AN EMPIRICAL INVESTIGATION OF THE INTER-LINKAGES BETWEEN DIFFERENT SEGMENTS OF THE FINANCIAL MARKETS USING VAR METHODOLOGY

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ABSTRACT

The paper investigates inter-relation between three popular asset classes viz. NSE Nifty, MCX COMDEX & Rupee-Dollar Exchange Rate. The relationship has been built around unrestricted VAR with all the three endogenous variables stated in terms of their lags which have been determined optimally using lag specification Criteria. For interpretation of VAR relation, the study employs econometric tests of granger causality and Variance Decomposition. The Stability of the VAR System has been tested using A R Characteristic roots. Other tests employed in the study include JB Normalcy test, Augmented Dickey Fuller(ADF) & KPSS test for variable stationarity & Johansen Co-integration test. The results of the study show that all the three variables are return stationary (first difference). The variables were however not co-integrated , but granger causality is detected ; Nifty was causing movement in both the other financial markets viz. Commodity and rupee-dollar forex markets & similar result was also indicated by VAR. VAR Model was also stable as given by Characteristic roots. The results of the variance decomposition showed that the proportional impact on variance of NSE Nifty due to other variables was negligible even at lag ten. On the other hand the impact on MCX Comdex due to variation in other two indices viz. NSE Nifty & forex at lag ten was approximately 2.2 % & 0.5 % respectively. Also the variance decomposition of Forex at lag ten due to Nifty variation was found to be quite high at 18 %. Also rupee-dollar was seen impacting the MCX COMDEX & MCX COMDEX impacting the Nifty asymmetrically (but only at 10 % significance levels) which was shown by the extreme tail test using Dummy in these two cases

Keywords : *VAR, Variance Decomposition, Asymmetric Relation, Causality, Dummy Variable*

Introduction

Although equities and bonds have been the traditional favorites when it comes to portfolio choice and have also been the first choice amongst the researchers, the alternate assets including commodities and currency trading are now giving a tough fight to these traditional assets. When it comes to research in financial assets, one of the prime areas has been inter linkages & co-movement between the same assets traded on the financial markets e.g. studying the co-movement of different countries stock indices. On the other hand the studies on alternate assets like gold, oil, foreign exchange have focused on whether or not the asset could be used as a hedging tool by the investors who usually aim for diversification of their portfolio with the intention of risk mitigation. Alternate

assets have also been studied from the angle of being a safe haven especially during the period of crisis in financial markets. The prime reason for this kind of interest amongst the investors has been the fact that each alternate class of asset is influenced by separate set of factors which are entirely different from factors impacting traditional financial assets and therefore movement of these assets need not necessarily be linked to the movement of traditional assets *(Chaubey, N., et.al 2016)*. However since financial markets are known for their uncertainties, the last decade have altered these equations & the world's financial markets have witnessed remarkable co-movements between the traditional & nontraditional assets especially during the period of any financial crisis thanks to advances in IT & liberalized capital movements (*Mahajan A et al. 2014)*

Review of Literature

There is no dearth of existing literature on linking of financial markets; however these have mainly concentrated on movement of stock indices of different countries where the study has been either as a time series analysis between two markets or as multiple markets under a panel set up. Also there have been some studies where commodities have been taken, however here too there has been focus on two specific commodities viz. Oil & Gold where their movement has been explored against the stock market movement. Another important segment of the financial markets; foreign exchange market has also been tested viz. a viz. stock movement, however in most studies the foreign exchange markets have been taken as a macroeconomic indicator with its role being explored in the movement of the other financial markets. The review of literature includes all the study types discussed above as there are only a very limited studies which are similar to our present study which tries to develop inter-linkages between stock returns, foreign exchange rate and a basket of commodities using time series methodology

*Shahani, R., Tiwari,M., & Miglani, A (2018)*made an attempt to study the inter-relationship between the movement of movement of the NSE Nifty index & MCX Comdex Futuresfor the period April 2012 to March 2017. The results showed no co-integration amongst variables . VAR results showed that lag of MCX COMDEX was significant till lag '2' while NSE Nifty's lag was significant till Lag '3'. Causality was however seen flowing uni-laterally from NSE Nifty to MCX COMDEX. *SriRam, P. (2017)*investigated how crude oil prices impacted NIFTY, COMDEX, WPI & GDP in India Context for the period 2007-2016. The results showed that crude prices did impact the NSE, MCX, Inflation (Wholesale Price Index), and GDP. The study proved that crude oil did indeed predict the stock index Nifty but the two had low correlation. The same relation was also extended between COMDEX & Crude. As far as the WPI is concerned, there was a high positive correlation between the Crude and WPI, moreover crude was granger causing WPI. Finally between GDP and Crude, the study revealed inverse relation.*Chaubey, N., Gupta, A., & Shahani, R. (2016)*empirically tested for inter- linkages between Gold, Oil & Rupee movement in India for the period April 2005-March 2015. The methodology employed was ARDL Bounds approach which uses partial 'F' test to detect the Long term relation. The pre-requisite tests were satisfactory with respect to variable stationarity and CUSUM Stability. The 'F' Bounds test established long term co-integration for crude as a function of rupee and gold while the other ARDL regressions were rejected for not satisfying the long run co-integration

*Nirmala S & Deepthy. K(2015)*tested for cause effect relationship between Stock Index BSE Sensex & MCX Agri. Index for the period Jan 2014- Dec 2015. The regression results showed Index for MCX agri. impacting the BSE Sensex with a negative sign & causality results showed unidirectional causality moving from Sensex to MCX Agri.*Srinivasan, P., & Prakasam, K. (2014)* examined the linkages between gold, stock prices & Rupee-Dollar exchange rate for the period June 90-April 14. The ARDL results showed a long run relation between Rupee-Dollar exchange rate with both the other two variables viz. gold & stock prices. However no co-integration or causality was proved between gold & stock prices. Bhunia, A. (2013) Tried to investigate the inter-linkages between three financial variables; crude, gold & sensex and the study results showed that co-integration did exist between the variables . The causality was also proved bi-directionally between sensex & two commodities. The rise in the gold prices in India during the two decades 1991-2012 was attributed to rise in crude prices , inflation & interest rates, rise in gold consumption in India current account deficit, import duty, collapse of stock market & India's political situation.

Malarvizhi, K., & Jaya, M. (2012) made a study of relation between NSE Nifty & rupee-dollar exchange rate for the period 2001-2011. The econometric tools used in the study included ADF Stationarity test, Johansen Co-integration and Granger Causality. The results showed that both the variables were I(1) Stationary, co-integration was also not proved , however bidirectional causality was seen between Nifty & exchange rate *Rajiv Menon, N., Subha, M. V., & Sagaran, S. (2009)* tested for co-integration between Indian Stock Market & Stock Markets of US, China , Singapore & Hong Kong for the ten year period of daily closing index prices (April 1, 1997 to May 10, 2007).The test applied was two stage Engle Granger and the results showed for NSE-Nasdaq & NSE –Hang Seng accepted the Null Hypothesis of No-Co-integration at 1 %, 5 % 7 10 % levels , however for NSE-China it was accepting only at 1 % level, & rejecting at 5 & 10 % while for NSE-Singapore it was rejecting at all levels thus showing strong co-integration. *Valadkhani, A., & Chancharat, S. (2008)*examined stock market integrating relation between Thailand & its eleven trading partners for the period Dec 87-Dec 2005. The co-integration tool used was Gregory and Hansen (1996) co-integration test which showed no long term co-integration between Thailand and any of its trading partners. However short run bi-lateral causality was detected between Thailand and three of its trading partners & also unilateral causality moving from three other trading partners to Thailand and two cases of unilateral causality from Thailand to its trading partners.

*Smyth, R., & Nandha, M. (2003)*examined the relation between stock prices and exchange rates in select South Asian economies with daily data (1995-2001) using causality and co-integration techniques. The results showed no long run co-integrating relation between the variables in all the four countries which were included in the sample. However Causality results showed cause –effect relation moving from exchange rates to stock prices in India and Srilanka , with no causality being seen in rest of the two economies. *Bhattacharya, B., & Mookherjee, J. (2001)* tested for causal relations between BSE Sensex & three macro variables including rupee-dollar exchange rate, trade balance & foreign exchange reserves for the period April 1990-March 2001. The causality method used was the one proposed by Toda & Yamamoto (1995) and the results could not bring out any cause effect relation between the BSE Sensex & three macro variables. All the variables were I (1) Stationary.

Data and Econometric Tools used in the Study

The period of study has been taken to be ten years i.e. April 2008- March 2018and the study tries to capture the relation between *NSE Nifty, MCX COMDEX &Rupee-Dollar Exchange Rate*by taking the dailylog transformed closing prices for the these indices(variables) (total no. of observations are 2422 for each variable). The source of data are the websites of investing.com , nseindia.com & mcxindia.com The analysis has been carried both at levels & on first differenced (log returns) data. The econometric tools which have been applied in our study include (a) Augmented Dickey Fuller (ADF) and KPSS test of Stationarity of Variables (b) Johansen (1988) and Johansen & Juselius (1990) test for Co-integration of variables (d) Establishing a VAR Model with Optimal Lag Length Criteria (e) Causality of Variables (f) Impulse & Variance Decomposition (g) Dummy Variable test for asymmetry in returns (h) A R Characteristic Roots for VAR Stability.

Statistical Description of Data and Diagnostic test of Normality

The Statistical Description of our variables ; NSE Nifty, MCX COMDEX & Rupee-Dollar Exchange Ratefor the period; April 2008- March 2018 is given in Table I below. The analysis has been done at the closing returns to get a more meaningful comparative picture of the movement of the three indices. Table I provides information about Mean, Median, Maximum Return, Minimum Return from daily returns over the ten year period . The risk of the variable returns is shown in terms of Standard Deviation, while the Skewness & Kurtosistell about the normality of our returns data for each time series variableviz. NSE Nifty, MCX COMDEX & Rupee-Dollar Exchange Rate. A look at the table reveals that mean daily return of the Nifty is the highest while the mean daily return of the COMDEX is the lowest out of the three indices and the difference between the two is approximately two and a half times. The index Nifty also has the highest and lowest returns amongst all the three indices .AlsoNifty has the highest standard deviation which makes it highly risky while the forex has the lowest risk which is approximatley 1/3rd of the risk associated with investment in Nifty. In terms of their distribution, all the three indices have peakedness higher than the normal distribution as given by the kurtosis of each variable's distribution . On the other hand , when we compare the skewness of the variables , the skewness of forex is positive while the other two indices are negatively skewed which makes none of the three distributions anywhere close to being a normal distribution. This is also clear from Fig 1which gives the histogram of NSE Nifty, MCX COMDEX & Rupee-Dollar Exchange Rate and its comparison with the normal distribution. Another important statistic given in Table 1 is the test statistic of normalitiy (JB Statistic) which has been computed for all the three indices, however JB Statistic is nowhere close to the figure of 5.99which is for the normal distribution (Normal JB* <Chi Square at 2 df whose value is 5.99)

Table I: Statistical Description of NSE Nifty, MCX COMDEX & Rupee-Dollar Exchange Rate (daily closing log returns) for the period April 2008- March 2018

Statistic	LN_COMDEX	LN_FOREX	LN_NIFTY
Mean	0.000136	0.000200	**0.000313**
Median	0.000217	0.000000	0.000492
Maximum	0.054383	0.061016	**0.163343**
Minimum	-0.061568	-0.041653	**-0.194172**
Std. Dev.	0.010156	0.005722	**0.014013**
Skewness	-0.168036	0.445618	-0.558534
Kurtosis	6.640936	15.61089	**27.89385**
Jarque-Bera (JB)	1349.191	16129.40	62664.35
Observations	2422	2422	2422

$$JB = \frac{n}{6}\left(S^2 + \frac{1}{4}(K-3)^2\right)$$

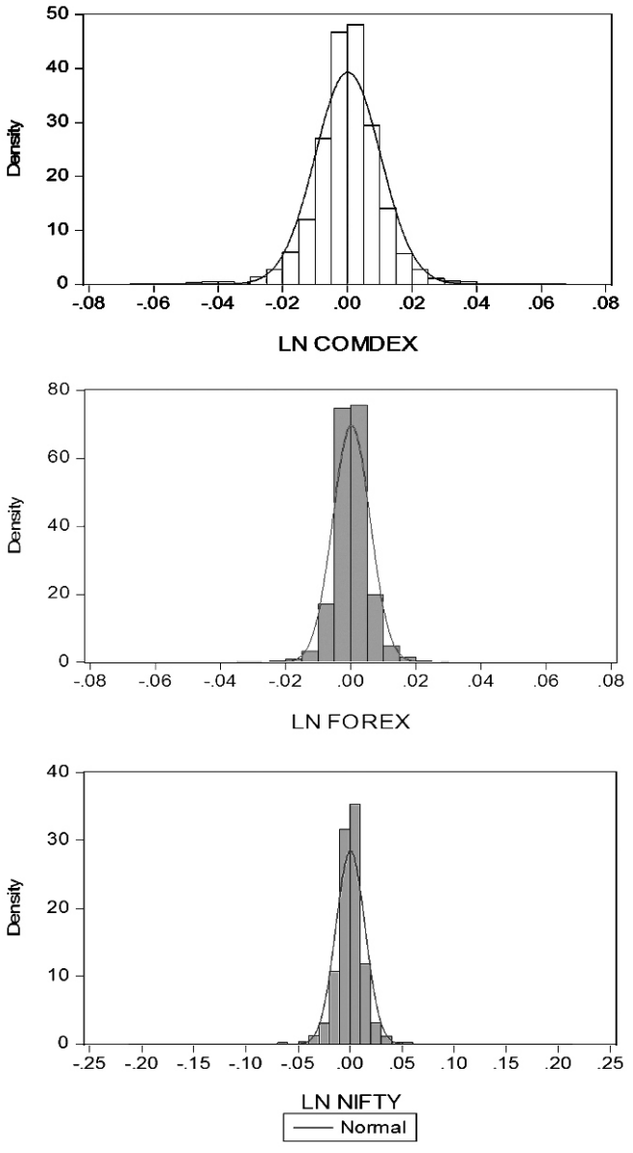

Fig 1 : Histogram of Comdex, Forex & Nifty

Research Methodology & Hypothesis to be tested

(a) Variable Stationarity

The first test under research methodology is to check for the stationarity of variables. Here we apply two type of tests, first is the popular Augmented Dickey Fuller Unit Root test and second is the KPSS test. For our three variables viz. Nifty, MCX COMDEX & Rupee-Dollar Exchange Rate we develop three equations for ADF unit root test as under

$$\Delta \text{Nifty}_t = \beta_1 + (\beta_2 - 1)\,\text{Nifty}_{t-1} + \sum_{i=1}^{m} \beta_{3i}\,\Delta\,\text{Nifty}_{t-i} + \text{ut} \ldots\ldots \text{eq.(i)}$$

(In the above equation (i), Δ Nifty $_t$ is change in Nifty in period t, (β_2-1) is the coefficient on the basis of which Unit root test is undertaken. The third term $\sum_{i=1}^{m} \beta_{3i} \Delta$ Nifty $_{t-i}$ is the augmented variable & takes care of autocorrelation and the term sums up 'm' times till the autocorrelation is removed. The term 'u_t is the residual disturbance term)

$$\Delta \text{MCX COMDEX}_t = \alpha_1 + (\alpha_2 - 1)\,\text{MCX COMDEX}_{t-1} + \sum_{i=1}^{m} \Delta\,\text{MCX COMDEX}_{t-i} + u_t \ldots\ldots \text{eq. (ii)}$$

$$\Delta \text{Rupee-Dollar}_t = \delta_1 + (\delta_2 - 1)\,\text{Rupee-Dollar}_{t-1} + \sum_{i=1}^{m} \Delta\,\text{Rupee-Dollar}_{t-i} + u_t \ldots\ldots \text{eq. (iii)}$$

For above equations (i), (ii) & (iii) we develop the following testable hypothesis :-

Null Hypothesis (H_0) : β_2 -1=0, α_2 -1=0, δ_2 -1=0 (The variable Nifty, MCX COMDEX & Rupee-Dollar is not stationary)

Alt Hypothesis (H_a) : β_2 -1<0, α_2 -1<0, δ_2 -1<0 (Nifty, MCX COMDEX & Rupee-Dollar is stationary) (this is kept one tail only to avoid explosive process)

We also test our variable stationarity using a second test; the KPSS as the ADF test is known to suffer from low power. Here the Null shall be presence of a trend in time series while the Alternative shall be Stochastic Unit root. Therefore if the null is accepted, time series has no stochastic root and is thus stochastic stationary. Under KPSS first we compute partial sum of the squares (S_{it}) which are then used to compute the KPSS statistic.

$$S_{it} = \sum_{w=1}^{m} \sum_{i=1}^{w} u_w \ldots\ldots \text{(iv)}$$

(i=1, 2, 3,...t, K=1, 2, 3,...m). Also we compute (σ^2 {u}), which are then put in the formula as under :-

$$\text{KPSS (u)} = m^2 \sum S_{iw}^2 / \sigma_u^2, \ldots\ldots\ldots\ldots (v)$$

where m is the no. of observations in the sample

Hypothesis $\boldsymbol{H_o}$: Presence of a trend, $\boldsymbol{H_a}$: Presence of Stochastic Unit root

If KPSS (u) >critical value of KPSS, $\boldsymbol{H_o}$ is Rejected.

(b) VAR Model (with variance decomposition)

We set up an unrestricted VAR Model with the no. of lags being determined by the AIC criteria

$$\text{Ret Nifty}_t = \sum_{j=1}^{t-1} \lambda 1J\ \text{Ret Nifty}_{t-j} + \sum_{i=1}^{t-1} \lambda 1i\ \text{Ret MCX COMDEX}_{t-i} + \sum_{k=1}^{t-1} \lambda 1k\ \text{Rupee-Dollar}_{t-k} + u_{1t} \ldots \text{eq. (vi)}$$

$$\text{Ret MCX COMDEX}_t = \sum_{j=1}^{t-1} \lambda 2J\ \text{Ret Nifty}_{t-j} + \sum_{i=1}^{t-1} \lambda 2i\ \text{Ret MCX COMDEX}_{t-i} + \sum_{k=1}^{t-1} \lambda 2k\ \text{Rupee-Dollar}_{t-k} + u_{2t} \ldots \text{eq. (vii)}$$

$$\text{Ret Rupee-Dollar}_t = \sum_{j=1}^{t-1} \lambda 3J\ \text{Ret Nifty}_{t-j} + \sum_{i=1}^{t-1} \lambda 3i\ \text{Ret MCX COMDEX}_{t-i} + \sum_{k=1}^{t-1} \lambda 3k\ \text{Rupee-Dollar}_{t-k} + u_{3t} \ldots \text{eq. (viii)}$$

(c) Granger Causality

Since we have considered our variable as return which comes out to be stationary in all the three variables we set up a Granger Causality as under :-

$$\text{Ret Nifty}_t = \theta_1 + \sum_{j=1}^{n} \alpha_j\,\text{Ret MCX COMDEX}_{t-j} + \sum_{i=1}^{n} \beta_j\,\text{Ret Nifty}_{t-i} + e_{1t} \ldots\ldots \text{(ix)}$$

$$\text{Ret MCX COMDEX}_t + \rho_1 + \sum_{j=1}^{n} \lambda j\ \text{Ret Nifty}_{t-j} + \sum_{i=1}^{n} \pi j\ \text{Ret MCX COMDEX}_{t-i} + e_{2t} \ldots \text{(x)}$$

The causality hypothesis to be tested is given as under :

$H_{01} : \alpha_j \neq 0, \lambda_j = 0$ (j = 1, 2, 3..... n) ; Causality flows from Ret MCX COMDEX to Ret Nifty but not vice versa

$H_{02} : \alpha_j = 0, \lambda_j \neq 0$ (j = 1, 2, 3..... n) ; Causality flows from Ret Nifty to Ret MCX COMDEX but not vice versa

$H_{03} : \alpha_j \neq 0, \lambda_j \neq 0$ (j = 1, 2, 3..... n) ; Causality is bi-directional, from Ret Nifty to Ret MCX COMDEX & also vice versa

$H_{04} : \alpha_j = 0, \lambda_j = 0$ (j= 1, 2, 3..... n) ; No Causality

On similar lines (eq ix & x) we set up our causality hypothesis for other pairs of variables viz . *Ret Nifty & Ret Rupee-Dollar & Ret COMDEX & Ret Rupee-Dollar*

(d) Variable Asymmetric Impact (tail values)

To study the asymmetric impact of the independent variable on the dependent variable, we run an OLS on our variables and include dummy of each of the independent variables *(see Baur and Lucey 2010)*. We do not use VAR as lag of dummy cannot be defined.

$$\text{Ret Nifty}_t = \pi 1 + \pi 2 \text{ Ret MCX COMDEX } t + \pi 3 \text{ Ret Rupee - Dollar}_t + D_{1t} + D_{2t} + \upsilon_{1t} \ldots \text{(xi)}$$

Where two dummies D_{1t} & D_{2t} have been added, where D_{1t} would account for positive and negative extreme shocks capturing 5% lower quartile and 5% upper quartile observations of **Ret MCX COMDEX** while D_{2t} would account for positive and negative extreme shocks of **Ret MCX COMDEX.** Here if the particular observation falls in upper or lower quartile range, it's value is taken as '1', else '0'. A significant dummy with a negative sign does indicate the asset gives an asymmetric impact. Further on similar lines we build up equations for our other two variables viz. **Ret MCX COMDEX** & Ret Rupee-Dollar which are given below as eq. (xii) & eq. (xiii)

$$\text{Ret MCX COMDEX}_t = \Omega_1 + \Omega_2 \text{ Ret Ret Nifty}_t + \Omega_3 \text{ Ret Rupee-Dollar}_t + D_{3t} + D_{4t} + \upsilon_{2t} \ldots \text{(xii)}$$

$$\text{Ret Rupee-Dollar}_t = \theta_1 + \theta_2 \text{ Ret MCX COMDEX}_t + \theta_3 \text{ Ret Nifty}_t + D_{5t} + D_{6t} + \upsilon_{3t} \ldots \text{(xiii)}$$

Results and Inferences of the Study

The appendices give the results of the study in a tabular format. **Appendix I & II** are the results of tests for Stationarity of variables using ADF and KPSS methodologies respectively. Beginning with the results of the ADF unit root test; **Appendix I** we find that all the three variables (MCX COMDEX, Nifty and Rupee-Dollar) are stationary only at 1st difference which is evident from both computed't' values and also the corresponding 'p' values & therefore Null Hypothesis that Variable has a Unit root is rejected by all the three variables only at 1st difference. **Appendix II** gives the results of KPSS test, here too we find that Null of KPSS is accepted for all the three variables only at 1st difference i.e. the variables are stochastic stationary only at 1st difference. **Appendix III** gives the results of Johansen Co-integration test. Two tables (III a & III b) have been prepared for Unrestricted Co-integration Rank Test (one for Trace & second for Max Eigen Values). Probability 'p' value corresponding to 'NONE' Category is 0.9204 for Table III (a) while it is 0.8061 for Table III (b), both these values are higher than 0.05 indicating that Null hypothesis of No Co-integration is accepted showing that no pair of variables is co-integrated.

Appendix IV gives the results of our selection of optimal VAR model (i.e. no. of lags required) using various techniques (Forecast Prediction Error (FPE) , Akaike Information (AIC), Schwarz Criteria(SC) & Hannan-Quinn (HQ). To get a clear result of the optimal model, maximum no. of lags are placed at 20. The results however do not give a consensus about the of no. of lags whereby criteria AIC & FPE place no. of lags at '13' as optimal, it is lag '1' according to the SC Criteria, while criteria HQ considers lag '2' as the best model .Since two of our criteria, AIC & FPE which are also used in most research studies have identified lag '13' as optimal, we would go with these results **Appendix V** gives the results of unrestricted Vector Autoregressive Regression (VAR) which has been established till optimal lag 13. The general interpretations are that Return on MCX COMDEX is determined by 1st and 2nd lags of Nifty daily return, on the other hand its own lags do not influence movement of MCX COMDEX at any level reflecting the efficiency of the MCX COMDEX Markets. On the other hand the rupee-dollar exchange rates is influenced by its own lag and lags of both the other variables viz. return on Nifty and Return on COMDEX. Finally Ret on Nifty does not seem to be influenced either by its own lags or lags of other variables *(Note: The assumption we are making here is that If the Lag 1 of variable 1 is not influencing Variable 2, we shall assume that higher lags of the Variable 1 also do not influence Variable 2 even if these are significant)*

Appendix VI gives the pair wise causality results and the results show that NIFTY is Granger causing MCX COMDEX as well as Rupee-Dollar Exchange rate . No other cause – effect relation could be found out from the results of the study. **Appendix VII** gives the results for the VAR Model stability& the figure clearly shows that all the points lie within the circle; hence the VAR Model is stable. This stability condition also serves as a pre-requisite for Granger Causality. Further in a VAR Model, we can easily decompose the total fluctuations in the dependent variable as due to lags of own variable (we call this own shock) and also due to lagged other variables (other shocks).These results are given in **Appendix VIII** which shows the Variance Decomposition at lag1, lag 5 and lag 10 for all the three variables If we see the variance decomposition of Nifty we find that there is only slight fall in terms of own shocks impacting variance of nifty (from 100 % in period 1 to 99.2 % in period 10). On the other hand the fall in terms of own shocks impacting the MCX COMDEX are larger where by the end of period ten; 97.2 % of the variance is due to its own shock. This fall is highest in case of rupee-dollar exchange rates in period ten, where own shocks contribute only 81.2 % of variation while 18 % of the variation is contributed by Nifty to the variability of rupee-dollar in period ten. **Appendix IX** gives the results of impact of asymmetric impact of independent variable on dependent variable during extreme

situations. We find that there is asymmetric impact for the tail end (5 % both tails) in only two cases however these are significant only at 10 %. First case is rupee-dollar is seen impacting the MCX COMDEX *(Corresponding Dummy Beta coefficient is -0.001858 with a 'p' value of 0.0651)* and second case is MCX COMDEX impacting the Nifty*(Corresponding Dummy Beta coefficient is-0.002569 with a 'p' value of 0.0707).* No other tail asymmetric relation is noticed in the study.

Conclusion

The paper investigated inter-relation between NSE Nifty, MCX COMDEX & Rupee-Dollar Exchange Rate using VAR methodology & additional VAR tools like Granger Causality and Variance Decomposition. The results of the study showed that all the three variables are return stationary (first difference) but not co-integrated and therefore unrestricted VAR Model was built up with thirteen lags as determined by the Lag Criteria AIC & HQ. The Granger Causality results showed that Nifty was causing movement in MCX COMDEX & Rupee-Dollar Exchange Rate markets &similar result was also indicated by VAR. The results of the variance decomposition showed that the proportional impact on variance of NSE Nifty due to other variables was negligible even at lag ten as its own shock contributed 99.2 % of variation in period 10. On the other hand the impact on MCX Comdex due to its own variation at lag ten was 97.2 %, while the same for rupee-dollar was lowest where own shocks contributed only 81.2 % of variation. Results of impact of asymmetric impact of independent variable on dependent variable during extreme situations was seen in two cases; rupee-dollar on MCX COMDEX& MCX COMDEX on Nifty (but only at 10 % significance levels).

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Websites : investing.com, nseindia.com & mcxindia.com

APPENDICES

Appendix I : Test of Stationary of Variables : Unit root ADF

Null Hypothesis	*Computed ADF 't' valuesat level ('p' values in parenthesis)*	*Computed ADF 't' valuesat 1st difference('p' values in parenthesis)*	*TestResult*
MCX COMDEX has a unit root	*-1.460308 (0.8428)*	*-47.89817 (0.0000)*	Null Hypothesis rejected at 1st difference
Rupee-Dollar has a unit root	*-2.344211 (0.4092)*	*-13.70528 (0.0000)*	Null Hypothesis rejected at 1st difference
NIFTY has a unit root unit root	*-3.001545 (0.1319)*	*-34.60142 (0.0000)*	Null Hypothesis rejected at 1st difference

Note : *Critical 't' value at 5 % level for ADF (with trend and intercept) is* -3.411664

Appendix II : Test of Stationary of Variables : **KPSS**

Null Hypothesis	**KPSS-test statistic computed LM values *(Level)***	**KPSS-test statistic computed LM values*(1st difference)***	*TestResult*
MCX COMDEX is trend non-random	0.960292	0.097793	Null Hypothesis is rejected at level & accepted at 1st difference
Rupee-Dollar is trend non- random	0.467793	0.056896	Null Hypothesis is rejected at level & accepted at 1st difference
NIFTY is trend non- random	0.383421	0.037943	Null Hypothesis is rejected at level & accepted at 1st difference

Critical Values for KPSS test(with intercept and trend) : 1 % : 0.216000 &5 % 0.146000

Appendix III (a) Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	**Trace Statistic**	**0.05Critical Value**	**Prob.**
None	12.31310	29.79707	0.9204
At most 1	2.996606	15.49471	0.9670
At most 2	0.295433	3.841466	0.5868

Appendix III (b) Unrestricted Co-integration Rank Test (Max Eigen value)

Hypothesized No. of CE(s)	**Max Eigen Statistic**	**0.05 Critical Value**	**Prob.**
None	9.316491	21.13162	0.8061
At most 1	2.701173	14.26460	0.9646
At most 2	0.295433	3.841466	0.5868

Appendix IV Lag Order Selection Criteria for VAR Model

Lag	**FPE**	**AIC**	**SC**	**HQ**
0	6.42e-13	-19.56004	-19.55281	-19.55741
1	5.45e-13	-19.72409	**-19.69520***	-19.71358
2	5.38e-13	-19.73656	-19.68599	**-19.71816***
3	5.38e-13	-19.73729	-19.66505	-19.71101
4	5.39e-13	-19.73635	-19.64243	-19.70218
5	5.39e-13	-19.73618	-19.62060	-19.69413
6	5.38e-13	-19.73673	-19.59947	-19.68679
7	5.35e-13	-19.74212	-19.58319	-19.68430

8	5.38e-13	-19.73758	-19.55698	-19.67188
9	5.37e-13	-19.73957	-19.53730	-19.66599
10	5.31e-13	-19.74985	-19.52590	-19.66838
11	5.29e-13	-19.75394	-19.50833	-19.66459
12	5.28e-13	-19.75651	-19.48922	-19.65927
13	**5.25e-13***	**-19.76119***	-19.47223	-19.65607
14	5.27e-13	-19.75832	-19.44769	-19.64532
15	5.28e-13	-19.75548	-19.42318	-19.63459
16	5.30e-13	-19.75221	-19.39823	-19.62343
17	5.31e-13	-19.75106	-19.37541	-19.61441
18	5.30e-13	-19.75257	-19.35525	-19.60803
19	5.31e-13	-19.75133	-19.33233	-19.59890
20	5.32e-13	-19.74801	-19.30735	-19.58770

Appendix V : VAR Regression Resultsin terms of computed 't' values **for our variables MCX COMDEX, Rupee-Dollar Exchange Rate & Nifty (Optimal Lag : Lag 13)**

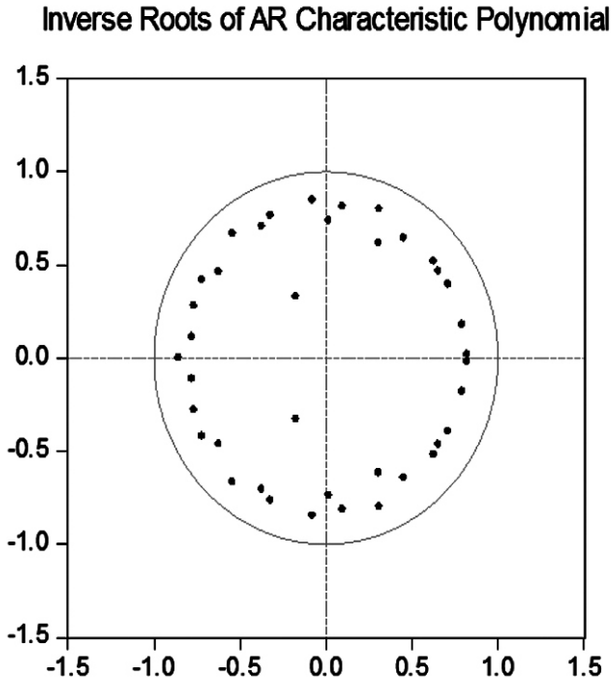
	Ret on MCXCOMDEX	**Ret on Rupee-Dollar**	**Ret on Nifty**
Ret on MCX COMDEX (-1)	[1.76124]	**[2.80666]**	[0.78847]
Ret on MCX COMDEX (-2)	[1.04349]	[0.76103]	[0.92098]
Ret on MCX COMDEX (-3)	[0.93252]	**[2.46396]**	[-0.78898]
Ret on MCX COMDEX (-4)	**[2.58738]**	[-0.81505]	[0.82876]
Ret on MCX COMDEX (-5)	[-0.67136]	[0.96003]	[-1.21065]
Ret on MCX COMDEX (-6)	[-1.04891]	[-1.37190]	[0.30863]
Ret on MCX COMDEX (-7)	[-0.49630]	[1.20161]	[1.50924]
Ret on MCX COMDEX*(-8)*	[1.08133]	[0.92416]	[1.19446]
Ret on MCX COMDEX (-9)	[0.56963]	**[-2.08810]**	[-0.48182]
Ret on MCX COMDEX (-10)	[-0.38479]	**[2.71898]**	**[-3.35005]**
Ret on MCX COMDEX (-11)	[-1.88993]	[-1.21521]	[-0.71367]
Ret on MCX COMDEX (-12)	[1.21761]	[-0.63691]	[0.24514]
Ret on MCX COMDEX (-13)	[0.66066]	[-4.07532]	**[2.79900]**
Ret on Rupee-Dollar(-1)	[-0.44541]	[**-4.71567**]	[-1.52627]
Ret on Rupee-Dollar(-2)	[1.02261]	[**-2.91862**]	[**-2.05441**]
Ret on Rupee-Dollar(-3)	[0.71759]	[-1.60871]	[0.82294]
Ret on Rupee-Dollar(-4)	[0.98232]	[-0.04275]	[-1.61915]
Ret on Rupee-Dollar(-5)	[-0.40423]	[1.22376]	[-0.49588]
Ret on Rupee-Dollar(-6)	[-1.30796]	[0.31134]	[1.04558]
Ret on Rupee-Dollar(-7)	**[2.41642]**	**[-2.67602]**	[0.55647]
Ret on Rupee-Dollar(-8)	[-0.42408]	[0.75217]	[1.19227]
Ret on Rupee-Dollar(-9)	[-1.46262]	[1.40818]	**[2.55076]**
Ret on Rupee-Dollar(-10)	[0.78989]	**[2.43818]**	**[-3.41137]**
Ret on Rupee-Dollar(-11)	[-1.52952]	[1.78500]	[-0.87607]
Ret on Rupee-Dollar(-12)	[0.75281]	[-0.76727]	[2.33929]
Ret on Rupee-Dollar(-13)	[-0.78902]	[-0.83324]	[0.78481]
Ret on Nifty (-1)	[**2.51183**]	[**-21.2291**]	[1.58430]
Ret on Nifty (-2)	**[-1.93163]**	[**-4.98406**]	[**-2.92584**]
Ret on Nifty (-3)	[1.56192]	[-1.88465]	[-1.45474]

Ret on Nifty (-4)	[0.26734]	[-1.78050]	[0.38567]
Ret on Nifty (-5)	[-0.46264]	[-1.33553]	**[-2.19695]**
Ret on Nifty (-6)	[-1.93458]	**[-2.69351]**	[-0.05884]
Ret on Nifty (-7)	[0.95789]	**[2.40051]**	[1.58893]
Ret on Nifty (-8)	[1.39678]	[0.36631]	[-0.13258]
Ret on Nifty (-9)	[-1.28343]	[0.30344]	[1.98449]
Ret on Nifty (-10)	[1.52115]	[0.96358]	[1.46354]
Ret on Nifty (-11)	[-0.55235]	**[2.49042]**	[0.90696]
Ret on Nifty (-12)	[1.73655]	**[-2.85582]**	**[2.16276]**
Ret on Nifty (-13)	[0.57759]	**[2.23342]**	[-0.33569]

Appendix VI : Results of the Granger Causality (Pairwise)

Kind of Relation tested	Obs	'F' Stats	Prob.
MCX COMDEX '!NIFTY	2420	0.50714	0.6023
MCX COMDEX'! Rupee-Dollar	2420	0.07341	0.9292
NIFTY'!MCX COMDEX	2420	**6.85499**	**0.0011**
NIFTY'! Rupee-Dollar	2420	**221.292**	**6.E-89**
Rupee-Dollar'!MCX COMDEX	2420	0.37587	0.6867
Rupee-Dollar'!NIFTY	2420	2.12086	0.1202

Appendix VII : Results of the VAR Model (Stability test)



Appendix VIII : Results of the Variance Decomposition of the variables of the VAR Model

(a) Variance Decomposition of NIFTY

Period	NIFTY COMDEX	MCX DOLLAR	RUPEE-
1	100.0000	0.000000	0.000000
5	99.45544	0.152549	0.392016
10	99.21183	0.341878	0.446294

(b) Variance Decomposition of MCX COMDEX

Period	NIFTY	MCX COMDEX	RUPEE-DOLLAR
1	1.307722	98.69228	0.000000
5	1.973127	97.90110	0.125771
10	2.247241	97.23978	0.512980

(c) Variance Decomposition of RUPEE-DOLLAR

Period	NIFTY	MCX COMDEX	RUPEE-DOLLAR
1	2.877639	0.035924	97.08644
5	17.57592	0.467258	81.95683
10	18.18482	0.580414	81.23476

Appendix IX : Regression Results of the test for asymmetric movement of dependent variable

(a) Dependent Variable Ln COMDEX,

Independent Variables : Ln Rupee Dollar, Ln NIFTY, Dummy Rupee-Dollar(D_1) & Dummy NIFTY(D_2)

Dummy Variables	*Beta Coefficient*	*t-Statistic*	*'p' value*
D_1	**-0.001858**	-1.845147	**0.0651**
D_2	-0.001719	-1.543264	0.1229

(b) Dependent Variable Ln RUPEE-DOLLAR

Independent Variables : Ln COMDEX, Ln NIFTY, Dummy NIFTY(D_2) ,Dummy COMDEX(D_3)

Dummy Variables	*Beta Coefficient*	*t-Statistic*	*'p' value*
D_3	-0.000636	-1.295153	0.1954
D_2	0.000762	1.400874	0.1614

(c) Dependent Variable Ln NIFTY

Independent Variables : Ln COMDEX, Ln RUPEE-DOLLAR, Dummy RUPEE-DOLLAR (D_1) ,Dummy COMDEX(D_3)

Dummy Variables	*Beta Coefficient*	*t-Statistic*	*'p' value*
D_3	**-0.002569**	-1.808401	**0.0707**
D_1	-2.53E-05	-0.020597	0.9836