	**Prob.**		***Coefficient***	**Prob.**
Return Crude	0.100556	0.0000	Return Crude	-0.606607	0.0000
Return Nifty	-0.082660	0.0036	Return Nifty	-0.749540	0.0000
Return Ex. Rate	-0.414679	0.0000	Return Ex. Rate	2.309779	0.0000
Return Gold (-1)	-0.262540	0.0000	Return VIX(-1)	-0.113560	0.0000
Return Crude (-1)	0.037756	0.0018	Return Crude (-1)	-0.006679	0.9165
Return Nifty (-1)	-0.000761	0.9749	Return Nifty (-1)	0.233187	0.0711
Return Ex. Rate (-1)	0.010300	0.8695	Return Ex. Rate (-1)	0.974189	0.0027
Return Gold (-2)	-0.067294	0.0005	Return VIX (-2)	-0.050416	0.0110
Return Crude (-2)	-0.001569	0.8961	Return Crude (-2)	-0.125846	0.0471
Return Nifty (-2)	-0.021384	0.3749	Return Nifty (-2)	0.014785	0.9072
Return Ex. Rate (-2)	-0.056212	0.3698	Return Ex. Rate (-2)	-0.298067	0.3598
Dummy 1A (Crude 1 %)	0.076444	0.1470	Dummy 1A (Crude 1 %)	-0.018915	0.2645
Dummy 1B (Crude 5 %)	-0.047116	0.4527	Dummy 1B (Crude 5 %)	0.005631	0.5771
Dummy 1C (Crude 10 %)	-0.039249	0.4345	Dummy 1C (Crude 10 %)	0.010135	0.1693
Dummy 2A (Nifty 1 %)	-0.073187	0.4401	Dummy 2A (Nifty 1 %)	0.006648	0.6951
Dummy 2B (Nifty 5 %)	-0.026973	0.8099	Dummy 2B (Nifty 5 %)	-0.012983	0.1970
Dummy 2C (Nifty 10 %)	0.119515	0.1685	Dummy 2C (Nifty 10 %)	0.016791	0.0236
Dummy 3A (Ex. Rate 1 %)	0.135738	0.5893	Dummy 3A (E. Rate 1 %)	0.001752	0.9175
Dummy 3B (Ex. Rate 5 %)	-0.100373	0.7326	Dummy 3B (E. Rate 5 %)	0.01099	0.2721
Dummy 3C (E. Rate 10 %)	-0.349540	0.1201	Dummy 3C(E.Rate 10 %)	0.004542	0.5347

Appendix II B: Results of Contemporaneous relation amongst the variables for Gold and India VIX : (Non-Linear Model)				
	Dep. Ret on Gold	Dep. Ret on Gold	Dep. Ret on India VIX	Dep. Ret on India VIX
Independent Variable	Coefficient	Prob.	Coefficient	Prob.
C	-0.001161	0.0440	-0.005244	0.0529
Nifty Return (+)	-0.113933	0.0045	-0.622115	0.0024
Nifty Return (-)	-0.016072	0.8048	-1.774356	0.0000
Return on Exc. Rate(+)	-0.108876	0.2892	2.111671	0.0001
Return on Exc. Rate(-)	-0.875546	0.0000	2.813902	0.0129
Return on Crude (+)	0.119409	0.0000	0.006422	0.9516
Return on Crude (-)	0.047499	0.1604	-0.799344	0.0000
Dummy 1A (Crude 1 %)	-0.007440	0.0611	-0.026888	0.1238
Dummy 1B (Crude 5 %)	0.000568	0.8550	0.001425	0.8896
Dummy 1C (Crude 10%)	0.001962	0.3875	0.006714	0.3792
Dummy 2A (Nifty 1 %)	0.004788	0.2348	-0.018490	0.3363
Dummy 2B (Nifty 5 %)	-0.000625	0.8409	-0.022607	0.0343
Dummy 2C (Nifty 10 %)	-0.001134	0.6120	-0.001935	0.04248
Dummy 3A (Ex. Rate 1 %)	-0.000773	0.8487	0.004236	0.8274
Dummy 3B (Ex. Rate 5%)	-0.000717	0.8162	0.003782	0.7231
Dummy 3C(Ex. Rate 10%)	0.000257	0.9091	0.010064	0.2509

Appendix III A : Quantile Regression results across Response Variable: (A) Gold Return & (B) India VIX Return (Linear Model)

Dependent variable	q	Intercept	Crude Dummy (10 % Obs)	Crude Dummy (5 % Obs)	Crude Dummy (1% Obs)	Return on Crude	Exch Rate Dummy (10 % Obs)	Exch Rate Dummy (5% Obs)	Exch Rate Dummy (1% Obs)	Return on Exchange Rate	Nifty Dummy (10% Obs)	Nifty Dummy (5% Obs)	Nifty Dummy (1% Obs)	Nifty Return
Gold Return	0.05	-0.01753 (0.0000)	0.165831 (0.1535)	0.027941 (0.7437)	0.013673 (0.9284)	0.0637^ (0.0000)	0.29092 (0.1904)	-0.55326 (0.1130)	0.76499* (0.0310)	-1.053@ (0.0000)	-0.220** (0.0517)	-0.6169* (0.0263)	-0.6384* (0.0366)	-0.1671# (0.0003)
Gold Return	0.10	-0.01225 (0.0000)	0.171395 (0.1839)	0.120447 (0.3435)	-0.12645 (0.3647)	0.0791^ (0.0255)	0.6379** (0.0818)	-0.34988 (0.6528)	0.15478 (0.8509)	-0.7938@ (0.0000)	0.19105 (0.1529)	0.06305 (0.6477)	0.02063 (0.9107)	-0.10592 (0.1076)
Gold Return	0.25	-0.00532 (0.0000)	0.097254 (0.3437)	0.069903 (0.3338)	-0.13414 (0.2257)	0.0646^ (0.0000)	0.24980 (0.3284)	0.03465 (0.919)	0.08316 (0.8337)	-0.639@ (0.0000)	0.15618 (0.243)	0.04549 (0.8432)	0.08171 (0.6885)	-0.0989# (0.0012)
Gold Return	0.50	0.000166 (0.4347)	-0.09713* (0.0276)	-0.02635 (0.7609)	0.073305 (0.1487)	0.0847^ (0.0000)	-0.17744 (0.3978)	0.07599 (0.8505)	-0.06094 (0.8494)	-0.362@ (0.0000)	0.14677 (0.0245)	-0.00158 (0.9943)	-0.04703 (0.6663)	-0.0664# (0.0068)
Gold Return	0.75	0.005774 (0.0000)	-0.15205* (0.0034)	0.087289 (0.2812)	-0.02068 (0.8208)	0.1026^ (0.0000)	-0.457** (0.0519)	0.21963 (0.6959)	-0.05724 (0.8527)	-0.2889@ (0.0000)	0.10609 (0.2402)	-0.05441 (0.5762)	-0.11385 (0.3109)	-0.04505 (0.1450)
Gold Return	0.90	0.012915 (0.0000)	-0.14482* (0.0073)	0.172648 (0.3495)	-0.16994 (0.3115)	0.1114^ (0.0002)	-0.69904 (0.1273)	0.48319 (0.4987)	-0.7534 (0.3423)	-0.15855 (0.2090)	-0.25508 (0.0872)	-0.17768 (0.5133)	0.1029 (0.5880)	0.01033 (0.835)
Gold Return	0.95	0.018019 (0.0000)	-0.1898** 0.0558	0.24524* 0.0192	-0.2259* 0.0192	0.0967^ (0.0000)	-1.531* (0.0000)	0.8944** (0.0733)	-1.2818* (0.0248)	-0.22556 (0.1621)	-0.3543 (0.0082)	-0.13626 (0.7496)	0.132972 (0.7490)	-0.00165 (0.9784)
VIX Return	0.05	-0.0914 (0.000)	-0.0273* (0.0268)	0.0246 (0.217)	0.0028 (0.866)	-0.652^ (0.000)	-0.031* (0.019)	-0.0440 (0.167)	0.0189 (0.387)	1.539@ (0.0036)	4.03E-0 (0.992)	0.043* (0.045)	-0.0164 (0.528)	-0.5243 (0.122)
VIX Return	0.10	-0.0713 (0.0000)	-0.0223* (0.0389)	0.0087 (0.584)	-0.0105 (0.503)	-0.66^ (0.000)	-0.0220 (0.105)	0.0222 (0.495)	0.0131 (0.5)	1.621@ (0.0000)	0.0012 (0.902)	0.0136 (0.334)	-0.0018 (0.899)	-0.4475 (0.114)
VIX Return	0.25	-0.0388 (0.0000)	-0.01441 (0.1786)	-0.0095 (0.7655)	0.0044 (0.7424)	-0.655^ (0.000)	0.00411 (0.615)	0.00933 (0.583)	0.00575 (0.681)	2.0164@ (0.0000)	-0.0001 (0.984)	0.00024 (0.983)	-0.0012 (0.9111)	-0.2314 (0.177)
VIX Return	0.50	-0.0065 (0.0000)	0.00929 (0.238)	-0.000 (0.984)	-0.001 (0.928)	-0.54^ (0.000)	0.0067 (0.331)	0.0115 (0.412)	0.0114 (0.193)	2.105@ (0.0001)	0.0090 (0.373)	-0.004 (0.953)	-0.000 (0.959)	-0.34 (0.057)
VIX Return	0.75	0.0293 (0.0000)	0.027*** (0.0042)	-0.013 (0.740)	0.0032 (0.8)	-0.442^ (0.000)	0.0081 (0.22)	0.0008 (0.950)	0.0129 (0.254)	2.116@ (0.0000)	0.03*** (0.004)	0.0099 (0.79)	-0.028 (0.117)	-0.7# (0.000)
VIX Return	0.90	0.0745 (0.0000)	0.0248* (0.035)	-0.084* (0.028)	0.064* (0.046)	-0.564^ (0.000)	0.0159 (0.261)	0.0318 (0.555)	-0.0009 (0.95)	2.824@ (0.011)	0.03*** (0.005)	0.0085 (0.880)	-0.0225 (0.293)	-0.699# (0.034)
VIX Return	0.95	0.1064 (0.0000)	0.0415 (0.127)	-0.1*** (0.000)	0.0610 (0.159)	-0.45^ (0.002)	0.0307 (0.14)	0.064* (0.02)	-0.003 (0.88)	4.251@ (0.03)	0.09** (0.054)	-0.07*** (0.00)	-0.018 (0.652)	-0.65# (0.01)

** Dummy significant at 10 % , * Dummy significant at 5 % , *** Dummy significant at 1 % levels

^ Crude significant at 5%, @ Exchange Rate significant at 5 %, # Nifty significant at 5 % levels

Appendix III B : Quantile Regression results across Response Variable: (A) Gold Return & (B) India VIX Return (Non-Linear Model)

Response Variable	q	Intercept	Nifty Return (+)	Nifty Return (-)	Nifty Dum10 % Ob	Nifty Dum5 % Ob	Nifty Dum 1% Ob	Return on Exch. Rate(+)	Return on Exch. Rate(-)	Exch Rate Dum10 % Ob	Exch Rate Dum5 % Ob	Exch Rate Dum 1% Ob	Return on Crude (+)	Return on Crude (-)	Crude Dum10 % Ob	Crude Dum 5% Ob	Crude Dum1 % Ob
Gold Return	0.05	-0.01382 (0.0000)	-0.37906* (0.0003)	0.2657 (0.0936)	0.005437 (0.2229)	0.02669** (0.0005)	-0.0256** (0.0007)	-0.9792# (0.0142)	-0.8593# (0.0368)	-0.00086 (0.7634)	-0.00041 (0.9309)	-0.00058 (0.8574)	0.032824 (0.063)	0.2070@ (0.0036)	0.000562 (0.9009)	-0.0026 (0.7399)	-0.00807 (0.3743)
Gold Return	0.10	-0.01015 (0.0000)	-0.27537* (0.0009)	0.26503 (0.0844)	-0.00014 (0.9716)	-0.00288 (0.7141)	0.004057 (0.4883)	-0.54489 (0.0544)	-1.0814# (0.0000)	-0.005## (0.0214)	-0.00141 (0.8502)	-0.00243 (0.4879)	0.014479 (0.5896)	0.1797@ (0.0015)	0.000196 (0.9482)	-0.00721 (0.429)	0.000319 (0.9593)
Gold Return	0.25	-0.00503 (0.0000)	-0.17546* (0.0000)	0.0528 (0.4964)	-0.00015 (0.9577)	-0.0009 (0.9092)	-0.00508 (0.3353)	-0.37681 (0.0532)	-0.8721# (0.0000)	-0.00271 (0.1691)	-0.00082 (0.8589)	-0.00338 (0.3054)	0.0493@ (0.0182)	0.11898@ (0.0033)	0.001679 (0.5882)	-0.00343 (0.6624)	0.003143 (0.4243)
Gold Return	0.50	-0.00101 0.0233	-0.04641 (0.25)	-0.12395* (0.0272)	-0.003** (0.0412)	-0.00574 (0.2963)	0.001003 (0.7755)	-0.1680# (0.0244)	-0.7709# (0.0000)	-0.00157 (0.4402)	-0.00301 (0.5633)	0.000396 (0.8927)	0.0874@ (0.0001)	0.0739@ (0.008)	0.00212 (0.2984)	0.000749 (0.8463)	-0.00047 (0.8472)
Gold Return	0.75	0.003167 (0.0000)	0.013142 (0.8517)	-0.11566 (0.13)	-0.00294 (0.308)	0.01082** (0.0158)	0.001736 (0.5609)	-0.11364 (0.1447)	-0.8464# (0.0000)	-0.00045 (0.8466)	-0.0053 (0.3923)	0.001636 (0.7028)	0.1682@ (0.0000)	-0.0005 (0.9889)	0.003834 (0.0726)	-0.00529 (0.356)	0.002286 (0.6348)
Gold Return	0.90	0.008699 (0.0000)	0.081156 (0.4571)	-0.16983 (0.1595)	0.003109 (0.4521)	0.0152** (0.0171)	-0.00342 (0.4618)	-0.01415 (0.9717)	-0.66859 (0.066)	0.001679 (0.6076)	0.003016 (0.8061)	0.004657 (0.5605)	0.2275@ (0.0000)	-0.142@ (0.0169)	0.004707 (0.6423)	-0.00538 (0.4145)	-0.00609 (0.6192)
Gold Return	0.95	0.013255 (0.0000)	0.152458 (0.4673)	-0.27444 (0.1744)	0.00059 (0.9032)	0.001943 (0.9044)	0.003983 (0.8103)	-0.09647 (0.7751)	-0.37062 (0.2778	0.0102## (0.0117)	-0.00557 (0.443)	0.019377 (0.1245)	0.2559@ (0.0047)	-0.14986 (0.0953)	0.012479 (0.2224)	-0.01765 (0.3899)	-0.00245 (0.841)
VIX Return	0.05	-0.08512 (0.0000)	-0.02942* (0.0178)	0.023189 (0.2227)	0.000321 (0.9845)	-0.4773** (0.002)	-0.3979** (0.0282)	-0.0155 (0.3699)	-0.03461 (0.3429)	0.013129 (0.6167)	1.1009## (0.0272)	2.81265 (0.3173)	0.007858 (0.6937)	0.0361@ (0.0214)	0.006889 (0.7736)	-1.19@@ (0.0000)	0.047674 (0.9516)
VIX Return	0.10	-0.06658 (0.0000)	-0.02526* (0.0203)	-0.00784 (0.5449)	0.003846 (0.809)	-0.4518** (0.0002)	-0.443** (0.0261)	-0.0103 (0.4039)	0.034226 (0.2846)	0.006354 (0.6992)	1.422## (0.001)	1.790422 (0.2)	0.009108 (0.5002)	0.018592 (0.1903)	0.007984 (0.5948)	-1.25@@ (0.0055)	0.158576 (0.8143)
VIX Return	0.25	(-0.0393) (0.0000)	-0.01353 (0.1659)	-0.00392 (0.9182)	-0.00289 (0.8205)	-0.2997** (0.0205)	-0.5604** (0.0008)	0.004772 (0.6139)	0.012142 (0.5807)	0.008737 (0.5192)	1.7908## (0.0094)	2.3943## (0.0354)	-0.00219 (0.8314)	-0.00543 (0.7002)	-0.00469 (0.7059)	-0.42571 (0.1531)	-0.63268 (0.2334)
VIX Return	0.50	-0.00959 (0.0011)	0.004536 (0.579)	-0.00909 (0.6622)	-0.00872 (0.5732)	-0.04977 (0.648)	-0.8015** (0.0000)	0.012448 (0.1225)	0.016519 (0.3601)	0.008074 (0.3961)	1.7219## (0.0038)	2.7328## (0.0258)	0.002805 (0.8173)	-0.02584 (0.4923)	-0.00661 (0.6046)	-0.44@@ (0.0423)	-1.12@@ (0.026)
VIX Return	0.75	0.024121 (0.0000)	0.021031* (0.0334)	-0.03393 (0.3022)	-0.00057 (0.9743)	0.034324 (0.783)	-0.7238** (0.0000)	0.010718 (0.2146)	0.007108 (0.5983)	0.005426 (0.5978)	1.9624## (0.0011)	2.4962## (0.0234)	0.018646 (0.2306)	0.000442 (0.9896)	-0.03341 (0.0549)	-0.58@@ (0.0178)	-1.97@@ (0.0064)
VIX Return	0.90	0.058767 (0.0000)	0.025893 (0.0704)	-0.08755* (0.0129)	0.027207 (0.4262)	0.143501 (0.6913)	-0.9671** (0.0108)	0.019613 (0.4062)	0.005159 (0.9211)	-0.00405 (0.8683)	4.0280## (0.0278)	2.520856 (0.3503)	-0.0216 (0.2432)	-0.063@ (0.0216)	-0.04786 (0.0127)	-0.48@@ (0.0393)	-4.54@@ (0.0000)
VIX Return	0.95	0.081368 (0.0000)	0.008015 (0.7121)	-0.10929* (0.0219)	0.058642 (0.1465)	0.906991 (0.0625)	-1.7086** (0.0002)	0.017619 (0.3965)	-0.03605 (0.3052)	-0.03024 (0.2383)	5.312795 (0.1546)	0.31398 (0.8871)	-0.00532 (0.9066)	-0.142@ (0.0236)	-0.07717 (0.1184)	-0.53221 (0.288)	-6.32@@ (0.0013)

** Nifty Return (+) & Nifty Return (-) sig at 5 % , ** Nifty Dummy Variable for extreme values 10, 5 & 1 sig at 5 %.*
 # Return on Ex. Rate (+) & Ex. Rate (-) sig. at 5 % , ## Dummy for extreme values of Ex. Rate sig at 5 %.
@ Return on Crude (+) & Return on Crude (-) significant at 5 %.

Appendix IV A : Results of Response Variable during the sub prime: Gold & VIX Return

	GOLD			INDIA VIX		
Variable	Coefficient	Prob. ('p' level)	Sig. / Not Sig (5% level)	Coefficient	Prob. ('p' level)	Sig. / Not Sig (5% level)
Return on Exchange Rate	-0.445	0.000	Sig.	2.013978	0.000	Sig.
Return on Nifty	-0.064	0.008	Sig.	-0.503618	0.000	Sig.
Return on Crude	0.085	0.000	Sig.	-0.617707	0.000	Sig.
Dummy for Sub Prime	-0.00013	0.446	Not Sig	0.00529	0.1402	Not Sig

Appendix IV B: Results of Response Variable during the sub prime : Gold Variability in Return during the Sub Prime Crisis

Variable	Prob ('p' values)	Sig/Not Sig at 5 %
RESID(-1)^2	0.00	Sig.
GARCH(-1)	0.04	Sig.
Dummy for Sub Prime (D1)	0.00	Sig.