VOLATILITY SPILLOVER BETWEEN STOCK AND FOREIGN EXCHANGE MARKET IN INDIA: USING SECTORAL INDICES

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Abstract: The present study aimed to contribute to the existing literature on volatility spillover between the stock and foreign exchange market in India using the diagonal BEKK-GARCH model. This study uses the daily data of BSE sector indices, namely BANKEX (Banking), IT (Information Technology), AUTO (Transport), CD (Consumer Durables), HCARE (Health care), POWER (Energy), and the everyday rupee exchange rate against US dollar. Using the closing prices for the period 1st January 2008 to 31st December 2018 the return series are calculated. The study found a bidirectional volatility spillover between the foreign exchange market and major stock market sectors in log run; even though they are very small in magnitude. The volatility spillover from stock market is found to have a negative impact on foreign exchange market and the volatility spillover from foreign exchange market is found to have a positive impact on the stock market. The changes in exchange market affects the stock market sectors largely based on whether they are import oriented or export oriented.

***Keywords*: Foreign exchange market, Sectoral stock market indices, Volatility.**

I. INTRODUCTION

The stock prices and exchange rate are highly fluctuating and interacting one. The Volatility can be defined as the dispersion of return of an asset or market index from its expected value. The fluctuation of a variable for a period of time is an indication of existence volatility; the higher the volatility the riskier the asset. The detection of volatility spillover across assets or markets is important because it explains about how a large shock in one market increases the volatility not only in its own asset but also affecting assets of other markets as well (Hong, 2001). The volatility spillovers are usually attributed to cross-market hedging and the changes in generally accessible information, which may concurrently impact the outlook of various participants across markets. By meaning, the spillover effects indicate the externalities of economic activity that influence those markets or persons who are not directly involved. The study of volatility spillover is correlated to market efficiency, which dictates that it should not be able to predict the returns or volatility in one market using lagged information generated in another market. For a country like India, that is going through a transitional phase with its present government pushing for greater foreign investments for boosting the country's economy, it is necessary to pay attention to the fluctuations in foreign exchange and the stock market, and how will they interact to each other.

II. THEORETICAL AND EMPIRICAL LITERATURE

In theoretical perspective, to explain the linkage between stock market and exchange rates there are mainly two views. In flow-oriented model (Dornbusch and Fisher 1980), assumes the current account and trade balance performance of a country are important factors of its exchange rate determination. The model suggests a positive relationship between exchange rate and stock prices with causality relationship running from exchange rate to stock prices. The stock-oriented model suggests that the demand and supply of the financial assets decides the exchange rate. The stock-oriented model divided into the portfolio balance model and the monetary model. The portfolio balance model (Frankel 1983, Branson and Henderson 1985) suggests a negative relationship between stock prices and exchange rates; causality runs from stock prices to exchange rates. Finally, the monetary approach provides a weaker or no relationship between the exchange rates and stock prices.

The evidences of correlation between exchange rate and stock prices were first appeared in the studies conducted by Aggarwal (1981). The volatility effect between the markets has been studied by many researchers with ARCH-GARCH framework (Engle, 1982) and this model was further improvised by Bollerslev and Nelson. Kanas (2000) examines the volatility spillover between exchange rates and stock markets for some developed countries and documents that there exist a symmetric volatility spillover from stock return to exchange rate. In contrast to this symmetric nature, Assoe (2001) found evidence of asymmetric volatility spillover from foreign exchange markets to stock markets for some of the countries while investigating in developed markets. Yang and Doong (2004) shows that stock price movements will influence the movements of future exchange rate. But the exchange rate changes will have lesser impact on future stock returns

When considering about volatility spillover between different financial market and foreign exchange market in India, Ghosh (2012) documents that the volatility spillover in the foreign exchange market is mainly influenced by the stock market. Studies conducted by Jebran and Iqbal (2016) finds that the positive shocks have less impact than the negative shocks and the foreign exchange volatility is found to be greater than the stock market volatility. In contrast to these findings there are studies which indicate no significant relationship between stock and foreign exchange markets (Kutty (2010) and Muhammad and Rasheed (2003)).

III. RESEARCH METHODOLOGY

The present study uses the daily data of BSE sector indices, namely BANKEX (Banking), IT (Information Technology), AUTO (Transport), CD (Consumer Durables), HCARE (Health care), POWER (Energy), and the everyday rupee exchange rate against US dollar is used for foreign exchange market. Using the closing prices for the period 1st January 2008 to 31st December 2018 dollar exchange rate and BSE sectoral indices daily return is calculated. The daily closing data for stock indices have been collected from the BSE official website and the exchange rate data collected from RBI website.

The Diagonal BEKK model

The specification for the conditional mean can be expressed as:

$$Y_t = \mu + \Gamma Y_{t-1} + \varepsilon_t \quad (1)$$

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (2)$$

Where, the return vector, $Y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix}$, y_{1t} is the exchange rate return and y_{2t} is the stock rate return at time t. The parameter vector $\mu = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}$ represents the constant and $\Gamma = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}$ is a 2×2 matrix of coefficients for autoregressive terms. The residuals $\varepsilon_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$ is the random error vector at time t, which indicates that the markets have been affected by innovation at that moment, $\varepsilon_t \mid I_{t-1} \sim N(0, H_t)$, H_t is a 2×2 corresponding conditional variance-covariance matrix and I_{t-1} is the information set of time t-1.

The parameter γ_{ij} indicates the mean of spillovers effects. γ_{11} indicates that the change rate of exchange rate affected by its lag value, γ_{12} is the mean spillovers from foreign exchange market to stock market, γ_{21} is the mean spillovers from stock market to exchange rate market, and γ_{22} indicates the stock return affected by its lag value.

The conditional variance and covariance matrix (H_t) can be presented as:

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + G'H_{t-1}G \quad (3)$$

Where, C is an upper triangular 2×2 matrix consists of parameters in the conditional variance and covariance matrices. A and G are diagonal matrices. Matrix G captures the correlation between the current conditional variances and past variances and matrix A captures the relationship between the conditional variances and past residual terms ε.

$$H_t = \begin{bmatrix} h_{iit} & h_{ijt} \\ h_{jit} & h_{jjt} \end{bmatrix} = \begin{bmatrix} c_{ii} & c_{ij} \\ 0 & c_{jj} \end{bmatrix}' \begin{bmatrix} c_{ii} & c_{ij} \\ 0 & c_{jj} \end{bmatrix} + \begin{bmatrix} \alpha_{ii} & 0 \\ 0 & \alpha_{jj} \end{bmatrix}' \begin{bmatrix} \varepsilon_{it-1}{}^2 & \varepsilon_{it-1}\,\varepsilon_{jt-1} \\ \varepsilon_{jt-1}\,\varepsilon_{it-1} & \varepsilon_{jt-1}{}^2 \end{bmatrix}$$

$$\begin{bmatrix} \alpha_{ii} & 0 \\ 0 & \alpha_{jj} \end{bmatrix} + \begin{bmatrix} g_{ii} & 0 \\ 0 & g_{jj} \end{bmatrix}' \begin{bmatrix} h_{iit-1} & h_{ijt-1} \\ h_{jit-1} & h_{jjt-1} \end{bmatrix} \begin{bmatrix} g_{ii} & 0 \\ 0 & g_{jj} \end{bmatrix} \quad (4)$$

According to Chang *et al.* (2018), the volatility spillover can be expressed as:

$$\frac{H_{ij}}{\varepsilon_{i,t-1}} = a_{ii} \times a_{jj} \times \varepsilon_{i,t-1}, i \neq j \quad (5)$$

Where a_{ii} and a_{jj} are derived from the diagonal matrix A. h_{ij} is the conditional covariance among market i and j, and $\varepsilon_{i,t-1}$ is the return to shock at time t-1 from market i. Following the definition of Chang *et al.* (2018), the test of null hypothesis on volatility spillover effect is $H_0: a_{ii}a_{jj} = 0$. If the null hypothesis is rejected it indicates that there is spillover on market j from market i at time t-1. However, shock to return from market j do not have spillover on market i concurrently.

IV. EMPRICAL ANALYSIS

Table 1: Descriptive statistics

Variable	DR	AR	BR	CDR	HR	ITR	PWR
Mean	0.02	0.05	0.04	0.04	0.04	0.04	-0.03
Std. Deviation	0.52	1.449	1.89	1.74	1.17	1.62	1.66
Skewness	0.17	-0.10	0.23	-0.29	-0.44	-0.09	0.02
Kurtosis	7.68	7.85	9.73	8.96	8.34	8.56	12.66
Jarque- Bera	2431.82	2608.76	5027.63	3959.32	3233.64	3409.34	10297.4
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	2648	2648	2648	2648	2648	2648	2648
PP	-51.21	-44.54	-46.11	-48.25	-46.44	-50.83	-47.1
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ADF	-51.15	-44.55	-46.27	-47.5	-46.38	-38.44	-47.07
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Note: Figures in parentheses are p-values and t- statistics for PP and ADF

The sectoral stock market returns are found to be more volatile than the foreign exchange returns. The positive skewness value indicates that the positive returns are more common than the negative returns which are true for DR, BR and PWR. Kurtosis is substantially higher than 3 for all the variables considered and thus leptokurtic. Furthermore, the Jarque - Bera test is significant at 1 per cent level and rejected the null hypothesis of normal distribution for all the variables. All these statistics confirm that the dollar return and the sectoral stock returns are not normally distributed. The correlogram of squared residuals Q-statistics, Breusch-Godfrey LM and the ARCH –LM test were considered for checking the auto correlation of squared residuals and the ARCH effect. The rejection of null of auto and the observation of ARCH effects in the residuals validate the use of ARCH type of models.

While checking the Granger Causality Test, for every sector, the null hypothesis is rejecte. For the sectors like auto (AR), bank (BR), health care (HR) and IT (ITR) there found to have a unidirectional causality. The consumer durables (CD), power (PWR) sectors shows bidirectional causality by rejecting both the null hypothesis. The results indicate the presence of endogeneity between the two variables and the necessity of MGARCH model over the univariate models.

Table 2 Granger Causality Test Results

Null Hypothesis	F-Statistic	Probability
AR does not Granger Cause DR	43.57	0.00
DR does not Granger Cause AR	0.28	0.76
BR does not Granger Cause DR	64.52	0.00
DR does not Granger Cause BR	1.13	0.32
CDR does not Granger Cause DR	21.40	0.00

DR does not Granger Cause CDR	6.44	0.00
HR does not Granger Cause DR	28.96	0.00
DR does not Granger Cause HR	0.87	0.42
ITR does not Granger Cause DR	12.89	0.00
DR does not Granger Cause ITR	0.41	0.66
PWR does not Granger Cause DR	62.09	0.00
DR does not Granger Cause PWR	4.65	0.01

To examine the volatility spillover effects between the two markets, the data is arranged into different groups and for each group the volatility spill over effect is tested. The diagonal elements in matrix A capture own past shocks effect (ARCH effects) and the diagonal elements in matrix G measures the own past volatility effects (GARCH effects). The volatility spillover effects tested from analysing the significance of diagonal elements in matrix A of the diagonal BEKK model.

Table 3 and Table 4 present the estimation results from the conditional mean equations and conditional variance equations, respectively. The lag for each group is selected on the basis of AIC criteria. Also, the fitted models checked for auto correlation and heteroscedascity. Both test results rejected the null hypothesis indicating that the fitted model is free from serial correlation and heteroscedascity.

Based on this result we can reject our null hypothesis, H_0: $a_{11} \times a_{22} = 0$ i.e, there is volatility spillover effects between the foreign exchange market and the major sectors of stock market. Since the magnitude of volatility spillover changes over time, we take the average return to shocks of the sample period to calculate the volatility spillover. The average return to shocks is estimated using VAR models. The derived results are given in Table 5.

Table 3: Estimation Results of Conditional Mean Equations

Var.	Con.	DR(-1)	DR(-2)	DR(-3)	DR(-4)	AR(-1)	AR(-2)	AR(-3)	AR(-4)						
DR	0.011	-0.025	-0.045**	0.019	0.042**	-0.043*	-0.003	-0.010**	-0.001						
	(1.488)	(-1.284)	(2.442)	(1.054)	(2.179)	(-8.021)	(-0.519)	(-1.975)	(-0.145)						
AR	0.079***	-0.029	-0.020	-0.032	0.066	0.095***	0.004	-0.021	-0.023						
	(3.438)	(-0.595)	(-0.409)	(-0.732)	(1.436)	(4.674)	(0.231)	(-1.205)	(-1.300)						
	Con.	**DR(-1)**	**DR(-2)**	**DR(-3)**	**DR(-4)**	**DR(-5)**	**DR(-6)**	**BR(-1)**	**BR(-2)**	**BR(-3)**	**BR(-4)**	**BR(-5)**	**BR(-6)**		
DR	0.011	-0.049**	-0.058***	0.006	0.028	0.013	0.033**	-0.043***	-0.008**	-0.009*	-0.003	-0.005	0.006		
	(1.511)	(-2.470)	(-3.168)	(0.299)	(1.468)	(0.692)	(2.081)	(-10.018)	(-2.060)	(-2.017)	(-0.810)	(-1.175)	(1.300)		
BR	0.089*	-0.051	0.039	-0.052	-0.041	0.022	-0.056	0.066***	-0.014	0.008	-0.010	-0.035	-0.012*		
	(3.567)	(-0.928)	(0.702)	(-0.894)	(-0.719)	(0.379)	(-1.030)	(3.592)	(-0.778)	(0.401)	(-0.534)	(-1.828)	(-0.639)		
	Con.	**DR(-1)**	**DR(-2)**	**DR(-3)**	**DR(-4)**	**HR(-1)**	**HR(-2)**	**HR(-3)**	**HR(-4)**						
DR	0.009	0.006	-0.049***	0.016	0.042**	-0.031***	0.005	-0.004	0.004						
	(1.158)	(0.324)	(-2.699)	(0.849)	(2.129)	(-4.956)	(0.764)	(-0.580)	(0.761)						
HR	0.065***	-0.024	-0.007	-0.055	0.019	0.108***	0.022	0.043**	-0.030*						
	(3.194)	(-0.693)	(-0.182)	(-1.425)	(0.479)	(5.332)	(1.131)	(-2.381)	(-1.717)						
	Con.	**DR(-1)**	**DR(-2)**	**DR(-3)**	**DR(-4)**	**DR(-5)**	**DR(-6)**	**DR(-7)**	**CDR(-1)**	**CDR(-2)**	**CDR(-3)**	**CDR(-4)**	**CDR(-5)**	**CDR(-6)**	**CDR(-7)**
DR	0.009	-0.001	-0.058***	0.014	0.043**	0.019	0.022	-0.000	-0.022***	-0.005	-0.004	0.003	0.000	0.002	0.001
	(1.133)	(-0.055)	(-3.290)	(0.731)	(2.089)	(0.926)	(1.071)	(-0.015)	(-4.824)	(-0.983)	(-0.717)	(0.617)	(0.003)	(0.374)	(0.135)
CDR	0.102***	-0.171***	-0.090*	-0.132**	-0.120	-0.052	0.048	-0.110**	0.061***	0.016	-0.017	-0.044**	-0.004	0.045**	-0.011
	(3.726)	(-3.447)	(-1.691)	(-2.449)	(-2.361)	(-1.015)	(0.839)	(-2.087)	(3.703)	(0.848)	(-0.918)	(-2.472)	(-0.249)	(2.432)	(-0.670)
	Con.	**DR(-1)**	**DR(-2)**	**DR(-3)**	**DR(-4)**	**ITR(-1)**	**ITR(-2)**	**ITR(-3)**	**ITR(-4)**						
DR	0.007	0.012	0.039**	0.025	0.035*	-0.017	-0.007	0.003***	-0.002						
	(0.948)	(0.618)	(-2.141)	(1.428)	(1.949)	(-3.733)	(-1.587)	(0.611)	(-0.418)						
ITR	0.057**	0.039	-0.050	0.001	0.119**	0.026	-0.032	-0.053	0.014						
	(2.044)	(0.786)	(-1.010)	(0.010)	(2.471)	(1.414)	(-1.578)	(-2.577)	(0.716)						
	Con.	**DR(-1)**	**DR(-2)**	**DR(-3)**	**DR(-4)**	**DR(-5)**	**DR(-6)**	**PWR(-1)**	**PWR(-2)**	**PWR(-3)**	**PWR(-4)**	**PWR(-5)**	**PWR(-6)**		
DR	0.008	-0.034*	-0.059***	0.014	0.034*	0.008	0.029*	-0.044***	-0.008	-0.007	-0.003	-0.006	0.009*		
	(1.090)	(-1.764)	(-3.384)	(0.791)	(1.883)	(0.508)	(1.809)	(-9.209)	(-1.715)	(-1.446)	(-0.791)	(-1.357)	(1.836)		
PWR	-0.004	-0.141	-0.074	-0.131***	-0.036	-0.017	0.004	0.044**	0.013	-0.026	-0.032*	-0.018**	-0.041		
	(-0.177)	(-2.974)	(-1.639)	(-2.896)	(-0.746)	(-0.352)	(0.074)	(2.331)	(0.784)	(-1.4595)	(-1.821)	(-0.974)	(-2.352)		

Note: *, **, *** indicates significant at 10 per cent, 5 per cent and 1 per cent levels, respectively. Figures in parentheses are t-statistics.

Table 4: Estimation Results of Conditional Variance Equations

Group	C		A		G	
	DR	**AR**	**DR**	**AR**	**DR**	**AR**
DR	0.047***		0.2668***		0.961***	
	(6.961)		(13.621)		(162.505)	
AR	-0.075***	0.205***		0.266***		0.9525***
	(-4.254)	(8.877)		(15.178)		(144.393)
	DR	**BR**	**DR**	**BR**	**DR**	**BR**
DR	0.057***		0.296***		0.949***	
	(0.007)		(0.020)		(0.007)	
BR	-0.054***	0.130***		0.213***		0.973***
	(0.013)	(0.018)		(0.014)		(0.003)
	DR	**HR**	**DR**	**HR**	**DR**	**HR**
DR	0.068***		0.339***		0.933***	
	(6.151)		(9.697)		(64.395)	
HR	-0.034***	0.126***		0.192***		0.975***
	(-3.126)	(5.140)		(10.645)		(185.803)
	DR	**CDR**	**DR**	**CDR**	**DR**	**CDR**
DR	0.049***		0.272***		0.959***	
	(6.792)		(10.37)		(120.22)	
CDR	-0.076***	0.277***		0.273***		0.947***
	(-3.444)	(14.660)		(13.256)		(145.960)
	DR	**ITR**	**DR**	**ITR**	**DR**	**ITR**
DR	0.065***		0.331***		0.936***	
	(7.808)		(12.725)		(88.662)	
ITR	-0.014	0.091***		0.130***		0.989***
	(-1.309)	(6.499)		(13.764)		(647.970)
	DR	**PWR**	**DR**	**PWR**	**DR**	**PWR**
DR	0.051***		0.281***		0.956***	
	(7.129)		(13.364)		(141.700)	
PWR	-0.063***	0.165***		0.258***		0.959***
	(-4.663)	(9.100)		(15.332)		(195.100)

Note: *, **, *** indicates significant at 10 per cent, 5 per cent and 1 per cent levels, respectively. Figures in parentheses are t-statistics.

Table 5: Average returns shock.

Variable		Average Return to Shocks	Variable		Average Return to Shocks
From	**To**		**From**	**To**	
DR	AR	0.014	AR	DR	-0.032
DR	BR	0.014	BR	DR	-0.048
DR	CDR	0.013	CDR	DR	-0.055
DR	HR	0.013	HR	DR	-0.016
DR	ITS	0.013	ITS	DR	-0.039
DR	PWR	0.015	PWR	DR	-0.015

Analysing the average return to shocks from dollar return to stock market sectors, it is highest for power (PWR) sector then, auto (AR), bank (BR), health care (HR), IT (ITR) and consumer durables (CDR). For average return to shocks from sectors to dollar return, taking the absolute value, it is highest for consumer durables (CDR) and least for power (PWR).

Using this average return to shocks, the volatility spillover from dollar returns (foreign exchange market) to sectoral stocks (stock market) is estimated using the formula:

$$\frac{\mathrm{H}_{ij}}{\varepsilon_{i,t-1}} = a_{ii} \times a_{jj} \times \varepsilon_{i,t-1}, i \neq j \qquad (6)$$

The results are given in Table 6

Table 6: Volatility spillover effects

Variable		Average volatility spillover	Variable		Average volatility spillover
From	**To**		**From**	**To**	
DR	AR	0.0010	AR	DR	-0.0022
DR	BR	0.0009	BR	DR	-0.0030
DR	CDR	0.0009	CDR	DR	-0.0041
DR	HR	0.0009	HR	DR	-0.0011
DR	ITS	0.0006	ITS	DR	-0.0017
DR	PWR	0.0011	PWR	DR	-0.0011

Thus, from the estimated results it indicates that in the long run the average volatility spillover from foreign exchange market (dollar return) to major stock market sectors are positive and average volatility spillover from major stock market sectors to foreign exchange market are negative, even though they are small in magnitude. Interestingly, in long run the average volatility spillover from stock market sectors to foreign exchange market is higher than the average volatility spillover from foreign exchange market to stock market sectors. The sectors like consumer durables, bank, automobiles, IT sectors seemed to have greater impact on foreign exchange market.

V. CONCLUSION

The present study makes an attempt to analyse the volatility spillover between the foreign exchange market and major stock market sectors in India using diagonal BEKK GARCH model. Since, the various sectoral participants of the stock market not always need to produce the same trend as the general stock index, focusing on these sectors will provide some understanding on how these sectors behave with the return to shock from foreign exchange market.

The study found a bidirectional volatility spillover between the foreign exchange market and major stock market sectors in log run; even though they are very small in magnitude. The average volatility spillover from major stock market sectors to foreign exchange market is higher in magnitude than the average volatility spillover from foreign exchange market to major stock market sectors. The volatility spillover from stock market is found to have a negative impact on foreign exchange market. Further, the volatility spillover from foreign exchange market is found to have a positive impact on the stock market. The findings from the present study are similar to the related studies conducted by Mishra *et al*. (2007) and Kumar (2013). These studies also account for bidirectional volatility spillover between the stock market and foreign exchange market in India; even though, the magnitude of volatility spillover is very low, nearly zero for foreign exchange to stock market. The positive relationship between volatility spillover from foreign exchange market to stock market can be explained with help of flow-oriented model and the negative relationship running from stock market to foreign exchange market, with the support of portfolio balance model. However, in long run the results show a higher influence of negative stock market volatility spillover on the foreign exchange market, thereby giving more emphasis on the portfolio channel. The changes in exchange market affects the stock market sectors largely based on whether they are import oriented or export oriented. The export-oriented sectors are benefited when there is depreciation of the domestic currency. On the other hand, the import-oriented sectors are benefited by the appreciation of the domestic currency.

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