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BID-ASK SPREADS, TRADING VOLUME AND RETURN VOLATILITY: INTRADAY EVIDENCE FROM INDIAN STOCK MARKET

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Abstract

This paper empirically examines the relationship between stock return volatility, trading volume and bid-ask spread within the scope of mixture of distribution hypothesis (MDH) and sequential information arrival hypothesis (SIAH) in the Indian stock market using high frequency 5-minute data set over the period of 2 July 2012 to 31 December 2012. This is the first kind of study in India using bid-ask spread as an additional information variable along with trading volume to investigate the relationship with stock return volatility. Our empirical findings provide evidence of a positive contemporaneous relationship between return volatility and trading volume, and also between return volatility and bid-ask spread. Moreover, the results of Granger causality test show that the information content of trading volume and bid-ask spread are useful for predicting stock return volatility. Our results indicate that information arrival to investors tends to follow a sequential rather than a simultaneous process. This finding is consistent with the sequential information arrival hypothesis and contradicts the mixture of distribution hypothesis.

Keywords: Intraday, Volatility, Trading Volume, Bid-Ask Spread, Granger Causality, MDH, SIAH

1. Introduction

The relationship between stock return volatility and trading volume has been the matter of subject for several empirical studies over the past years. The major inspiration for these studies is the central role played by trading volume in the pricing of financial assets through the arrival of new information. It has been proposed that there exists a positive contemporaneous relationship between return volatility and trading volume in financial markets. At the theoretical level, the existence of such a positive relationship explained mainly by two major underlying hypotheses; the mixture of distribution hypothesis (MDH) and the sequential information arrival hypothesis (SIAH).

Mixture of distribution hypothesis (MDH) of Clark (1973), Epps and Epps (1976), Tauchen and Pitts (1983) and Harris (1986) argues that stock return volatility and trading volume should be positively related because they jointly depend on a common factor, which is assumed to be the flow of new information in the market. The more information arrives at the market, the more volume it will create and the more stock prices will tend to fluctuate. In MDH, equilibrium prices are immediately established and new information is disseminated

simultaneously to all the traders. The implication is that, with simultaneous information arrival there is no information in the past volume that can be used in forecasting future volatility that are not yet contained in the past volatility. Hence, the mixture of distribution hypothesis supports only positive contemporaneous relationship but no causal linkage between trading volume and return volatility.

The sequential information arrival hypothesis (SIAH) proposed by Copeland (1976) and discussed further in Jennings *et al.* (1981) suggest that the new information is disseminated sequentially rather than simultaneously to all the traders. In these models, some trader observes the information ahead of the market and trade on it, thereby creating volume and volatility. As a result, volume and volatility move in same direction. Hence, there is a positive contemporaneous relationship exists between volatility and volume. Smirlock and Starks (1988) have further extended the hypothesis that as the information comes sequentially, the past values of trading volume may have the ability to predict future volatility and vice versa, which means that a causal relationship may exist in either directions between volatility and volume.

The contemporaneous and causal relationship between stock return volatility and trading volume has also been the subject of a substantial stream of empirical studies. Lee and Rui (2002) found evidence of a positive contemporaneous as well as a feedback relationship between trading volume and volatility in US, UK and Japanese markets. Leon (2007) found that trading volume had predictive power for stock return volatility in the regional stock exchange of the West African Economic and Monetary Union. Khan and Rizwan (2008) examined the relationship between return volatility and trading volume in Pakistan's stock market and found a positive contemporaneous relationship between them. At the same time they observed that there exists a bidirectional causal relationship between volatility and volume. Medeiros and Doornik (2008) found the support for a positive contemporaneous as well as bidirectional causal relationship between return volatility and trading volume in Brazilian stock market. Mahajan and Singh (2009) traced a positive contemporaneous relationship between return volatility and trading volume in the Indian stock market. Their study also provided evidence of one-way causality from volatility to trading volume. Thammasiri and Pattarathammas (2010) found a positive contemporaneous relationship between return volatility and trading volume in TFEX market, however, no causal relation from trading volume to return volatility was established. Tripathy (2011) examined the Indian market and found a positive contemporaneous as well as bidirectional causal relationship between return volatility and trading volume. Chuang *et al.* (2012) studied the Asian markets and found evidence of a positive contemporaneous relationship for 6 out of 10 markets. Their study also provided some evidence of bidirectional causal relationship for 8 out of 10 markets. And a significant causality running from volatility to volume was detected only for China. They didn't find any causal effect for Thailand. Choi and Kang (2013) found a positive volume-volatility relationship for four Asian markets: Korea, Japan, China and Hong-Kong. Their study found volume causes volatility in cases of Hong-Kong, China and Japan whereas volatility causes volume in cases of Hong-Kong, China and Korean market. Celik (2013) also found evidence of a positive relationship between volatility and volume in Istanbul stock market both in pre-crisis and post-crisis periods whereas bidirectional causality was traced in post-crisis period and in pre-crisis period no causality was established.

Research on market microstructure also focused in explaining and exploring bid-ask spread and its relationship with price changes and volatility. In the literature it is widely documented that intraday variations of bid-ask spread and intraday return volatility are expected to be positively correlated because an information arrival is supposed to stimulate an increase in volatility which in turn widens the bid-ask spread (Copeland and Galai, 1983; Glosten and Milgrom, 1985; Richardson, 2000; Wang and Yau, 2000; Rahman *et al.* 2002).

In line with the market microstructure theory, some studies also empirically examined the relationship between return volatility and bid-ask spread and found evidence of a significant positive relationship between them. Such studies include Wei (1991), Bollerslev and Melvin (1994), Galati (2000), McGroarty *et al.* (2009), Gtifa and Lioune (2013) in foreign exchange market, Ding and Chong (1997), Wang and Yau (2000), Frank and Garcia (2011), Wang *et al.* (2014) in futures market and Rahman *et al.* (2002) and Hussain (2011) in equity market.

A considerable amount of effort has made, empirically and theoretically, to understand the relationship between stock return volatility and trading volume. Although the majority of the findings have confirmed the existence of a positive contemporaneous relationship between return volatility and trading volume, the studies of different stock markets have given mixed results about the causal relationship. Similarly in the context of India, Tripathy (2011) found the evidence of causality from volume to volatility whereas Mahajan and Singh (2009) did not trace any causal relationship from volume to volatility. Interestingly enough none of the studies in India focused on intraday relationship. Similarly, spread-volatility relation has not been explored widely and thus the relationship is unclear. Particularly in Indian context, there is relatively a dearth of research on this aspect. Therefore, in the present study, we made an attempt to empirically investigate the intraday contemporaneous as well as the causal relationship between return volatility, trading volume and bid-ask spread for 50 stocks of S&P CNX NIFTY index to bridge this research gap.

2. Data and Variables Description

Our primary data set consists of transaction price, trading volume, and the close bid and ask quote for each 5-minute intervals from 2 July 2012 to 31 December 2012 for all the stocks of S&P CNX Nifty Index between trading timing 09:15 am to 15:30 pm IST. S&P CNX Nifty Index is a well diversified 50 stock index accounting for 25 sectors of the Indian economy. Table A1 provides the list of companies and their industry type. All the data are obtained electronically from Bloomberg terminal.

Stock return volatility, trading volume and bid-ask spread are relevant for this study. The percentage return of the stock is defined as $R_t = \log(P_t/P_{t-1}) * 100$, where R_t is the logarithmic percentage return at time t and P_t represents current 5 minutes interval trading price and P_{t-1} is the trading price for immediately preceding five minutes interval. Following Leon (2007), Medeiros and Doornik (2008) and Tripathy (2011), squared return (R_t^2) is used as measures of price volatility.

Following Wei (1991), Abhyankar *et al.* (1997) and Hussain (2011), the 5-minute proportional bid-ask spreads are calculated as $S = Ask - Bid/[(Ask + Bid)/2]$.

Next, the trading volume is the total number of shares traded at each five minute interval. Following Tian and Guo (2007) and Al-Jafari and Tliti (2013), the study uses logarithmic value of volume instead of raw volume to improve the normality properties of the series.

3. Methodology

3.1. Unit Root Test

To avoid spurious relation in time series model, the study adopts a test for a unit root to ensure that each variable is stationary. The unit root test is carried out by using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) Test.

3.2. Contemporaneous Relationship

The contemporaneous relationship between return volatility and trading volume and between return volatility and bid-ask spread have been investigated using the following OLS regression equations respectively.

$$R_t^2 = \alpha_1 + \beta_1 V_t + u_{1t} \quad (1)$$

$$R_t^2 = \alpha_2 + \beta_2 S_t + u_{2t} \quad (2)$$

where, R_t^2, V_t and S_t are return volatility, trading volume and spread respectively at time t. The estimated parameter β_1 in equation (1) measures the contemporaneous relationship between return volatility and trading volume. A statistically significant and positive value of β_1 would indicate a positive contemporaneous relationship between return volatility and trading

volume. Similarly, β_2 in equation (2) measures the contemporaneous relationship between return volatility and spread.

3.3. Causal Relationship

Our study covers not only the contemporaneous but also the causal relationship. Based on sequential information arrival hypothesis (SIAH) we test whether the information content of trading volume and bid-ask spread are useful for predicting stock return volatility. The pair wise causality between return volatility and trading volume has been checked through Granger causality test (Granger, 1969) by the following unrestricted equations:

$$R_t^2 = c_1 + \sum_{i=1}^{p} \alpha_i R_{t-i}^2 + \sum_{j=1}^{p} \beta_j V_{t-j} + u_{1t} \quad (3)$$

$$V_t = c_2 + \sum_{i=1}^{p} \lambda_i R_{t-i}^2 + \sum_{j=1}^{p} \delta_j V_{t-j} + u_{2t} \quad (4)$$

where, R_t^2 and V_t are return volatility and trading volume respectively at time t. c_1 and c_2 are intercepts, and α_i , β_j , λ_i and δ_j are parameters and p denotes the lag length. We formulate the linear Granger causality restrictions as follows: If some of β_j values are statistically not zero, then trading volume is said to granger cause return volatility, which is the main hypothesis of interest. Similarly if some of λ_i values are statistically not zero, then stock returns volatility are said to Granger cause volume. If both β_j and λ_i are statistically significant then a feedback relationship is said to exist. The optimum lag length is selected based on Schwarz information criterion (SC). Similarly we checked the causality between stock return volatility and bid-ask spread.

4. Empirical Findings

4.1. Unit Root Test

The ADF and PP test statistics are reported in Table A2, A3 and A4 respectively for return volatility (squared return), volume and spread. The results show that the null hypothesis that return volatility, trading volume and bid-ask spread are non-stationary (i.e. has a unit root) is rejected at 1% of level for all the series. This confirms that all the series are stationary for every one of the stocks and are therefore, suitable for further statistical analysis.

4.2. Cross-Correlation Analysis

As the first step, to investigate the relationship between volatility, volume and spread, we computed the cross-correlation coefficients for all the stocks. The correlation coefficients are reported in Table A5. We found return volatility is positively correlated with trading volume and lagged trading volume in case of all the 50 stocks. We also found positive correlation between return volatility and spread in case of 90% of the stocks except COAL, ICICIBC, LT, TPWR and TTMT. Similarly, return volatility is positively correlated with lagged spread in case of 92% of the stocks except COAL, LT, TPWR and TTMT. The lagged correlation gives an indication for causal relationship.

4.3. Contemporaneous Relationship between Volatility and Volume

The results of the OLS regression using equation 1 to explain the contemporaneous relationship between volatility and volume are reported in Table A6. The parameter β_1, which measures the contemporaneous relationship between volatility and volume, is statistically significant and positive for all the 50 stocks, suggesting a positive contemporaneous relationship between return volatility and volume.

Finally, the regression results also show that contemporaneous volume explains a relatively small portion of return volatility as evidenced by low R-square values. This weak positive contemporaneous relationship between trading volume and return volatility indicate

that, the Indian market is informationally inefficient. The information flow in market may well be disseminated sequentially instead of instantaneously as required in mixture distribution hypothesis (MDH). This relationship gives an indication of sequential information flow in Indian market.

4.4. Contemporaneous Relationship between Volatility and Spread

The results of the OLS regression using equation 2 to explain the contemporaneous relationship between volatility and spread are reported in Table A7. The parameter β_2 is statistically significant and positive for 40 stocks out of total 50, suggesting a positive contemporaneous relationship between return volatility and spread. We also found statistically significant negative β_2 for 5 stocks (COAL, ICICIBC, LT, TPWR and TTMT) and statistically insignificant relationship for remaining 5 stocks (DLFU, HNDL, INFO, PNB and RBXY). Likewise volume, the contemporaneous spread also explains relatively a very small portion of volatility and gives an indication of sequential information flow in the market.

4.5. Causal Relationship between Volatility and Volume

The Granger causality test results between return volatility and trading volume are reported in Table A8. The lag lengths for the causality test are determined on the basis of Schwartz information criterion (SC) and the selected lag period for each stock are reported in the same table. The null hypothesis that lagged volume does not granger cause return volatility is rejected in case of 44 stocks except AXSB, BHARATI, GRASIM, HUVR, SBIN and SESA. On the other hand, the null hypothesis that the past volatility does not granger cause volume is rejected for 35 stocks out of 50. For all these 35 stocks, we also found feedback relationship. Only in case of AXSB, BHARATI, GRASIM, HUVR, SBIN and SESA, no causality was traced in either direction. The Granger causality results show that volume causes volatility and that the volatility also causes volume but in lesser number of cases. This finding implies that in the presence of current and past volatility, trading volume adds some significant predictive power for future return volatility.

4.6. Causal Relationship between Volatility and Spread

The Granger causality test results between return volatility and spread are reported in Table A9. The test results show that the null hypothesis that lagged spread does not granger cause volatility is rejected in case of 49 stocks except INFO, whereas, the null hypothesis that lagged volatility does not granger cause spread is rejected only for 24 stocks. For all these 24 stocks, we also found feedback relationship between them. Only in case of INFO, no causality was traced in either direction. This clearly indicates that in the presence of current and past volatility, spread adds some significant predictive power for future return volatility.

5. Summary and Conclusion

This study investigated the contemporaneous and causal relationship between return volatility, trading volume and bid-ask spread using 5-minutes interval high frequency data from 50 stocks of S&P CNX NIFTY Index over the period of 2 July 2012 to 31 December 2012.

The findings provide evidence of a positive contemporaneous relationship between return volatility and trading volume as well as between return volatility and spread. However, in both cases the explanatory power of this contemporaneous relation is weak. This indicate that, the Indian market is informationally inefficient and the information flow in market may well be disseminated sequentially instead of instantaneously as required in mixture distribution hypothesis (MDH).

Our study not only focused on the contemporaneous relationship but also investigated the causal relationships. We investigated the information content of volume and spread for

future returns volatility by means of Granger causality test and found for majority of the cases, volume and spread caused return volatility.

The overall findings suggest that information arrival follows a sequential rather than a simultaneous process which contradicts the mixture of distribution hypothesis (MDH) and supports the sequential information arrival hypothesis (SIAH).

The past information of trading volume and bid-ask spread is useful to improve the prediction of future return volatility. The study suggests that regulators and market participants can use past information for monitoring the stock price movement in the market.

This study could help the marginal and uninformed traders who cannot afford the cost of information acquisition; they can keep a close eye on the movements of both volume and spread for their investment decisions. Especially, this study may help the intraday investors for making their trading strategy.

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Appendix

Table A1. List of constituents of S&P CNX NIFTY index

Sl.No.	Company code	Company name	Industry
1	ACC	ACC Ltd.	Cement
2	ACEM	Ambuja Cements Ltd.	Cement
3	APNT	Asian Paints Ltd.	Chemicals
4	AXSB	Axis Bank Ltd.	Banks
5	BHARATI	Bharti Airtel Ltd.	Telecommunication services
6	BHEL	Bharat Heavy Electricals Ltd.	Electrical equipment
7	BJAUT	Bajaj Auto Ltd.	Automobile
8	BOB	Bank of Baroda Ltd.	Banks
9	BPCL	Bharat Petroleum Corporation Ltd.	Oil and Gas
10	CAIR	Carirn India Ltd.	Oil and Gas
11	CIPLA	Cipla Ltd.	Pharmaceuticals
12	COAL	Coal India Ltd.	Metals and Mining
13	DLFU	DLF Ltd.	Real Estate
14	DRRD	Dr. Reddy's Laboratories Ltd.	Pharmaceuticals
15	GAIL	GAIL (India) Ltd.	Energy, Petrochemicals
16	GRASIM	Grasim Industries Ltd.	Building materials
17	HCLT	HCL Technologies Ltd.	IT service; IT consulting
18	HDFC	Housing Development Finance Corporation Ltd.	Financial services
19	HDFCB	HDFC Bank Ltd.	Banks
20	HMCL	Hero Moto Corp Ltd.	Automobile
21	HNDL	Hindalco Industries Ltd.	Metals
22	HUVR	Hindustan Unilever Ltd.	Consumer goods
23	ICICIBC	ICICI Bank Ltd.	Banks
24	IDFC	IDFC Ltd.	Financial services
25	INFO	Infosys Ltd.	IT services, IT consulting
26	ITC	ITC Ltd.	FMCG
27	JPA	Jaiprakash Associates Ltd.	Infrastructure
28	JSP	Jindal Steel & Power Ltd.	Steel, Energy
29	KMB	Kotak Mahindra Bank Ltd.	Banks
30	LPC	Lupin Ltd.	Pharmaceuticals
31	LT	Larsen & Toubro Ltd.	Engineering and construction
32	MM	Mahindra & Mahindra Ltd.	Automotive
33	MSIL	Maruti Suzuki India Ltd.	Automotive
34	NTPC	NTPC Limited	Electric utility
35	ONGC	Oil & Natural Gas Corporation Ltd.	Oil and Gas
36	PNB	Punjab National Bank	Banks
37	PWGR	PowerGrid Corporation of India Ltd.	Electric utility
38	RBXY	Ranbaxy Laboratories Ltd.	Pharmaceuticals
39	RELI	Reliance Infrastructure Ltd	Energy
40	RIL	Reliance Industries Ltd.	Multi-industry
41	SBIN	State Bank of India Ltd.	Banks
42	SESA	Sesa Sterlite Limited	Mining
43	SIEM	Siemens Ltd.	Multi-industry
44	SUNP	Sun Pharmaceutical Industries Ltd.	Pharmaceuticals
45	TATA	Tata Steel Ltd.	Steel
46	TCS	Tata Consultancy Services Ltd.	IT services, IT consulting
47	TPWR	Tata Power Co. Ltd.	Electric utility
48	TTMT	Tata Motors Ltd.	Automotive
49	UTCEM	UltraTech Cement Ltd.	Cement
50	WPRO	Wipro Ltd.	IT services, IT consulting

Table A2. Unit root test for squared return (volatility)

	Intercept		Intercept with Trend	
Stock	ADF	PP	ADF	PP
ACC	-39.6*	-84.9*	-39.6*	-84.9*
ACEM	-39.2*	-84.1*	-39.2*	-84.0*
APNT	-29.6*	-94.1*	-29.7*	-93.8*
AXSB	-36.5*	-51.7*	-36.5*	-51.7*
BHARATI	-39.1*	-57.5*	-39.1*	-57.5*
BHEL	-38.4*	-92.2*	-38.4*	-92.2*
BJAUT	-38.4*	-89.6*	-38.5*	-89.5*
BOB	-40.7*	-90.6*	-40.7*	-90.6*
BPCL	-40.8*	-90.8*	-40.9*	-90.8*
CAIR	-39.3*	-93.4*	-39.4*	-93.4*
CIPLA	-37.8*	-53.6*	-37.8*	-53.5*
COAL	-38.5*	-81.4*	-38.5*	-81.4*
DLFU	-39.4*	-88.8*	-39.4*	-88.8*
DRRD	-39.4*	-92.4*	-39.4*	-92.4*
GAIL	-41.7*	-93.1*	-41.7*	-93.1*
GRASIM	-36.2*	-50.9*	-36.2*	-50.9*
HCLT	-38.1*	-53.8*	-38.1*	-53.8*
HDFC	-40.4*	-93.4*	-40.5*	-93.3*
HDFCB	-38.1*	-92.4*	-38.1*	-92.4*
HMCL	-39.6*	-87.3*	-39.6*	-87.2*
HNDL	-42.0*	-94.0*	-42.0*	-94.0*
HUVR	-36.6*	-51.0*	-36.6*	-51.0*
ICICIBC	-41.4*	-86.6*	-41.4*	-86.5*
IDFC	-41.5*	-93.5*	-41.5*	-93.5*
INFO	-42.4*	-94.8*	-42.4*	-94.8*
ITC	-38.8*	-91.8*	-38.8*	-91.8*
JPA	-41.3*	-90.4*	-41.3*	-90.4*
JSP	-38.0*	-85.5*	-38.1*	-85.5*
KMB	-39.3*	-69.9*	-39.4*	-69.9*
LPC	-36.8*	-86.6*	-36.8*	-86.6*
LT	-41.3*	-79.6*	-41.3*	-79.6*
MM	-39.1*	-91.1*	-39.2*	-91.1*
MSIL	-41.1*	-85.9*	-41.2*	-85.9*
NTPC	-39.0*	-92.0*	-39.0*	-92.0*
ONGC	-39.9*	-90.4*	-39.9*	-90.3*
PNB	-40.6*	-86.1*	-40.6*	-86.1*
PWGR	-38.4*	-87.1*	-38.4*	-87.1*
RBXY	-39.0*	-91.2*	-39.2*	-91.0*
RELI	-40.9*	-90.1*	-41.0*	-90.1*
RIL	-39.3*	-92.4*	-39.3*	-92.4*
SBIN	-36.4*	-51.4*	-36.4*	-51.4*
SESA	-36.3*	-51.3*	-36.3*	-51.3*
SIEM	-40.4*	-92.2*	-40.5*	-92.1*
SUNP	-39.0*	-84.4*	-39.0*	-84.4*
TATA	-41.7*	-90.3*	-41.7*	-90.3*
TCS	-38.1*	-76.0*	-38.1*	-75.9*
TPWR	-39.7*	-61.6*	-39.7*	-61.6*
TTMT	-38.4*	-56.2*	-38.4*	-56.2*
UTCEM	-39.6*	-90.2*	-39.6*	-90.1*
WPRO	-38.1*	-89.5*	-38.1*	-89.5*

Notes: *Significant at 1% level.

Table A3. Unit root test for trading volume

	Intercept		Intercept with Trend	
Stock	ADF	PP	ADF	PP
ACC	-20.05*	-65.84*	-20.16*	-65.58*
ACEM	-18.59*	-66.17*	-18.64*	-66.21*
APNT	-20.08*	-68.73*	-20.25*	-68.46*
AXSB	-20.51*	-56.95*	-20.92*	-56.82*
BHARATI	-18.37*	-60.69*	-18.37*	-60.69*
BHEL	-17.60*	-51.81*	-17.60*	-51.82*
BJAUT	-19.31*	-73.14*	-19.72*	-73.39*
BOB	-19.00*	-64.17*	-19.13*	-64.27*
BPCL	-20.44*	-68.48*	-20.61*	-68.45*
CAIR	-18.28*	-51.50*	-18.28*	-51.49*
CIPLA	-18.50*	-64.87*	-18.60*	-64.97*
COAL	-18.97*	-66.11*	-18.97*	-66.11*
DLFU	-20.79*	-62.41*	-21.16*	-62.27*
DRRD	-19.44*	-69.81*	-19.45*	-69.81*
GAIL	-21.22*	-68.53*	-21.23*	-68.51*
GRASIM	-22.47*	-81.19*	-22.47*	-81.19*
HCLT	-18.37*	-67.32*	-18.37*	-67.32*
HDFC	-18.79*	-56.32*	-18.87*	-56.37*
HDFCB	-21.82*	-58.12*	-21.83*	-58.11*
HMCL	-20.42*	-59.06*	-20.47*	-58.90*
HNDL	-20.18*	-54.71*	-20.20*	-54.71*
HUVR	-18.84*	-60.72*	-18.87*	-60.72*
ICICIBC	-20.28*	-57.39*	-21.10*	-56.96*
IDFC	-20.80*	-63.31*	-20.90*	-63.05*
INFO	-18.39*	-51.60*	-18.39*	-51.60*
ITC	-18.75*	-53.48*	-18.79*	-53.48*
JPA	-21.54*	-59.63*	-21.72*	-59.34*
JSP	-18.58*	-55.19*	-18.61*	-55.22*
KMB	-30.78*	-112.68*	-31.79*	-107.70*
LPC	-18.26*	-74.51*	-18.32*	-74.57*
LT	-22.17*	-56.81*	-22.32*	-56.53*
MM	-18.61*	-58.26*	-18.67*	-58.29*
MSIL	-17.82*	-61.35*	-18.36*	-62.08*
NTPC	-19.74*	-71.78*	-19.90*	-71.75*
ONGC	-19.98*	-58.84*	-20.03*	-58.84*
PNB	-18.53*	-55.22*	-18.53*	-55.22*
PWGR	-20.12*	-66.81*	-20.20*	-66.82*
RBXY	-20.51*	-59.67*	-20.66*	-59.71*
RELI	-24.15*	-57.50*	-24.43*	-57.01*
RIL	-20.23*	-50.63*	-20.23*	-50.63*
SBIN	-22.96*	-57.20*	-23.29*	-56.65*
SESA	-20.25*	-56.91*	-20.92*	-56.43*
SIEM	-20.98*	-74.90*	-20.99*	-74.89*
SUNP	-20.14*	-64.92*	-20.14*	-64.91*
TATA	-21.59*	-51.98*	-21.64*	-51.94*
TCS	-17.75*	-49.84*	-17.88*	-50.02*
TPWR	-17.84*	-58.12*	-17.87*	-58.12*
TTMT	-20.20*	-51.40*	-20.23*	-51.40*
UTCEM	-19.81*	-74.65*	-21.05*	-74.10*
WPRO	-19.18*	-66.96*	-19.26*	-66.92*

Notes: *Significant at 1% level.

Table A4. Unit root test for spread

	Intercept		Intercept with Trend	
Stock	ADF	PP	ADF	PP
ACC	-31.75*	-109.50*	-31.81*	-109.25*
ACEM	-33.12*	-107.95*	-33.32*	-106.76*
APNT	-30.42*	-110.67*	-30.65*	-109.74*
AXSB	-42.40*	-95.65*	-42.40*	-95.65*
BHARATI	-40.36*	-95.70*	-40.35*	-95.70*
BHEL	-35.85*	-100.08*	-35.87*	-100.01*
BJAUT	-31.51*	-112.69*	-31.57*	-112.44*
BOB	-32.87*	-109.82*	-32.87*	-109.81*
BPCL	-32.00*	-112.37*	-32.00*	-112.35*
CAIR	-33.51*	-102.08*	-33.66*	-101.23*
CIPLA	-42.06*	-94.03*	-42.12*	-94.06*
COAL	-35.58*	-101.85*	-35.69*	-101.47*
DLFU	-37.98*	-100.24*	-38.54*	-98.45*
DRRD	-35.09*	-106.00*	-35.09*	-105.99*
GAIL	-33.32*	-102.73*	-33.39*	-102.44*
GRASIM	-38.83*	-95.71*	-38.84*	-95.57*
HCLT	-40.45*	-95.42*	-40.45*	-95.41*
HDFC	-41.25*	-95.13*	-41.25*	-95.13*
HDFCB	-33.08*	-102.52*	-33.09*	-102.19*
HMCL	-36.56*	-103.04*	-36.59*	-102.94*
HNDL	-37.88*	-97.78*	-37.87*	-97.77*
HUVR	-36.04*	-103.56*	-36.17*	-103.10*
ICICIBC	-34.60*	-102.57*	-34.73*	-102.09*
IDFC	-36.14*	-104.53*	-38.08*	-97.22*
INFO	-33.54*	-103.24*	-33.55*	-103.18*
ITC	-35.02*	-100.87*	-35.50*	-98.75*
JPA	-33.02*	-127.71*	-37.69*	-106.73*
JSP	-35.63*	-103.95*	-35.80*	-103.08*
KMB	-20.65*	-71.01*	-21.21*	-70.53*
LPC	-30.51*	-115.38*	-30.55*	-115.19*
LT	-41.45*	-95.04*	-41.51*	-95.09*
MM	-32.80*	-110.84*	-32.93*	-110.22*
MSIL	-32.27*	-108.76*	-32.31*	-108.63*
NTPC	-36.09*	-101.49*	-36.20*	-100.81*
ONGC	-33.71*	-99.98*	-33.90*	-98.99*
PNB	-35.96*	-101.45*	-36.02*	-100.95*
PWGR	-35.90*	-97.90*	-36.21*	-96.65*
RBXY	-32.40*	-112.16*	-32.49*	-111.37*
RELI	-42.39*	-95.42*	-42.40*	-95.42*
RIL	-36.03*	-102.71*	-36.53*	-100.52*
SBIN	-42.48*	-95.79*	-42.48*	-95.79*
SESA	-42.54*	-95.72*	-42.66*	-95.79*
SIEM	-30.00*	-111.83*	-30.20*	-110.56*
SUNP	-32.77*	-110.12*	-32.82*	-109.88*
TATA	-39.22*	-94.69*	-39.32*	-94.47*
TCS	-35.03*	-102.65*	-35.04*	-102.59*
TPWR	-41.20*	-94.50*	-41.27*	-94.49*
TTMT	-43.06*	-95.64*	-43.07*	-95.65*
UTCEM	-27.21*	-115.49*	-27.57*	-114.27*
WPRO	-30.55*	-113.04*	-30.61*	-112.80*

Notes: *Significant at 1% level.

Table A5. Cross correlation coefficients

Stock	Volatility↔Volume	Volatility↔Spread	Volatility↔Lag Volume	Volatility↔Lag Spread
ACC	0.214	0.066	0.143	0.073
ACEM	0.237	0.084	0.163	0.094
APNT	0.208	0.045	0.141	0.043
AXSB	0.048	0.694	0.035	0.699
BHARATI	0.082	0.603	0.054	0.635
BHEL	0.285	0.041	0.182	0.083
BJAUT	0.222	0.048	0.145	0.118
BOB	0.157	0.025	0.102	0.059
BPCL	0.170	0.074	0.099	0.071
CAIR	0.200	0.034	0.106	0.066
CIPLA	0.062	0.618	0.048	0.719
COAL	0.195	-0.159	0.147	-0.162
DLFU	0.249	0.010	0.121	0.111
DRRD	0.172	0.072	0.138	0.085
GAIL	0.118	0.043	0.07	0.091
GRASIM	0.058	0.67	0.037	0.639
HCLT	0.059	0.656	0.045	0.655
HDFC	0.217	0.100	0.125	0.062
HDFCB	0.200	0.073	0.167	0.164
HMCL	0.226	0.032	0.160	0.188
HNDL	0.176	0.001	0.095	0.040
HUVR	0.056	0.522	0.050	0.495
ICICIBC	0.162	-0.024	0.101	0.030
IDFC	0.179	0.036	0.095	0.103
INFO	0.113	0.007	0.065	0.016
ITC	0.237	0.038	0.172	0.100
JPA	0.187	0.021	0.081	0.046
JSP	0.224	0.124	0.143	0.115
KMB	0.158	0.04	0.112	0.087
LPC	0.21	0.038	0.136	0.079
LT	0.152	-0.394	0.098	-0.305
MM	0.214	0.053	0.157	0.131
MSIL	0.148	0.021	0.096	0.069
NTPC	0.167	0.171	0.140	0.078
ONGC	0.196	0.054	0.130	0.076
PNB	0.22	0.007	0.161	0.073
PWGR	0.197	0.069	0.154	0.097
RBXY	0.295	0.005	0.170	0.066
RELI	0.297	0.056	0.155	0.067
RIL	0.214	0.027	0.146	0.09
SBIN	0.047	0.706	0.031	0.695
SESA	0.047	0.702	0.029	0.676
SIEM	0.173	0.065	0.122	0.090
SUNP	0.203	0.039	0.137	0.106
TATA	0.200	0.06	0.123	0.103
TCS	0.191	0.216	0.143	0.246
TPWR	0.13	-0.595	0.101	-0.488
TTMT	0.102	-0.675	0.072	-0.632
UTCEM	0.122	0.061	0.091	0.039
WPRO	0.212	0.047	0.160	0.089

Table A6. Contemporaneous relationship between volatility and volume

$$R_t^2 = \alpha_1 + \beta_1 V_t + u_t$$

Stock	α_1	t-statistics	β_1	t-statistics	R-squared
ACC	-0.033	-17.9	0.011*	20.9	0.046
ACEM	-0.047	-20.4	0.012*	23.3	0.056
APNT	-0.023	-16.7	0.010*	20.4	0.043
AXSB	-0.242	-4.4	0.060*	4.6	0.002
BHARATI	-0.144	-7.3	0.033*	7.9	0.007
BHEL	-0.117	-26.4	0.028*	28.4	0.081
BJAUT	-0.038	-19	0.012*	21.8	0.049
BOB	-0.065	-13.5	0.020*	15.2	0.025
BPCL	-0.054	-14.5	0.016*	16.6	0.029
CAIR	-0.075	-18.3	0.018*	19.5	0.04
CIPLA	-0.196	-5.6	0.050*	5.9	0.004
COAL	-0.038	-16.8	0.010*	19	0.038
DLFU	-0.147	-22.9	0.033*	24.6	0.062
DRRD	-0.021	-13.7	0.007*	16.7	0.029
GAIL	-0.053	-10	0.016*	11.4	0.014
GRASIM	-0.039	-4.7	0.017*	5.6	0.003
HCLT	-0.126	-5.2	0.035*	5.6	0.003
HDFC	-0.084	-20.1	0.020*	21.3	0.047
HDFCB	-0.027	-17.3	0.007*	19.6	0.04
HMCL	-0.04	-19.5	0.013*	22.2	0.051
HNDL	-0.133	-15.9	0.030*	17.1	0.031
HUVR	-0.143	-5.1	0.035*	5.4	0.003
ICICIBC	-0.133	-14.9	0.031*	15.7	0.026
IDFC	-0.129	-16.1	0.029*	17.4	0.032
INFO	-0.182	-10.4	0.047*	10.9	0.013
ITC	-0.047	-21.5	0.011*	23.4	0.056
JPA	-0.283	-17.2	0.057*	18.2	0.035
JSP	-0.138	-19.9	0.035*	22	0.05
KMB	-0.029	-12.6	0.009*	15.3	0.025
LPC	-0.04	-17.9	0.012*	20.6	0.044
LT	-0.102	-13.8	0.026*	14.7	0.023
MM	-0.044	-18.7	0.012*	21	0.046
MSIL	-0.105	-13.3	0.030*	14.3	0.022
NTPC	-0.027	-13.8	0.007*	16.2	0.028
ONGC	-0.061	-17.5	0.015*	19.2	0.039
PNB	-0.067	-19.1	0.020*	21.6	0.048
PWGR	-0.028	-16.5	0.007*	19.2	0.039
RBXY	-0.049	-26.1	0.015*	29.6	0.087
RELI	-0.135	-27.4	0.034*	29.7	0.088
RIL	-0.058	-19.4	0.014*	21	0.046
SBIN	-0.361	-4.3	0.087*	4.5	0.002
SESA	-0.481	-4.2	0.120*	4.5	0.002
SIEM	-0.021	-13.1	0.009*	16.8	0.03
SUNP	-0.044	-17.6	0.013*	19.9	0.041
TATA	-0.129	-18.5	0.030*	19.6	0.04
TCS	-0.058	-17.2	0.016*	18.7	0.037
TPWR	-0.106	-11.5	0.026*	12.6	0.017
TTMT	-0.292	-9.3	0.061*	9.8	0.01
UTCEM	-0.026	-9.6	0.011*	11.8	0.015
WPRO	-0.055	-18.6	0.015*	20.7	0.045

Notes: *Significant at 1% level.

Table A7. Contemporaneous relationship between volatility and spread

$$R_t^2 = \alpha_2 + \beta_2 S_t + u_t$$

Stock	α_2	t-statistics	β_2	t-statistics	R-squared
ACC	0.0033	8.7	4.4*	6.4	0.0044
ACEM	0.0035	8.0	6.0*	8.1	0.0070
APNT	0.0031	7.2	2.9*	4.3	0.0020
AXSB	-0.0399	-11.8	240.8*	92.4	0.4820
BHARATI	-0.0443	-27.5	174.2*	72.3	0.3633
BHEL	0.0060	7.7	7.6*	3.9	0.0017
BJAUT	0.0040	11.3	3.7*	4.6	0.0023
BOB	0.0060	6.7	4.0*	2.4	0.0006
BPCL	0.0028	3.8	8.1*	7.1	0.0055
CAIR	0.0032	5.0	5.7*	3.2	0.0011
CIPLA	-0.0766	-23.1	235.5*	75.2	0.3818
COAL	0.0086	25.6	-11.5*	-15.5	0.0254
DLFU	0.0099	9.2	2.6	1.0	0.0001
DRRD	0.0033	12.5	3.0*	6.9	0.0052
GAIL	0.0033	3.2	6.8*	4.1	0.0019
GRASIM	-0.0580	-39.5	97.8*	86.3	0.4487
HCLT	-0.0533	-24.6	173.7*	83.3	0.4309
HDFC	0.0034	8.7	6.0*	9.6	0.0100
HDFCB	0.0022	10.8	4.3*	7.0	0.0053
HMCL	0.0045	13.2	2.0*	3.0	0.0010
HNDL	0.0096	5.7	0.2	0.1	0.0000
HUVR	-0.0900	-33.8	387.7*	58.6	0.2726
ICICIBC	0.0086	8.5	-9.9*	-2.3	0.0006
IDFC	0.0059	4.3	9.5*	3.4	0.0013
INFO	0.0059	2.5	4.8	0.6	0.0000
ITC	0.0030	8.9	3.7*	3.6	0.0014
JPA	0.0096	3.0	8.9**	2.0	0.0004
JSP	0.0016	1.3	32.8*	11.9	0.0153
KMB	0.0045	9.5	3.0*	3.8	0.0016
LPC	0.0046	10.9	3.1*	3.6	0.0014
LT	0.0176	28.8	-55.9*	-41.1	0.1555
MM	0.0040	11.8	4.8*	5.1	0.0028
MSIL	0.0056	4.1	6.8**	2.0	0.0004
NTPC	-0.0016	-3.9	11.9*	16.6	0.0292
ONGC	0.0032	6.0	6.2*	5.1	0.0029
PNB	0.0077	10.8	0.9	0.7	0.0001
PWGR	0.0019	4.6	4.4*	6.6	0.0047
RBXY	0.0060	15.0	0.4	0.5	0.0000
RELI	0.0097	20.4	3.3*	5.3	0.0031
RIL	0.0039	11.0	3.3*	2.5	0.0007
SBIN	-0.0493	-10.3	382.9*	95.4	0.4981
SESA	-0.2398	-29.5	505.3*	94.3	0.4923
SIEM	0.0028	5.2	4.2*	6.2	0.0042
SUNP	0.0040	9.2	3.5*	3.8	0.0016
TATA	0.0032	3.7	17.3*	5.8	0.0036
TCS	-0.0018	-3.9	31.1*	21.2	0.0468
TPWR	0.0621	59.5	-79.0*	-70.9	0.3542
TTMT	0.0565	34.1	-159.8*	-87.6	0.4556
UTCEM	0.0019	2.3	6.4*	5.9	0.0037
WPRO	0.0039	7.5	5.3*	4.5	0.0022

Notes: *Significant at 1% level and **Significant at 5% level.

Table A8. Granger causality test between volatility and volume

	Volume does not Granger cause Volatility			Volatility does not Granger cause Volume			Lag
Stock	F-Stat	Prob.	Null Hypothesis	F-Stat	Prob.	Null Hypothesis	Length
ACC	24.0*	0.00	Rejected	6.7*	0.00	Rejected	5
ACEM	43.7*	0.00	Rejected	15.2*	0.00	Rejected	4
APNT	16.9*	0.00	Rejected	3.8*	0.00	Rejected	6
AXSB	0.9	0.56	Not Rejected	0.5	0.86	Not Rejected	10
BHARATI	1.5	0.20	Not Rejected	1.1	0.34	Not Rejected	5
BHEL	66.1*	0.00	Rejected	11.0*	0.00	Rejected	4
BJAUT	41.5*	0.00	Rejected	7.1*	0.00	Rejected	4
BOB	21.9*	0.00	Rejected	2.4**	0.05	Rejected	4
BPCL	21.5*	0.00	Rejected	2.8**	0.03	Rejected	4
CAIR	22.2*	0.00	Rejected	7.6*	0.00	Rejected	4
CIPLA	2.0***	0.06	Rejected	1	0.43	Not Rejected	6
COAL	27.4*	0.00	Rejected	4.3*	0.00	Rejected	5
DLFU	22.0*	0.00	Rejected	6.2*	0.00	Rejected	5
DRRD	41.4*	0.00	Rejected	5.4*	0.00	Rejected	4
GAIL	11.0*	0.00	Rejected	0.8	0.52	Not Rejected	4
GRASIM	0.6	0.84	Not Rejected	1	0.43	Not Rejected	10
HCLT	2.9*	0.01	Rejected	0.9	0.52	Not Rejected	6
HDFC	46.7*	0.00	Rejected	5.8*	0.00	Rejected	**3**
HDFCB	78.1*	0.00	Rejected	10.6*	0.00	Rejected	3
HMCL	46.9*	0.00	Rejected	7.1*	0.00	Rejected	4
HNDL	34.6*	0.00	Rejected	3.5*	0.01	Rejected	3
HUVR	1.2	0.32	Not Rejected	1.4	0.17	Not Rejected	9
ICICIBC	2.4**	0.04	Rejected	6.8*	0.00	Rejected	5
IDFC	18.8*	0.00	Rejected	3.6*	0.00	Rejected	5
INFO	10.2*	0.00	Rejected	0.6	0.63	Not Rejected	4
ITC	63.9*	0.00	Rejected	10.2*	0.00	Rejected	4
JPA	14.8*	0.00	Rejected	1.7	0.13	Not Rejected	5
JSP	24.8*	0.00	Rejected	3.2*	0.01	Rejected	5
KMB	12.8*	0.00	Rejected	2.1***	0.08	Rejected	4
LPC	23.2*	0.00	Rejected	3.9*	0.00	Rejected	5
LT	20.1*	0.00	Rejected	1.3	0.27	Not Rejected	3
MM	39.7*	0.00	Rejected	8.5*	0.00	Rejected	5
MSIL	12.6*	0.00	Rejected	0.4	0.85	Not Rejected	5
NTPC	32.2*	0.00	Rejected	4.2*	0.00	Rejected	5
ONGC	33.8*	0.00	Rejected	8.1*	0.00	Rejected	4
PNB	48.7*	0.00	Rejected	4.5*	0.00	Rejected	4
PWGR	42.6*	0.00	Rejected	9.3*	0.00	Rejected	4
RBXY	28.8*	0.00	Rejected	7.6*	0.00	Rejected	6
RELI	70.6*	0.00	Rejected	10.9*	0.00	Rejected	3
RIL	41.9*	0.00	Rejected	5.5*	0.00	Rejected	4
SBIN	1.1	0.39	Not Rejected	0.4	0.96	Not Rejected	11
SESA	0.5	0.93	Not Rejected	0.4	0.96	Not Rejected	12
SIEM	33.7*	0.00	Rejected	2.8**	0.02	Rejected	4
SUNP	29.9*	0.00	Rejected	6.4*	0.00	Rejected	4
TATA	48.6*	0.00	Rejected	3.5**	0.02	Rejected	3
TCS	26.0*	0.00	Rejected	2.8**	0.02	Rejected	4
TPWR	8.1*	0.00	Rejected	0.6	0.69	Not Rejected	5
TTMT	4.2*	0.00	Rejected	0.7	0.66	Not Rejected	5
UTCEM	14.9*	0.00	Rejected	2.0***	0.08	Rejected	5
WPRO	45.4*	0.00	Rejected	4.0*	0.00	Rejected	5

Notes: *Significant at 1% level, **Significant at 5% level and ***Significant at 10% level.

Table A9. Granger causality test between volatility and spread

	Spread does not Granger cause Volatility			Volatility does not Granger cause Spread			Lag
Stock	F-Stat	Prob.	Null Hypothesis	F-Stat	Prob.	Null Hypothesis	Length
ACC	6.8*	0.00	Rejected	2.02***	0.06	Rejected	6
ACEM	14.2*	0.00	Rejected	3.44*	0.00	Rejected	5
APNT	5.1*	0.00	Rejected	1.64	0.13	Not Rejected	6
AXSB	485.6*	0.00	Rejected	0.84	0.50	Not Rejected	4
BHARATI	1464.9*	0.00	Rejected	4.85*	0.01	Rejected	2
BHEL	22.1*	0.00	Rejected	0.40	0.75	Not Rejected	3
BJAUT	19.3*	0.00	Rejected	1.04	0.40	Not Rejected	7
BOB	8.7*	0.00	Rejected	0.40	0.81	Not Rejected	4
BPCL	9.0*	0.00	Rejected	0.86	0.50	Not Rejected	5
CAIR	6.7*	0.00	Rejected	2.51**	0.02	Rejected	6
CIPLA	969.4*	0.00	Rejected	4.29*	0.00	Rejected	4
COAL	66.1*	0.00	Rejected	7.86*	0.00	Rejected	3
DLFU	112.6*	0.00	Rejected	1.23	0.27	Not Rejected	1
DRRD	20.5*	0.00	Rejected	0.15	0.93	Not Rejected	3
GAIL	27.2*	0.00	Rejected	6.58*	0.00	Rejected	3
GRASIM	114.6*	0.00	Rejected	12.99*	0.00	Rejected	6
HCLT	313.1*	0.00	Rejected	7.69*	0.00	Rejected	6
HDFC	4.2*	0.00	Rejected	913.3*	0.00	Rejected	8
HDFCB	51.1*	0.00	Rejected	1.68	0.14	Not Rejected	5
HMCL	112.9*	0.00	Rejected	3.31*	0.019	Rejected	3
HNDL	14.8*	0.00	Rejected	0.57	0.45	Not Rejected	1
HUVR	40.8*	0.00	Rejected	9.64*	0.00	Rejected	8
ICICIBC	4.0*	0.01	Rejected	2.91**	0.03	Rejected	3
IDFC	95.8*	0.00	Rejected	5.11**	0.02	Rejected	1
INFO	0.9	0.49	Not Rejected	0.12	0.99	Not Rejected	5
ITC	15.6*	0.00	Rejected	0.41	0.87	Not Rejected	6
JPA	2.5*	0.01	Rejected	1.78***	0.08	Rejected	8
JSP	20.4*	0.00	Rejected	0.56	0.73	Not Rejected	5
KMB	16.1*	0.00	Rejected	9.69*	0.00	Rejected	5
LPC	7.7*	0.00	Rejected	1.70***	0.10	Rejected	7
LT	658.7*	0.00	Rejected	1.09	0.30	Not Rejected	1
MM	38.5*	0.00	Rejected	2.85**	0.02	Rejected	4
MSIL	10.3*	0.00	Rejected	1.07	0.38	Not Rejected	5
NTPC	23.1*	0.00	Rejected	2.99**	0.05	Rejected	2
ONGC	16.1*	0.00	Rejected	0.67	0.57	Not Rejected	3
PNB	24.1*	0.00	Rejected	0.83	0.43	Not Rejected	2
PWGR	25.2*	0.00	Rejected	2.03	0.11	Not Rejected	3
RBXY	7.2*	0.00	Rejected	0.53	0.81	Not Rejected	7
RELI	37.1*	0.00	Rejected	0.44	0.51	Not Rejected	1
RIL	24.3*	0.00	Rejected	0.16	0.92	Not Rejected	3
SBIN	420.7*	0.00	Rejected	0.18	0.95	Not Rejected	4
SESA	152.5*	0.00	Rejected	2.48**	0.02	Rejected	6
SIEM	12.4*	0.00	Rejected	0.65	0.69	Not Rejected	6
SUNP	22.6*	0.00	Rejected	0.72	0.61	Not Rejected	5
TATA	91.4*	0.00	Rejected	3.42***	0.06	Rejected	1
TCS	74.6*	0.00	Rejected	1.99***	0.06	Rejected	6
TPWR	513.2*	0.00	Rejected	9.66*	0.00	Rejected	2
TTMT	1148.9*	0.00	Rejected	1.04	0.35	Not Rejected	2
UTCEM	2.9*	0.00	Rejected	2.15**	0.04	Rejected	7
WPRO	15.6*	0.00	Rejected	0.96	0.44	Not Rejected	5

Notes: *Significant at 1% level, **Significant at 5% level and ***Significant at 10% level.