

The Dynamic Relationship between Stock Returns, Trading Volume and Volatility: Evidence from Indian Stock Market

Brajesh Kumar¹
Priyanka Singh²

Abstract

This paper empirically examines the relationship between returns, volatility and trading volume for 50 Indian stocks. Three measures of trading volume namely number of transactions, number of shares traded and value of shares traded are used. The contemporaneous correlation between returns and trading volume and asymmetric relation between level of trading volume and returns is examined. The dynamic relation as marked by lead-lag relationship is also investigated between the returns and volume. In case of volatility, the contemporaneous and asymmetric relation is examined between unconditional volatility and volume. The Mixture of Distributions Hypothesis (MDH), which tests the GARCH vs Volume effect, is also studied between the conditional volatility and volume. The evidence for positive contemporaneous relation between returns and volume as well as conditional and unconditional volatility and volume is found. We also find that the level of volume is dependent on the direction of price change only in case of 60% of the stocks in the sample. The results of VAR model, Granger causality, impulse response function and variance decomposition, indicate that in some stocks returns Granger cause trading volume, which is easily conceivable in the context of an emerging market where development of the market causes sequential information dissemination (Assogbavi, 2007). While analyzing the MDH, the results provide mixed conclusions, neither entirely rejecting the MDH nor giving it an unconditional support. Similar kind of result has been found by Ane and Ureche-Rangau (2008) in the context of MDH. It is also found that in Indian stock market, the number of transactions may be a better proxy of information than the number of shares traded and the value of shares traded.

Keywords: Trading volume, Volatility, Mixture of distributions hypothesis, GARCH, Granger Causality, VAR, Impulse response function, Variance decomposition

¹ Doctoral Student, Indian Institute of Management Ahmedabad, email: brajeshk@iimahd.ernet.in

² Doctoral Student, Indian Institute of Management Ahmedabad, email: priyankas@iimahd.ernet.in

The authors are thankful to Prof. Ajay Pandey, Indian Institute of Management Ahmedabad, for valuable guidance. We also thank the two anonymous referees for their comments on the proposal, which helped in improvising the research undertaken. The views expressed in this paper are that of authors and not necessarily of NSE.

The Dynamic Relationship between Stock Returns, Trading Volume and Volatility: Evidence from Indian Stock Market

1. Introduction

In financial economics, considerable attention has been given to understand the relationship between return, volatility and trading volume. As argued by Karpoff (1986, 1987), price-volume relationship is important because this empirical relationship helps in understanding the competing theories of dissemination of information flow into the market. This may also help in event (informational event/liquidity event) studies by improving the construction of test and its validity. This relationship is also critical in assessing the empirical distribution of returns as many financial models are based on an assumed distribution of return series.

There are extensive empirical studies which support the positive relationship between price, trading volume and volatility of a tradable asset (Crouch, 1970; Epps and Epps, 1976; Karpoff, 1986 1987, Assogbavi et al., 1995; Chen et al, 2000). Various theoretical models have been developed to explain the relationship between price and trading volume. These include sequential arrival of information models (Copeland, 1976; Morse, 1980 and Jennings and Barry, 1983), a mixture of distributions model (Clark, 1973; Epps and Epps, 1976; Tauchen and Pitts, 1983; and Harris, 1986 Lamoureux & Lastrapes, 1990) asymmetric information models (Kyle, 1985; Admati and Piederer, 1988), and differences in opinion models (Varian, 1985, 1989; Harris and Raviv, 1993). All these models advocate the positive relationship between price, trading volume and volatility. In a similar strand of literature, the asymmetric nature of volume response to return (volatility) i.e. the trading volume is higher in which price ticks up than volume on downtick, has been explained (Epps 1975; Karpoff 1987, 1988; Assogbavi et al., 1995). The asymmetric nature is explained through heterogeneous expectation model and costs involved in short selling. Recently, Henry and McKenzie (2006) examined the relationship between volume and volatility allowing for the impact of short sales for Hong-Kong market and found that the asymmetric bidirectional relationship exists between volatility and volume.

Other than positive contemporaneous relationship between returns and trading volume and asymmetric relationship between level of volume and price changes, recent studies also report bidirectional causality between returns and volume (Smirlock and Starks, 1988; Hiemstra and Jones, 1994; Bhagat and Bhatiya, 1996; Chen, Firth, and Rui, 2001; and Ratner and Leal; 2001). This dynamic relationship between returns and volume is explained by various theoretical models. These include models developed by Blume, Easley, and O'Hara (1994), Wang (1994), He and Wang (1995) and Chordia and Swaminathan (2000). Most of these models assume volume as a proxy for quality and precision of information. It is found that the information content of volume and sequential processing of information may lead to dynamic relationship between returns and trading volume. Blume, Easley, and O'Hara (1994) developed a model in which prices and volume of the past carry information about the value of security and explained that the traders who include past volume measures in their technical analysis performed better. Wang (1994) and He and Wang (1995) developed a model based on asymmetric information and showed that the trading volume is related to information flow in the market and investor's private information is revealed through trading volume. Chordia and Swaminathan (2000) also

examined the predictability of short-term stock returns based on trading volume and concluded that high volume stocks respond promptly to market-wide information.

Similar to returns and volume, considerable attention has also been given to understand the relationship between volatility and trading volume of an asset by the researchers. Most of the studies report the evidence of ARCH effects in the time series of returns. However, very few of them try to give the theoretical economic explanation of the autoregressive nature of conditional volatility. One of the possible theoretical explanations is the mixture of distributions hypothesis (Clark, 1973; Epps and Epps, 1976; Tauchen and Pitts, 1983; and Lamoureux and Lastrapes, 1990). The Mixture of distributions hypothesis (MDH) explains the positive relationship between price volatility and trading volume as they jointly depend on a common factor, information innovation. According to MDH, returns are generated by mixture of distribution and information arrival is the mixing variable. This mixing variable causes momentum in the squared residual of daily returns and hence autoregressive nature of the conditional volatility. As, information arrival is unobserved, trading volume is usually considered as a proxy of information flow into the market. Any unexpected information affects both volatility and volume contemporaneously and, therefore volatility and volume are hypothesized to be positively related.

While a fair amount of empirical evidence on the daily returns, volatility and volume relationship, asymmetric relationship between volume and price change, and mixed distribution hypothesis exists for developed countries, very few empirical studies have been reported from emerging markets and specifically from Indian stock market. This paper reports some empirical evidence on those issues for Indian Stock market which is an order driven continuous market. All the 50 stocks of S&P CNX Nifty, a value-weighted stock index of National Stock Exchange (www.nseindia.com), Mumbai, derived from prices of 50 large capitalization stocks, for the period of 1st January 2000 to 31st December 2008 are analyzed. We specifically address the following issues related to relationship between returns, volatility and trading volume in this paper.

- What kind of relationship exists between trading volume and returns? Is the relationship asymmetric in nature?
- Do trading volume and returns exhibit dynamic relationship? If yes then, what is direction and extent of relationship between these variables?
- What kind of relationship exists between trading volume and price volatility (unconditional)? Is the relationship asymmetric in nature?
- Does there exist ARCH effects in the stock returns? If yes then, is this ARCH effects diminished or reduced when trading volume is incorporated as an explanatory variable in the GARCH equation?

The remainder of this paper is organized as follows. A brief review of empirical literature is given in section 2. Section 3 explains the sample and basic characteristics of the data. The empirical models of the contemporaneous and dynamic relationship between returns and trading volume, and models of the mixture of distributions hypothesis are explained in section 4. Section 5 discusses the empirical findings and the last section summarizes them and gives a conclusion.

2. Literature on Relationship among Returns, Trading Volume and Volatility

There have been number of empirical studies in developed markets that provide evidence on the relationship between trading volume and stock returns. Crouch (1970) studied the relationship between daily trading volume and daily absolute changes of market index and individual stocks and found positive correlation between them. Rogalski (1978) used monthly stock data and Epps (1975, 1977) used transactions data and found a positive contemporaneous correlation between trading volume and absolute returns. In an emerging market context, Brailsford (1996) for the Australian stock market, Saatcioglu and Starks (1998) for Latin America stock market found a positive contemporaneous relationship between absolute returns and volatility. Smirlock and Starks (1988) analyzed the dynamic relationship between trading volume and returns using individual stock transactions data and found a positive lagged relation between volume and absolute price changes. Using nonlinear Granger causality test, Hiemstra and Jones (1994) analyzed the bidirectional causality between trading volume and returns for New York Stock Exchange and found support for positive bidirectional causality between them. However, Bhagat and Bhatia (1996) found strong one-directional causality running from price changes to trading volume while analyzing the lead-lag relationship between trading volume and volatility using Granger causality test. Moosa and Al-Loughani (1995) examined the dynamic relationship between price and volume for four Asian stock markets excluding India and found a strong evidence for bi-directional causality for Malaysia, Singapore, and Thailand. Assogbavi (2007) used vector auto-regression model to analyze dynamic relationship between returns and trading volume using weekly data of individual equities of the Russian Stock Exchange. They found a strong evidence of bi-directional relationship between volume and returns.

The relationship between stock return volatility and trading volume has also been analyzed in several studies. Harris (1987) used the number of transactions as a measure of volume and found a positive correlation between changes in volume and changes in squared returns for individual NYSE stocks. In the U.S. stock market, Andersen (1996), Gallo and Pacini (2000), Kim and Kon (1994), and Lamoureux and Lastrapes (1990, 1994) found support for the MDH. In emerging markets context, Pyun et al. (2000) investigated 15 individual shares of the Korean stock market, Brailsford (1996) analyzed the effect of information arrivals on volatility persistence in the Australian stock market and Lange (1999) for the small Vancouver stock exchange. All of them found support for the mixed distribution hypothesis. Wang et al. (2005) examined the Chinese stock market and investigated the dynamic causal relation between stock return volatility and trading volume. They found support for the MDH as the inclusion of trading volume in the GARCH specification of volatility reduced the persistence of the conditional variance. In general, most of empirical studies in the developed and developing market context have found evidence that the inclusion of trading volume in GARCH models for volatility results in reduction of the estimated persistence or even causes it to vanish. However, Huang and Yang (2001) for the Taiwan Stock Market and Ahmed et al. (2005) for the Kuala Lumpur Stock Exchange found that the persistence in return volatility remains even after volume is included in the conditional variance equation.

The relationship between volume and volatility has also been studied in the market microstructure strand of literature. However, the results are not consistent. For example, the model of Admati and Pfleiderer (1988) which assumes three kinds of traders, informed traders

who trade on information, discretionary liquidity traders who can choose the time they want to trade but must satisfy their liquidity demands before the end of the trading day, and non discretionary traders who transact due to the reasons exogenous at a specific time and don't have the flexibility of choosing the trade time, supports the positive relationship between volatility and trading volume. On the other hand Foster and Viswanathan (1990) model suggests that this relationship does not necessarily follow even when they use the same classification of traders as used by Admati and Pfleiderer.

Another very important issue that has been addressed by researchers is the measurement of trading volume. Generally, three kinds of measures, namely, number of trades, volume of trade or total dollar value of trades have been used as a proxy of volume. The theoretical models of the past did not support the effect of trade size in the volatility volume relationship. However, recent models consider the effect of trade size on the volume volatility relationship but contradictory results. On one hand, some models (Grundy and McNichols, 1989; Holthausen and Verrecchia, 1990; Kim and Verrecchia, 1991) show that informed traders prefer to trade large amounts at any given price and hence size is positively related to the quality of information and is therefore correlated with price volatility. On the other hand, some other models (Kyle, 1985; Admati and Pfleiderer, 1988) indicate that a monopolist informed trader may disguise his trading activity by splitting one large trade into several small trades. Thus trade size may not necessarily convey adverse information.

Given the mixed results between price and trading volume especially in emerging markets context, some additional results from other emerging financial markets are needed to better understand the price-volume relationship. Very few studies have examined the price-volume relationship in Indian market. This paper represents one such attempt to investigate returns, volatility and trading volume relationship in Indian Stock market.

2. The Sample and its Characteristics

In this study our data set consists of all the stocks of S&P CNX Nifty Index. S&P CNX Nifty is a well diversified 50 stock index accounting for 21 sectors of the Indian economy. Table 1 provides the list of these companies, industry type and the period considered in the analysis. Data has been collected for the period of 1st January 2000 to 31st December 2008. For companies that were listed after 1st January 2000, the data has been taken from the listing date to 31st December 2008. The data set consists of 82674 data points of adjusted daily closing prices and three different measures of daily volume (number of transactions, number of shares traded and total value of shares). The daily adjusted closing prices have been used for estimating daily returns.

The percentage return of the stock is defined as $R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \times 100$, where, R_t is logarithmic daily percentage return at time t and P_{t-1} and P_t are daily price of an asset on two successive days $t-1$ and t respectively. Table 2 presents the basic statistics relating to the returns and the squared returns of each stock in the sample.

Table 1: List of Constituents of S&P CNX Nifty

This table provides the list of constituents of 50 large capitalization stocks of S&P CNX Nifty, a value-weighted stock index of National Stock Exchange, Mumbai. Their industry type and data period are also presented.

Company Name	Symbol	Industry	Data Period
ABB Ltd.	ABB	ELECTRICAL EQUIPMENT	Jan 2000 to Dec 2008
ACC Ltd.	ACC	CEMENT AND CEMENT PRODUCTS	Jan 2000 to Dec 2008
Ambuja Cements Ltd.	AMBUJA	CEMENT AND CEMENT PRODUCTS	Jan 2000 to Dec 2008
Bharat Heavy Electricals Ltd.	BHEL	ELECTRICAL EQUIPMENT	Jan 2000 to Dec 2008
Bharat Petroleum Corporation Ltd.	BPCL	REFINERIES	Jan 2000 to Dec 2008
Bharti Airtel Ltd.	BHARTI	TELECOMMUNICATION - SERVICES	Feb 2002 to Dec 2008
Cairn India Ltd.	CAIRN	OIL EXPLORATION/PRODUCTION	Jan 2000 to Dec 2008
Cipla Ltd.	CIPLA	PHARMACEUTICALS	Jan 2000 to Dec 2008
DLF Ltd.	DLF	CONSTRUCTION	Jul 2007 to Dec 2008
GAIL (India) Ltd.	GAIL	GAS	Jan 2000 to Dec 2008
Grasim Industries Ltd.	GRASIM	CEMENT AND CEMENT PRODUCTS	Jan 2000 to Dec 2008
HCL Technologies Ltd.	HCL	COMPUTERS - SOFTWARE	Jan 2000 to Dec 2008
HDFC Bank Ltd.	HDFC	BANKS	Jan 2000 to Dec 2008
Hero Honda Motors Ltd.	HONDA	AUTOMOBILES - 2 AND 3 WHEELERS	Jan 2000 to Dec 2008
Hindalco Industries Ltd.	HINDALCO	ALUMINIUM	Jan 2000 to Dec 2008
Hindustan Unilever Ltd.	HLL	DIVERSIFIED	Jan 2000 to Dec 2008
Housing Development Finance Corporation Ltd.	HDFCORP	FINANCE - HOUSING	Jan 2000 to Dec 2008
I T C Ltd.	ITC	CIGARETTES	Jan 2000 to Dec 2008
ICICI Bank Ltd.	ICICI	BANKS	Jan 2000 to Dec 2008
Idea Cellular Ltd.	IDEA	TELECOMMUNICATION - SERVICES	Mar 2007 to Dec 2008
Infosys Technologies Ltd.	INFOSYS	COMPUTERS - SOFTWARE	Jan 2000 to Dec 2008
Larsen & Toubro Ltd.	L&T	ENGINEERING	Jan 2000 to Dec 2008
Mahindra & Mahindra Ltd.	M&M	AUTOMOBILES - 4 WHEELERS	Jan 2000 to Dec 2008
Maruti Suzuki India Ltd.	MARUTI	AUTOMOBILES - 4 WHEELERS	Jul 2003 to Dec 2008
NTPC Ltd.	NTPC	POWER	Nov 2004 to Dec 2008
National Aluminium Co. Ltd.	NALCO	ALUMINIUM	Jan 2000 to Dec 2008
Oil & Natural Gas Corporation Ltd.	ONGC	OIL EXPLORATION/PRODUCTION	Jan 2000 to Dec 2008
Power Grid Corporation of India Ltd.	POWER&G	POWER	Oct 2007 to Dec 2008
Punjab National Bank	PNB	BANKS	Apr 2002 to Dec 2008
Ranbaxy Laboratories Ltd.	RANBAXY	PHARMACEUTICALS	Jan 2000 to Dec 2008
Reliance Communications Ltd.	RCOMM	TELECOMMUNICATION - SERVICES	Jul 2006 to Dec 2008
Reliance Industries Ltd.	RELIANC	REFINERIES	Jan 2000 to Dec 2008
Reliance Infrastructure Ltd.	RINFRA	POWER	Jan 2000 to Dec 2008
Reliance Petroleum Ltd.	RPETRO	REFINERIES	May 2006 to Dec 2008
Reliance Power Ltd.	RPOWER	POWER	Feb 2008 to Dec 2008
Satyam Computer Services Ltd.	SATYAM	COMPUTERS - SOFTWARE	Jan 2000 to Dec 2008
Siemens Ltd.	SIEMENS	ELECTRICAL EQUIPMENT	Jan 2000 to Dec 2008
State Bank of India	SBI	BANKS	Jan 2000 to Dec 2008
Steel Authority of India Ltd.	SAIL	STEEL AND STEEL PRODUCTS	Jan 2000 to Dec 2008
Sterlite Industries (India) Ltd.	STERLIT	METALS	Jan 2000 to Dec 2008
Sun Pharmaceutical Industries Ltd.	SUNPHAR	PHARMACEUTICALS	Jan 2000 to Dec 2008
Suzlon Energy Ltd.	SUZLON	ELECTRICAL EQUIPMENT	Oct 2005 to Dec 2008
Tata Communications Ltd.	TATACOM	TELECOMMUNICATION - SERVICES	Jan 2000 to Dec 2008
Tata Consultancy Services Ltd.	TCS	COMPUTERS - SOFTWARE	Aug 2004 to Dec 2008
Tata Motors Ltd.	TATAMOT	AUTOMOBILES - 4 WHEELERS	Jan 2000 to Dec 2008
Tata Power Co. Ltd.	TATAPOW	POWER	Jan 2000 to Dec 2008
Tata Steel Ltd.	TATASTE	STEEL AND STEEL PRODUCTS	Jan 2000 to Dec 2008
Unitech Ltd.	UNITECH	CONSTRUCTION	Jan 2000 to Dec 2008
Wipro Ltd.	WIPRO	COMPUTERS - SOFTWARE	Jan 2000 to Dec 2008
Zee Entertainment Enterprises Ltd.	ZEE	MEDIA & ENTERTAINMENT	Jan 2000 to Dec 2008

Table 2: Sample Summary Statistics of Return and Return²

This table provides descriptive statistics for return and return² of all constituents companies of NIFTY: Symbol; Mean, Standard Deviation, Skewness, and Kurtosis over the period from January 2000 through December 2008.

Company	N	Mean	SD	Return		Mean	SD	Return ²	
				Skewness	Kurtosis			Skewness	Kurtosis
ABB	2251	0.095	2.428	-0.313	4.311	0.059	0.147	8.875	140.915
ACC	2252	0.026	2.714	-0.368	3.840	0.074	0.178	7.828	95.368
AMBUJA	2251	0.020	2.497	-0.055	2.639	0.062	0.134	4.824	31.722
BHARTI	1720	0.162	2.762	0.355	2.601	0.077	0.165	6.441	63.474
BHEL	2251	0.111	2.927	-0.169	3.706	0.086	0.204	9.717	185.074
BPCL	2251	0.028	3.074	-0.107	3.577	0.094	0.223	8.960	147.877
CIPLA	2251	0.020	2.354	-0.292	4.327	0.055	0.139	6.947	72.852
CAIRN	489	0.046	3.603	-0.633	4.360	0.130	0.325	7.227	70.480
DLF	544	-0.129	5.839	5.194	74.871	0.341	2.964	22.445	515.794
GAIL	2250	0.049	3.007	-1.110	22.117	0.090	0.443	26.301	872.561
GRASIM	2251	0.045	2.571	-0.137	3.482	0.066	0.155	5.805	44.921
HCL	2246	-0.055	3.844	-0.368	3.256	0.148	0.339	5.697	43.596
HDFC	2252	0.077	2.447	0.123	8.382	0.060	0.193	16.891	413.665
HDFCORP	2251	0.101	2.594	0.230	3.489	0.067	0.158	6.740	73.649
HINDALC	2251	-0.016	2.635	-0.404	5.240	0.069	0.187	9.078	125.359
HLL	2252	0.002	2.219	0.048	3.345	0.049	0.114	8.583	139.917
HONDA	2251	0.054	2.518	0.237	2.561	0.063	0.136	6.705	77.248
ICICI	2251	0.079	3.249	-0.033	3.798	0.106	0.254	7.001	80.119
IDEA	449	-0.108	3.479	-0.198	2.453	0.121	0.255	4.409	23.217
INFOSYS	2252	0.006	3.020	-0.616	7.784	0.091	0.285	19.167	590.222
ITC	2251	0.057	2.275	0.005	3.002	0.052	0.116	4.914	30.288
L&T	2227	0.011	3.199	-5.260	108.311	0.102	1.073	42.884	1933.382
M&M	2252	0.009	2.988	-0.178	4.021	0.089	0.219	7.747	98.052
MARUTI	1373	0.084	2.639	-0.005	2.006	0.070	0.139	4.925	33.410
NALCO	2251	0.047	3.290	-0.252	5.295	0.108	0.292	9.618	149.576
NTPC	1034	0.084	2.362	-0.138	4.151	0.056	0.138	7.792	95.744
ONGC	2251	0.069	2.570	0.025	5.201	0.066	0.177	9.780	142.111
PNB	1673	0.158	3.136	-0.121	4.084	0.099	0.242	10.026	157.137
POWER&G	305	-0.062	3.588	-0.515	3.494	0.128	0.300	6.379	53.452
RANBAXY	2251	-0.009	2.535	-0.381	5.377	0.064	0.174	8.995	133.088
RCOMM	702	-0.035	3.756	-0.535	5.178	0.141	0.377	7.459	78.859
RELIANC	2252	0.070	2.546	-0.931	11.762	0.065	0.239	21.938	699.775
RPOWER	216	-0.308	4.024	0.326	1.671	0.162	0.304	5.873	51.373
RINFRA	2251	0.047	3.233	-0.533	8.719	0.105	0.341	11.798	221.447
RPETRO	658	0.003	3.168	-0.733	7.056	0.100	0.301	7.936	79.429
SAIL	2251	0.078	3.671	0.330	4.708	0.135	0.349	7.651	92.106
SATYAM	2252	-0.015	3.672	-0.454	6.004	0.135	0.381	18.550	573.982
SBI	2252	0.077	2.533	-0.290	3.051	0.064	0.144	6.803	75.823
SIEMENS	2251	0.073	2.690	-0.061	4.312	0.072	0.181	7.433	90.187
STERLIT	2131	0.058	6.206	-22.682	825.253	0.385	11.057	46.102	2127.278
SUNPHAR	2251	0.086	2.588	0.121	3.052	0.067	0.151	4.619	27.179
SUZLON	795	-0.100	4.396	-1.827	21.858	0.193	0.944	22.663	584.854
TATACOM	2251	-0.012	3.599	-0.803	13.167	0.129	0.504	26.604	980.581
TATAMOT	2251	-0.012	2.935	-0.379	2.780	0.086	0.188	6.458	67.960
TATAPOW	2252	0.101	2.973	-0.178	5.581	0.088	0.243	8.767	116.384
TATASTE	2252	0.034	2.978	-0.416	3.340	0.089	0.204	6.239	55.549
TCS	1085	-0.003	2.355	-0.186	3.444	0.055	0.129	5.245	36.135
UNITECH	2021	0.237	4.536	-1.778	33.203	0.206	1.213	38.556	1621.010
WIPRO	2252	-0.031	3.581	-0.160	4.276	0.128	0.321	6.197	52.582
ZEE	2252	-0.095	3.916	-0.445	5.088	0.153	0.409	11.943	254.012

The statistics from Table 2 show that most of the stock returns are negatively skewed during the period, although the skewness statistics are not large. The negative skewness implies that there is higher probability of earning negative returns. These stock returns also show higher kurtosis (>3). This implies that the distribution of returns have fat tails compared to the normal distribution. In squared return series the kurtosis is much higher than three. This implies fat tails in volatility and is an indicator of ARCH effect.

Given the multiple possible measures of trading volume and the inconsistent results from previous research, we have employed three different measures of trading volume:

- The daily number of equity traded or daily number of transactions (trade);
- The daily number of shares traded (volume);
- The daily total value of shares traded (value).

Table 3 presents the year wise description of average daily measurement of volume of the constituents of NIFTY stocks on each of three measures. Table 4 reports the basic statistics relating to the three measures of trading volume of each stock. For the sample period, the average daily number of transactions of Nifty stocks was around 7025 with around 0.84 million of traded shares. The average value of share traded per day was around Rs. 319.3 million.

Table 3: Year wise description of average daily measurements of trading volume of Nifty stocks

This table provides the yearly estimates of three measures of daily volume i.e, Number of transactions, Number of shares traded and Value of shares for the data period.

Year	N	Number of transaction (Trade)	Number of shares traded (Volume)	Value of shares traded (Value) (Rs. Million)
2000	9113	5608.5	956429.6	525.0
2001	9087	6239.6	923933.9	286.4
2002	9512	4352.1	594220.5	161.2
2003	10000	5238.1	902284.3	217.9
2004	10260	7332.0	1014290.3	333.5
2005	10592	4026.9	596276.1	236.3
2006	11120	6473.6	660513.6	313.2
2007	11833	7596.8	763866.5	348.8
2008	12436	14310.35	1144107	430.8

Table 5 presents the Pearson correlation between the three measures of daily trading volume. The three measures of volume are closely related. For most of the companies we found high correlation between all the three measures of volume: the number of shares traded, the value of trades, and number of transactions (more than 0.8). The measures of trading volume have been standardized for further analysis. The stationarity of the returns, squared returns and all three

standardized measures of volume is tested using Augmented Dickey-Fuller (1979) test. The results confirm that all series used in our sample are stationary³.

Table 4: Sample Summary Statistics of Value, Volume and Trade

This table provides basic Summary Statistics of daily trading volume. Daily trading volume is measured in three ways: the daily total value of shares traded (value), the daily number of shares traded (volume) and the daily number of equity trades (trade). The mean, standard deviation, skewness and kurtosis of standardized value of value, volume and trade are presented.

Company	N	Value				Volume				Trade			
		Mean	SD	Skew	Kurtosis	Mean	SD	Skew	Kurtosis	Mean	SD	Skew	Kurtosis
ABB	2005	3.74	6.53	4.26	29.28	35451.45	55731.48	4.89	38.93	1029.04	1471.66	3.42	18.59
ACC	2006	22.99	26.37	3.53	23.53	878988.10	1233818.85	3.39	15.46	5879.72	4602.28	1.75	4.50
AMBUJA	2005	10.35	37.52	20.47	482.80	728747.17	2993375.17	19.75	446.34	2832.16	2661.72	2.86	13.39
BHARTI	1474	23.47	83.35	20.85	534.72	767458.16	3743614.29	23.93	630.59	4492.28	4787.61	2.48	9.58
BHEL	2005	19.67	24.52	2.96	13.70	360201.88	534149.26	4.94	36.66	5365.15	7137.97	3.57	17.51
BPCL	2005	8.33	11.87	4.59	33.34	279488.88	433194.20	5.67	52.85	2537.74	3192.89	4.47	33.82
CIPLA	2005	8.43	10.39	4.76	38.27	222584.94	329762.41	5.96	77.07	3082.61	3180.56	4.99	60.40
CAIRN	243	29.34	38.59	3.85	19.08	1386952.18	1411329.80	2.80	10.02	11166.57	12281.76	3.24	13.97
DLF	298	85.51	57.75	3.04	17.01	1648922.88	1457564.28	2.63	9.46	29083.34	19129.31	1.72	4.39
GAIL	2004	9.41	17.54	4.40	25.07	419829.28	767146.78	4.31	23.53	3191.10	5118.45	3.88	19.80
GRASIM	2005	8.89	9.62	3.41	21.68	134660.54	238392.66	4.77	29.22	1994.68	1744.25	2.51	9.65
HCL	2000	11.30	14.91	3.59	18.32	396505.73	746944.48	6.51	69.23	3916.33	5496.71	4.63	35.03
HDFC	2006	10.42	37.23	17.50	368.86	168999.76	604985.22	17.03	323.05	1804.83	2733.53	4.09	18.92
HDFCORP	2005	18.87	53.38	12.07	191.72	176226.03	515674.58	15.43	301.22	2162.18	3507.99	4.64	26.66
HINDALC	2005	11.03	14.12	3.58	22.45	563649.47	1146765.39	6.94	89.59	3592.06	4957.97	3.60	21.56
HLL	2006	17.86	18.53	3.81	25.05	823898.03	866183.36	4.28	33.37	4556.28	3282.28	2.74	15.23
HONDA	2005	6.74	8.79	4.09	25.64	141002.24	175686.70	3.16	14.63	1877.00	1838.22	2.86	13.22
ICICI	2005	27.75	58.18	8.34	140.64	596030.80	2425773.21	35.45	1485.36	6851.40	13230.94	4.72	31.85
IDEA	203	21.63	24.19	3.07	13.42	2079519.70	2355836.12	3.55	17.20	9713.33	7634.24	2.59	9.87
INFOSYS	2006	119.46	124.47	3.00	11.85	328460.86	219980.48	2.52	11.82	14481.96	9026.58	1.71	5.88
ITC	2005	23.61	25.34	3.29	16.43	681104.58	867784.29	2.77	11.31	5114.87	4193.46	2.20	7.70
L&T	1981	40.07	46.26	2.75	13.02	673051.52	988466.78	3.46	15.36	8760.43	9983.06	2.98	11.96
M&M	2006	10.91	13.49	6.15	94.07	314364.89	393258.30	5.31	48.62	2968.94	2365.46	2.42	9.54
MARUTI	1127	44.74	48.95	2.27	6.04	941812.17	1186215.37	2.17	5.51	10149.56	9754.84	2.02	4.35
NALCO	2005	3.34	4.45	5.39	74.39	190747.27	287505.20	12.64	332.22	1645.60	1860.91	2.50	12.85
NTPC	788	26.59	30.25	2.75	9.88	1774449.62	1878713.66	3.87	27.71	9513.87	9539.89	2.10	5.86
ONGC	2005	25.54	38.74	7.38	119.98	309834.52	451538.81	7.40	124.28	5333.25	5779.40	2.08	7.28
PNB	1427	11.34	12.55	4.55	40.51	418256.72	589642.56	4.28	29.26	4171.15	3949.89	2.81	14.06
POWER&G	59	42.41	78.87	4.30	22.33	3528412.82	6201691.80	4.72	26.89	20179.14	27122.61	3.84	18.66
RANBAXY	2005	23.80	33.18	6.91	89.99	409201.59	598897.49	7.65	101.44	5471.11	6810.49	8.38	125.46
RCOMM	456	97.40	68.69	2.78	12.10	2311692.31	1551220.51	2.25	8.91	28595.06	17815.64	2.64	17.29
RELIANC	2006	159.73	149.75	6.70	103.15	2611330.65	2569210.70	4.17	35.53	21326.52	17752.69	3.38	17.89
RPOWER		43.55	71.80	5.13	29.24	1687040.33	4777774.38	6.01	38.41	18220.00	34596.65	5.53	33.02
RINFRA	2005	34.22	76.97	4.32	24.89	427554.55	719914.60	5.25	65.98	8140.61	15658.96	2.94	9.76
RPETRO	412	104.67	160.09	4.59	35.57	6520920.44	7370820.46	3.10	18.53	39399.63	43571.68	2.18	9.42
SAIL	2005	22.62	28.84	2.45	10.70	3803178.49	5196293.87	3.46	19.50	8446.00	9036.99	1.77	6.26
SATYAM	2006	139.13	164.92	2.36	6.52	3576395.12	4044647.85	2.37	9.26	21367.27	17282.18	4.55	49.80
SBI	2006	66.37	57.44	1.26	2.43	1076105.38	978484.62	1.91	5.18	12092.54	11051.33	2.24	7.32
SIEMENS	2005	6.67	13.66	6.62	71.86	69587.82	124093.60	7.98	114.58	1818.98	3120.26	5.48	53.96
STERLIT	1885	19.82	37.44	4.70	32.85	354466.84	550069.40	2.69	9.41	4694.99	6760.16	2.75	11.06
SUNPHAR	2005	3.05	6.72	10.88	168.79	38902.14	80519.61	14.27	327.97	726.75	763.74	3.48	24.06
SUZLON	549	43.12	37.18	2.31	8.21	1777182.89	4357273.51	4.37	21.83	15161.21	19072.08	2.96	11.54
TATACOM	2005	10.33	21.17	5.94	55.14	291456.74	530506.55	5.34	43.99	3156.20	4220.57	3.92	24.94

³ Results of the Augmented Dickey-Fuller (1979) test on the returns, squared returns, and standardized measures of volume (Number of transactions, Number of shares traded and Value of trades) can be obtained from authors on request.

TATAMOT	2005	30.88	37.74	2.87	13.11	881526.29	954301.10	2.75	11.39	6616.81	5654.44	2.18	6.95
TATAPOW	2006	12.08	19.50	6.53	88.38	365480.22	563410.08	3.87	20.44	3839.11	4629.52	3.18	17.37
TATASTE	2006	62.33	60.79	1.81	5.22	1835355.03	1586852.39	1.88	4.94	15284.43	13244.27	1.67	3.94
TCS	839	33.08	50.02	12.47	201.75	291734.72	432902.45	12.60	212.48	7335.67	5070.67	2.61	12.25
UNITECH	1775	14.94	30.55	3.83	27.95	836164.22	3218366.11	7.57	65.05	6393.04	12930.64	3.09	13.37
WIPRO	2006	45.23	60.64	2.54	7.15	347324.16	318408.38	4.71	52.28	10688.26	9723.47	1.87	4.07
ZEE	2006	66.60	124.68	2.93	8.90	2496313.24	3265417.64	2.59	9.82	12859.34	12288.60	1.48	2.03

Table 5: Pearson Correlation between Measures of Daily Trading Volume

This table presents the Pearson Correlation between Measures of Daily Trading Volume namely Number of Transactions, Traded Quantity and Turnover for the whole period.

Company	Number of Transactions and Traded Quantity	Number of Transactions and Turnover	Traded Quantity and Turnover
ABB	0.75	0.80	0.70
ACC	0.74	0.85	0.72
AMBUJA	0.27	0.29	0.96
BHARTI	0.30	0.39	0.93
BHEL	0.36	0.91	0.35
BPCL	0.95	0.91	0.94
CIPLA	0.81	0.85	0.76
CAIRN	0.89	0.95	0.95
DLF	0.95	0.70	0.75
GAIL	0.94	0.92	0.95
GRASIM	0.82	0.77	0.72
HCL	0.94	0.80	0.86
HDFC	0.14	0.26	0.92
HDFCORP	0.16	0.27	0.84
HINDALC	0.89	0.84	0.80
HLL	0.74	0.77	0.87
HONDA	0.79	0.59	0.86
ICICI	0.33	0.72	0.76
IDEA	0.75	0.78	0.97
INFOSYS	0.83	0.76	0.73
ITC	0.81	0.66	0.58
L&T	0.36	0.83	0.41
M&M	0.79	0.69	0.75
MARUTI	0.96	0.95	0.93
NALCO	0.66	0.81	0.87
NTPC	0.70	0.87	0.83
ONGC	0.74	0.69	0.96
PNB	0.90	0.88	0.82
POWER&G	0.98	0.99	0.99
RANBAXY	0.90	0.81	0.92
RCOMM	0.82	0.72	0.76
RELIANC	0.27	0.62	0.68
RPOWER	0.99	0.97	0.97
RINFRA	0.80	0.87	0.82
RPETRO	0.97	0.94	0.96
SAIL	0.65	0.89	0.77
SATYAM	0.89	0.61	0.63
SBI	0.48	0.84	0.68
SIEMENS	0.86	0.86	0.72
STERLIT	0.91	0.77	0.85

SUNPHAR	0.39	0.39	0.89
SUZLON	0.91	0.70	0.56
TATACOM	0.91	0.89	0.97
TATAMOT	0.82	0.89	0.77
TATAPOW	0.81	0.88	0.71
TATASTE	0.70	0.79	0.84
TCS	0.43	0.37	0.97
UNITECH	0.80	0.81	0.54
WIPRO	0.75	0.85	0.73
ZEE	0.92	0.78	0.75

3. Models for Investigating Empirical Relationships among Returns, Volume and Volatility

The study reported in this paper investigates relationship between trading volume and return, its asymmetric nature, and dynamic relationship using OLS and VAR modeling approach. The relationship between volume and unconditional volatility and its asymmetric effect is investigated using OLS. We also test the mixed distribution hypothesis (MDH) using GARCH model in which contemporary volume is used as an explanatory variable in the GARCH specification.

3.1 Trading Volume and Stock Price Changes

The relationship between trading volume and returns and asymmetric nature is usually investigated through estimating contemporaneous correlation between absolute returns and trading volume by using OLS equation as follows (Brailsford, 1996):

$$V_t = \alpha + \beta_1|r_t| + \beta_2D_t|r_t| \quad [1]$$

where, V_t = standardized trading volume at time t , r_t is the return at time t and $D_t=1$ when $r_t < 0$ and $D_t=0$ when $r_t \geq 0$. Three alternative measures of trading volume, daily total value of shares traded (value), daily number of shares traded (volume) and daily number of equity trades (trade) have been used in the equation as the dependent variable. The parameter β_1 measures the partial correlation between returns and volume irrespective of the direction of return. The parameter β_2 captures the asymmetry in the relationship. A statistically significant negative value of β_2 would indicate that the relation between return and trading volume for negative returns is smaller than for positive returns.

3.2 Causal Relation between Trading Volume and Stock Price Changes

The dynamic relationship between returns and trading volume is estimated using bivariate VAR model in which returns and trading volume are used as endogenous variables. Similar approach has been In this case also three alternative measures of trading volume, daily value of trades, daily number of shares and daily number of transactions have been used.

$$\begin{aligned}
r_t &= \alpha_0 + \sum_{i=1}^5 \alpha_i r_{t-i} + \sum_{j=1}^5 \beta_j V_{t-j} \\
V_t &= \gamma_0 + \sum_{i=1}^5 \gamma_i V_{t-i} + \sum_{j=1}^5 \delta_j r_{t-j}
\end{aligned}
\tag{2}$$

The coefficients α_i and β_j represents the effect of lagged returns and lagged volume on the present returns. If $\beta_j=0$ then it can be concluded that volume does not cause returns. Similarly, γ_i and δ_j represents the effect of lagged volume and lagged return on the present volume. The significance of the parameters δ_j indicates that the causality runs from returns to volume. If both parameters β and δ are significant then there exists bi-directional causal relation between returns and trading volume. We report both Granger Causality test and VAR parameter estimates to understand the dynamic relationship between volume and returns. We also investigate the dynamic relationship between returns and volume through impulse response function and variance decomposition techniques.

3.2.1 Impulse Response Function and Variance Decomposition of Returns and Trading Volume

One of the well established methods of VAR analysis is the impulse-response function, which simulates the effects of a shock to one variable in the system on the conditional forecast of another variable (Sims, 1972, 1980; Abdullah and Rangazas, 1988). It explains the impact of an exogenous shock in one variable on the other variables of the system. We use the impulse-response function to analyze the impact of change in prices on volume and vice versa.

Under the VAR representation, the variance decomposition explains the relative impact of one variable on another variable. This analysis measures the percentage of the forecast error of one endogenous variable that is explained by other variables.

3.3 Trading Volume and Unconditional Volatility

The relationship between trading volume and unconditional volatility and its asymmetric nature are estimated through contemporaneous correlation between trading volume and squared returns. The OLS regression used are as follows:

$$V_t = \alpha + \beta_1 r_t^2 + \beta_2 D_t r_t^2,$$
[3]

where V_t = standardized trading volume at time t, r_t is the return at time t and $D_t=1$ when $r_t < 0$ and $D_t=0$ when $r_t \geq 0$. As explained in section 3.1 the parameter β_1 captures the correlation between squared returns and volume and β_2 the asymmetric relationship. The significant and negative value of the parameter β_2 would indicate that the correlation between unconditional volatility (r^2) and volume would be lesser for negative returns than positive returns.

3.4. Trading Volume and Conditional Volatility

The conditional volatility of the returns is measured through GARCH model developed by Bollerslev (1986). Let r_t is the return at time t. The GARCH (1,1) model is given by:

$$\begin{aligned}
r_t &= a + \sum_{i=1}^5 b_i r_{t-i} + \varepsilon_t \\
\varepsilon_t | \psi_{t-1} &\sim N(0, \sigma_t^2) \text{ and} \\
\sigma_t^2 &= \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2.
\end{aligned} \tag{4}$$

The parameters α and β measure the dependence of present volatility (σ^2) on innovation term (ε_{t-i}) and past volatility (σ_{t-j}) respectively. The persistence of the conditional volatility is measured by $\alpha+\beta$. The relationship between conditional volatility and trading volume is modeled by modifying GARCH equation. The contemporaneous volume is used as explanatory variable in GARCH equation (Lamoureux and Lastrapes, 1990) as follows:

$$\begin{aligned}
r_t &= a + \sum_{i=1}^5 b_i r_{t-i} + \varepsilon_t \\
\varepsilon_t | \psi_{t-1} &\sim N(0, \sigma_t^2) \text{ and} \\
\sigma_t^2 &= \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 + \chi V_t.
\end{aligned} \tag{5}$$

The significance of the coefficient estimate (χ) of volume indicates the influence of trading volume on the conditional volatility.

4. Results and Discussions on Relationship between Volume, Returns and Volatility

In this section of the paper we present empirical results on the relationship between trading volume, returns and volatility (conditional and unconditional). Firstly we report the relationship between trading volume and price changes. Later, we report the relationship between volume and unconditional and conditional volatility.

4.1 Trading Volume and Stock Price Changes

The results of the OLS regression using equation [1] to explain the relation between volume and price changes and its asymmetric nature are presented in Table 6. The estimates of β_1 , which measure the relationship between price changes and volume irrespective of the direction of the price change, are significant and positive at 1% level (except for Idea Cellular Ltd., where the coefficient is significant at 5% level and Reliance Power, where it is not significant) across all three measures of trading volume. The coefficients are higher for most of the companies, when the number of transactions is taken as a measure of trading volume.

The asymmetric behavior of relation between volume and returns is indicated by coefficient β_2 . In most of the cases, β_2 is significant and negative i.e. for most stocks β_2 is negative for at least two out of the three trading volume measures. The negative value of β_2 indicates that the relation between price changes and trading volume is smaller for negative returns than for positive

returns. This is consistent with Karpoff (1986, 1987) and Assogbavi et al. (1995) who relate the observed price-volume asymmetry in developed markets to the higher cost of short sales as compared to margin buying. However, some of the companies do not show asymmetric behavior for at least two of the trading volume measures. Out of 50 stocks, such companies are 18 who do not show asymmetric behavior. These companies are Bharti, Cipla, DLF, HDFC, HDFC Corp., ICICI, Infosys, NTPC, Reliance Infra, Reliance industries, Reliance power, Reliance Petroleum, Satyam, Siemens, Sterlite, Tata Power, TCS and Unitech. The parameter β_2 is not significant at even 5% level. This non-asymmetric behavior supports the finding of Assogbavi (2007) that clearly indicates the absence of asymmetric relationship in emerging markets. This means that the cost of taking a long position might not be different from that of taking a short position in these stocks. In India, till 2006, short selling was prohibited for “Institutional investors” viz. the Foreign Institutional Investors (FIIs) and the mutual funds registered with SEBI, banks and insurance companies. After 2006, they were allowed short selling. However, the short selling has been banned time to time. Hence, the proportion of retail investors and institutional investors might be the reason behind mixed results of the asymmetric relationship between price changes and trading volume for some Indian stocks.

Table 6: Relationship between Standardized Trading Volume and Returns

This table provides the coefficient estimates from regressions of trading volume against absolute price changes (absolute returns) and asymmetric coefficient of the OLS equation $V_t = \alpha + \beta_1|r_t| + \beta_2D_t|r_t|$, where V_t = standardized trading volume at time t, r_t is the return at time t and $D_t=1$ when $r_t < 0$ and $D_t=0$ when $r_t \geq 0$. Three measures of trading volume, the daily total dollar value of shares traded (value), the daily number of shares traded (volume) and the daily number of equity trades (trade) are considered. Parameter estimates of all 50 companies are presented.

Company	Value				Volume				Trade			
	α	β_1	β_2	RSQ	α	β_1	β_2	RSQ	α	β_1	β_2	RSQ
ABB	-0.17*	0.13*	-0.05*	0.034	-0.31*	0.21*	-0.06*	0.102	-0.307*	0.203*	-0.047*	0.100
ACC	-0.27*	0.17*	-0.07*	0.078	-0.27*	0.19*	-0.09*	0.086	-0.337*	0.221*	-0.092*	0.124
AMBUJA	-0.06	0.05*	-0.04**	0.006	-0.05	0.05*	-0.04**	0.005	-0.312*	0.205*	-0.060*	0.100
BHARTI	-0.11*	0.04*	0.03	0.011	-0.09*	0.04*	0.01	0.008	-0.420*	0.205*	0.008	0.158
BHEL	-0.29*	0.15*	-0.03**	0.086	-0.34*	0.19*	-0.05*	0.118	-0.319*	0.157*	-0.007	0.100
BPCL	-0.25*	0.14*	-0.06*	0.066	-0.27*	0.14*	-0.05*	0.071	-0.273*	0.147*	-0.048*	0.075
CIPLA	-0.36*	0.25*	-0.06*	0.146	-0.27*	0.16*	0.00	0.078	-0.382*	0.248*	-0.026	0.161
CAIRN	-0.26*	0.13*	-0.08*	0.083	-0.25*	0.12*	-0.07*	0.106	-0.305*	0.143*	-0.065*	0.104
DLF	-0.07**	0.03*	-0.03*	0.040	-0.13*	0.04*	-0.02	0.049	-0.167*	0.042*	-0.002	0.047
GAIL	-0.20*	0.12*	-0.04*	0.051	-0.21*	0.13*	-0.05*	0.058	-0.229*	0.137*	-0.044*	0.069
GRASIM	-0.23*	0.17*	-0.09*	0.065	-0.24*	0.17*	-0.07*	0.065	-0.351*	0.243*	-0.100*	0.139
HCL	-0.32*	0.14*	-0.05*	0.112	-0.29*	0.12*	-0.03**	0.085	-0.324*	0.129*	-0.020	0.103
HDFC	-0.09*	0.06*	-0.02	0.009	-0.06**	0.05*	-0.03	0.006	-0.336*	0.194*	0.011	0.125
HDFCORP	-0.15*	0.07*	0.01	0.022	-0.13*	0.07*	0.00	0.017	-0.427*	0.220*	0.029**	0.186
HINDALC	-0.37*	0.24*	-0.08*	0.152	-0.41*	0.25*	-0.06*	0.183	-0.452*	0.267*	-0.036**	0.222
HLL	-0.35*	0.28*	-0.12*	0.133	-0.25*	0.21*	-0.09*	0.072	-0.415*	0.304*	-0.089*	0.171
HONDA	-0.15*	0.10*	-0.04**	0.026	-0.24*	0.16*	-0.06*	0.063	-0.299*	0.181*	-0.032**	0.086
ICICI	-0.24*	0.10*	0.02	0.060	-0.13*	0.05*	0.01	0.018	-0.325*	0.128*	0.032*	0.113
IDEA	-0.06	0.04**	-0.05*	0.019	-0.11**	0.05*	-0.04**	0.022	-0.147*	0.083*	-0.073*	0.053
INFOSYS	-0.31*	0.16*	-0.02	0.104	-0.33*	0.16*	0.00	0.122	-0.394*	0.195*	-0.013	0.168
ITC	-0.42*	0.28*	-0.04**	0.174	-0.29*	0.19*	-0.01	0.085	-0.423*	0.280*	-0.039**	0.178
L&T	-0.33*	0.22*	-0.11*	0.145	-0.27*	0.18*	-0.10*	0.097	-0.313*	0.192*	-0.075*	0.129
M&M	-0.07**	0.07*	-0.08*	0.017	-0.15*	0.12*	-0.09*	0.040	-0.208*	0.147*	-0.098*	0.060
MARUTI	-0.26*	0.16*	-0.06*	0.064	-0.24*	0.15*	-0.06*	0.057	-0.279*	0.167*	-0.055*	0.071
NALCO	-0.23*	0.14*	-0.08*	0.073	-0.22*	0.13*	-0.07*	0.068	-0.324*	0.173*	-0.060*	0.125
NTPC	-0.37*	0.20*	0.03	0.213	-0.19*	0.10*	0.00	0.111	-0.520*	0.287*	0.044**	0.328
ONGC	-0.15*	0.09*	-0.02	0.024	-0.19*	0.12*	-0.03	0.038	-0.274*	0.168*	-0.031**	0.080
PNB	-0.33*	0.19*	-0.09*	0.127	-0.41*	0.23*	-0.09*	0.185	-0.433*	0.232*	-0.086*	0.196
POWER&G	-0.24*	0.13*	-0.09*	0.091	-0.27*	0.13*	-0.09*	0.118	-0.304*	0.153*	-0.092*	0.122
RANBAXY	-0.33*	0.22*	-0.05*	0.125	-0.38*	0.24*	-0.04**	0.160	-0.380*	0.239*	-0.042*	0.161

RCOMM	-0.24*	0.11*	-0.04**	0.064	-0.38*	0.16*	-0.04**	0.175	-0.459*	0.194*	-0.038**	0.229
RELIANC	-0.35*	0.20*	0.01	0.140	-0.33*	0.21*	-0.04*	0.119	-0.445*	0.244*	0.019	0.223
RPOWER	-0.04*	0.00*	0.02*	0.002	-0.05	0.00	0.02	0.004	-0.060	0.009	0.019	0.004
RINFRA	-0.33*	0.18*	-0.04*	0.152	-0.40*	0.22*	-0.06*	0.227	-0.372*	0.188*	-0.023	0.190
RPETRO	-0.40*	0.21*	-0.03	0.211	-0.48*	0.25*	-0.04**	0.325	-0.465*	0.235*	-0.026	0.281
SAIL	-0.26*	0.12*	-0.04*	0.083	-0.31*	0.15*	-0.05*	0.116	-0.314*	0.134*	-0.020	0.111
SATYAM	-0.34*	0.14*	-0.02	0.116	-0.33*	0.13*	-0.01	0.107	-0.409*	0.157*	0.000	0.164
SBI	-0.32*	0.20*	-0.04**	0.096	-0.32*	0.20*	-0.06*	0.097	-0.361*	0.208*	-0.024	0.118
SIEMENS	-0.25*	0.15*	-0.03	0.072	-0.35*	0.17*	0.04**	0.141	-0.330*	0.167*	0.023	0.120
STERLIT	-0.17*	0.10*	-0.08*	0.063	-0.20*	0.11*	-0.07*	0.096	-0.175*	0.097*	-0.065*	0.070
SUNPHAR	-0.13*	0.09*	-0.03	0.020	-0.13*	0.09*	-0.04*	0.022	-0.371*	0.234*	-0.056*	0.158
SUZLON	-0.33*	0.14*	-0.07*	0.202	-0.37*	0.15*	-0.04*	0.162	-0.452*	0.171*	-0.040*	0.257
TATACOM	-0.14*	0.09*	-0.07*	0.038	-0.15*	0.10*	-0.07*	0.040	-0.177*	0.108*	-0.068*	0.051
TATAMOT	-0.08*	0.06*	-0.04*	0.009	-0.24*	0.15*	-0.08*	0.059	-0.205*	0.119*	-0.046*	0.039
TATAPOW	-0.33*	0.17*	-0.02	0.123	-0.29*	0.16*	-0.04*	0.093	-0.335*	0.171*	-0.016	0.124
TASTATE	-0.26*	0.14*	-0.04*	0.066	-0.30*	0.17*	-0.06*	0.091	-0.396*	0.196*	-0.019	0.149
TCS	-0.10**	0.06*	-0.02	0.009	-0.16*	0.10*	-0.02	0.025	-0.376*	0.212*	0.007	0.190
UNITECH	-0.21*	0.08*	-0.03*	0.049	-0.30*	0.10*	-0.01	0.092	-0.294*	0.094*	-0.004	0.089
WIPRO	-0.27*	0.13*	-0.03*	0.085	-0.25*	0.12*	-0.03*	0.072	-0.320*	0.142*	-0.023**	0.117
ZEE	-0.26*	0.11*	-0.03**	0.066	-0.32*	0.14*	-0.05*	0.105	-0.360*	0.155*	-0.049*	0.134

*(**) represents significance of the parameter at 1 %(5%) significance level.

4.2 Causal Relation between Returns and Trading Volume

In order to investigate the dynamic relationship between returns and trading volume, we analyze these variables through bivariate VAR model. We also explore lead-lag relationship between returns and trading volume by using Granger Causality (Smirlock and Starks, (1988), and Assogbavi et al. (1992). Granger Causality test is a F test which checks the block exogeneity. In equation 2 given earlier, it tests the null hypothesis that return series is not affected by past volume ($\beta_j = 0$) and that the volume is not affected by past returns ($\delta_j = 0$) separately. Results of the test are reported in Table 6.

The results of the Granger causality test indicate mixed results on past returns effect on trading volume. When the number of transactions is taken as a measure of volume, in case of 23 stocks the null that past returns does not cause trading volume ($\delta_j = 0$) is rejected at 1% significance level, and for 7 stocks it is rejected at 5% significance level. On the other hand, the null hypothesis that the past volume does not cause returns ($\beta_j = 0$) is rejected in case of 6 stocks at 1% significance level, and for 4 stocks at 5% significance level. Similar⁴ kind of results are found when other two measures of volume, daily number of shares traded and daily value of stocks traded are used to test the dynamic relationship between returns and volume. The Granger causality results show that returns cause volume and that the volume also causes returns albeit to a lesser extent. The evidence that in Indian market, the past returns cause trading volume is easily conceivable as in case of most emerging markets where the development of the market possibly does not allow spontaneous information dissemination. It supports the sequential processing of information hypothesis argued by Smirlock and Starks (1985). They propose that

⁴ In case of total number of daily shares traded, 13 stocks at 1% significance level and by 7 stocks at 5% significance level have rejected the null that returns do not cause volume. When the daily value of shares traded is used, 13 stocks at 1% significance level and by 8 stocks at 5% significance level. Granger causality from volume to returns is rejected by 2 stocks at 1% significance level and by 5 stocks at 5% significance level and 7 stocks at 1% significance level and by 4 stocks at 5% significance level when total number of shares traded and total value of shares are considered respectively.

the information arrives sequentially rather than simultaneously in the market. The evidence that volume Granger causes returns supports some theoretical models which imply that there is information content in volume for predicting future returns. The difference in direction of causality among stocks may be due to nature of type of the industry, types of investors etc.

The autoregressive coefficient of return and partial coefficient of return on past volume and autoregressive coefficient of volume and volume on past returns are also estimated through bivariate VAR model as explained in equation [2]. In this case also, three measures of volume have been considered and the results are presented in Table 8. It has been found that the all three measures of volume are highly autocorrelated with past volume. These results provide evidence that in Indian market, information is processed sequentially. Even after high autocorrelation nature of volume, the partial correlation between volume and past returns are significant and most of the significance is found with only last day return (21 stocks when number of trades, 26 stocks when volume and 25 stocks when value is taken as measure of traded volume). The return series are also autocorrelated up to lag 1 or 2 (in most of the stocks) and the coefficients are small. In some cases, (lesser than dependence of volume on past returns) we found significant partial correlation between returns and past volume and in these cases also, most of the significant coefficients are for relation between return and last day volume (7 stocks when number of trades, 4 stocks when volume and 6 stocks when value is taken).

Table 7: Granger Causality Test (Wald Test)

This table provides the F test results of restriction on autoregressive parameters $\beta_j=0$ and $\delta_j=0$ of the bivariate VAR

model $r_t = \alpha_0 + \sum_{i=1}^5 \alpha_i r_{t-i} + \sum_{j=1}^5 \beta_j V_{t-j}$ and $V_t = \gamma_0 + \sum_{i=1}^5 \gamma_i V_{t-i} + \sum_{j=1}^5 \delta_j r_{t-j}$. where V_t is the standardized

trading volume at time t, and r_t is the return at time t. Three measures of trading volume, the daily total dollar value of shares traded (value), the daily number of shares traded (volume) and the daily number of equity trades (trade) are considered. Parameter estimates of all 50 companies are presented.

Company	Value		Volume		Trade	
	$\beta_i=0$	$\delta_i=0$	$\beta_i=0$	$\delta_i=0$	$\beta_i=0$	$\delta_i=0$
ABB	1.98	4.61	8.63	1.36	4.31	3.94
ACC	3.87	23.78*	2.16	21.31*	2.27	13.24**
AMBUJA	3.96	3.55	4.48	3.91	4.85	17.01*
BHARTI	9.14	0.9	7.09	2.44	2.1	5.09
BHEL	8.07	16.38*	1.62	17.88*	8.62	29.27*
BPCL	17.52*	8.98	11.34**	4.1	14.94**	5.28
CIPLA	3.99	23.61*	3.01	5.71	3.05	16.68*
CAIRN	2.38	13.32**	2.09	11.09**	2.21	14.35**
DLF	0.83	1.58	3.35	3.04	3.56	1.77
GAIL	8.4	6.27	4.09	2.92	7.38	6.97
GRASIM	3.97	12.07**	3.73	12.38**	4	4.62
HCL	9.15	3.33	15.02**	40.58*	6.01	43.66*
HDFC	1.05	1.31	1.3	2.77	5.91	7.28
HDFCORP	15.26*	12.93**	5.71	11.91**	6.41	32.47*
HINDALC	13.92**	15.03**	13.2**	47.93*	6.05	24.53*
HLL	2.06	6.22	1.35	9.15	5.42	9.53
HONDA	4.09	7.06	1.25	14.77*	1.67	14.93**
ICICI	12.6**	4.76	3.97	4.52	13.58**	19.7*
IDEA	2.63	3.61	4.08	3.26	1.93	2.47
INFOSYS	15.37*	11.59**	6.62	33.38*	7.5	45.08*
ITC	15.71*	28.12*	4.94	3.58	8.84	5.82
L&T	6.37	11.27**	7.96	9.78	6.95	13.28**
M&M	5.29	5.9	5.53	4.49	2.65	3.62

MARUTI	2.01	7.24	2.15	17.61*	2.35	23.39*
NALCO	5.28	17.01*	1.74	11.58**	5.18	24.06*
NTPC	16.76*	20.98*	5.4	7.15	29.9*	5.44
ONGC	8.18	3.07	5.88	2.74	3.89	11.05
PNB	11.33	12.6	14.99**	10.94	6.71	7.82
POWER&G	8.85	5.32	9.95	2.69	6.87	1.92
RANBAXY	10.42	10.9	7.68	13.8**	7.98	24.68*
RCOMM	6.16	2.31	5.88	5.7	10.64	8.57
RELIANC	8.19	12.04**	4.03	9.19	14.37**	7.91
RPOWER	7.36	0.49	6.22	0.27	6.48	0.9
RINFRA	14.34**	4.37	7	7.38	17.72*	8.07
RPETRO	7.38	23.75*	4.75	13.79**	5.9	13.63**
SAIL	8.14	43.76*	6.1	48.39*	7.6	20.42*
SATYAM	10.16	33.63*	8.52	39.95*	6.43	39.27*
SBI	4.59	21.39*	2.85	17.14*	7.88	17.91*
SIEMENS	5.82	8.65	11.55**	9.6	5.02	15.75*
STERLIT	190.34	78.76	67.15	20.33	63*	17.96*
SUNPHAR	12.59**	6.5	6.53	4.58	12.54**	22.57*
SUZLON	8.61	7.07	27.91*	21.39*	20.81*	18.29*
TATACOM	5.7	5.47	5.63	4.19	5.07	5.18
TATAMOT	0.84	11.11**	4.63	17.94*	2.11	13.8**
TATAPOW	40.51*	79.04*	22.31*	37.94*	25.21*	24.31*
TATASTE	6.12	17.55*	7.44	6.96	3	20.87*
TCS	0.67	0.11	1.24	2.57	1.57	19.06*
UNITECH	5.44	10.73	10.49	92.56*	16.82*	77.95*
WIPRO	10.9	8.91	2.43	6.44	5.16	21.26*
ZEE	15.19*	15.39*	7.61	14.51**	6.89	12.95**

Table 8: Results of Bivariate VAR model

This table provides the parameter coefficient estimates of the bivariate VAR model $r_t = \alpha_0 + \sum_{i=1}^5 \alpha_i r_{t-i} + \sum_{j=1}^5 \beta_j V_{t-j}$ and $V_t = \gamma_0 + \sum_{i=1}^5 \gamma_i V_{t-i} + \sum_{j=1}^5 \delta_j r_{t-j}$. where V_t is the standardized trading volume at time t , and r_t is the return at time t . Three measures of trading volume, the daily total dollar value of shares traded (value), the daily number of shares traded (volume) and the daily number of equity trades (trade) are considered. Parameter estimates of all 50 companies are presented.

a) VAR model with returns and number of transactions as volume measure

Company	$r_t = \alpha_0 + \sum_{i=1}^5 \alpha_i r_{t-i} + \sum_{j=1}^5 \beta_j V_{t-j}$											$V_t = \gamma_0 + \sum_{i=1}^5 \gamma_i V_{t-i} + \sum_{j=1}^5 \delta_j r_{t-j}$										
	α_0	α_1	α_2	α_3	α_4	α_5	β_1	β_2	β_3	β_4	β_5	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	δ_1	δ_2	δ_3	δ_4	δ_5
ABB	0.09	0.06*	0.00	0.00	0.00	-0.01	0.06	0.00	-0.09	-0.07	0.01	0.00	0.64*	0.08*	0.01	0.08*	0.08*	0.00	0.00	-0.01	0.00	0.00
ACC	0.03	0.01	-0.04	0.00	0.03	-0.01	0.09	-0.03	-0.08	-0.04	0.10	0.00	0.48*	0.17*	0.06	0.09*	0.10*	0.01*	-0.01	0.01	0.00	0.00
AMBUJA	0.03	0.02	-0.05*	0.01	0.04	-0.02	0.02	-0.19	0.08	0.07	-0.03	0.00	0.52*	0.10*	0.11*	0.09*	0.05*	0.01*	-0.01	-0.01	0.01	-0.01*
BHARTI	0.18*	-0.01	-0.06*	-0.02	-0.03	0.02	0.02	0.04	-0.05	-0.10	0.02	0.00	0.47*	0.08*	0.08*	0.19*	0.05**	-0.01	0.01	0.00	-0.01	0.00
BHEL	0.12	0.04	-0.07*	-0.01	0.02	-0.02	-0.31**	0.13	0.29	-0.37	0.19	0.00	0.72*	0.09*	0.01	0.05**	0.07*	-0.01*	-0.01*	-0.01*	0.01	0.00
BPCL	0.03	0.08*	0.01	0.01	-0.01	-0.04	-0.35*	0.18	-0.04	0.19	-0.09	0.00	0.57*	0.00	0.09*	0.13*	0.06*	0.01	0.00	0.01	0.00	0.00
CIPLA	0.03	0.08*	-0.01	-0.05*	0.00	0.01	-0.09	0.03	0.01	-0.05	0.01	0.00	0.51*	0.04	0.15*	0.04	0.06*	0.02*	0.00	0.00	0.00	-0.01
CAIRN	0.04	0.03	0.02	-0.07	-0.15*	0.00	-0.06	-0.02	0.35	0.01	-0.36	0.00	0.66*	-0.07	0.21*	0.07	0.03	0.01	-0.01**	0.00	0.00	-0.02*
DLF	-0.16	0.01	-0.05	0.07	-0.01	-0.01	0.32	0.07	-0.34	0.46	-0.61	-0.01	0.29*	0.38*	-0.04	0.18*	0.03	-0.002	-0.004	0.001	-0.003	-0.002
GAIL	0.06	-0.01	-0.07*	0.01	0.01	-0.07*	-0.12	0.35	-0.27	0.09	-0.16	0.001	0.61*	0.06**	0.14*	0.09*	0.06*	0.000	-0.006	-0.004	-0.004	-0.002
GRASIM	0.03	0.06*	-0.03	0.06*	0.02	0.03	-0.04	0.08	-0.04	-0.11	0.16	0.001	0.51*	0.09*	0.08*	0.03	0.20*	0.001	-0.006	-0.003	-0.003	-0.007
HCL	-0.07	0.07*	-0.02	-0.06*	-0.02	-0.10*	-0.26	0.23	-0.28	0.29	-0.02	-0.001	0.60*	0.15*	0.05	-0.04	0.17*	-0.015*	-0.004	0.008*	-0.003	0.002
HDFC	0.09	-0.03	-0.05*	-0.02	-0.05*	-0.03	0.05	-0.19	0.25	-0.16	-0.01	0.004	0.42*	0.16*	0.11*	0.14*	0.13*	0.002	-0.005	-0.002	0.001	-0.007**
HDFCORP	0.13*	0.02	-0.09*	-0.06*	-0.02	-0.09*	-0.03	-0.17	-0.08	0.09	0.08	0.01	0.57*	0.02	0.14*	0.16*	0.07*	-0.01**	0.00	-0.01*	-0.01*	-0.01*
HINDALC	-0.02	0.12*	-0.01	-0.07*	0.02	0.01	-0.01	-0.05	0.14	-0.24**	0.07	0.001	0.57*	0.02	0.20*	0.11*	0.01	-0.004	0.005	-0.014*	0.001	-0.016*
HLL	0.00	0.04	-0.02	-0.03	0.01	-0.06*	0.06	0.04	-0.11	-0.06	0.03	0.00	0.45*	0.10*	0.09*	0.10*	0.07*	-0.01	0.00	-0.01	-0.01	-0.01
HONDA	0.06	0.04	-0.10*	-0.05*	-0.03	0.01	0.03	-0.01	0.05	-0.03	-0.07	0.00	0.59*	0.04	0.10*	0.01	0.09*	0.00	-0.02*	0.00	-0.01	-0.01
ICICI	0.08	0.12*	-0.06*	0.01	-0.03	-0.01	0.32	-0.12	0.13	-0.38	-0.10	0.004	0.63*	0.07*	-0.02	0.10*	0.18*	-0.009*	-0.001	0.005	-0.005	-0.001
IDEA	-0.12	0.10**	0.00	0.01	0.03	0.00	-0.15	-0.11	-0.10	0.19	0.25	-0.03	0.56*	-0.02	0.03	0.04	0.07	0.00	-0.01	0.01	0.01	0.00
INFOSYS	0.01	0.08*	-0.06*	0.00	-0.04	-0.03	-0.05	0.09	-0.25*	0.09	0.04	0.00	0.45*	0.14*	0.11*	0.06*	0.08*	-0.03*	0.00	-0.01	0.00	0.01
ITC	0.05	-0.01	-0.01	0.01	0.01	-0.01	-0.06	-0.06	0.02	-0.12	0.11	0.000	0.52*	0.08*	0.12*	-0.01	0.14*	0.009	-0.001	-0.012	0.000	-0.003
L&T	0.02	0.08*	-0.05**	0.02	0.01	-0.03	-0.15	0.10	0.19	-0.19	-0.08	0.002	0.53*	0.10*	0.08*	0.10*	0.13*	-0.002	-0.004	-0.009*	-0.002	-0.005
M&M	0.00	0.14*	-0.05**	-0.01	0.00	-0.05**	0.03	0.07	-0.08	0.13	-0.13	0.002	0.51*	0.07*	0.10*	0.10*	0.11*	-0.001	0.000	-0.007	-0.003	-0.002

company	α_0	α_1	α_2	α_3	α_4	α_5	β_1	β_2	β_3	β_4	β_5	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	δ_1	δ_2	δ_3	δ_4	δ_5
MARUTI	0.08	0.04	-0.05	0.00	0.01	-0.04	-0.17	0.20	0.00	0.13	-0.15	0.00	0.59*	0.05	0.18*	-0.02	0.15*	-0.02*	0.00	-0.01	0.00	-0.01
NALCO	0.04	0.04	0.01	-0.03	-0.01	0.02	-0.004	0.004	0.053	-0.160	-0.044	0.002	0.57*	0.01	0.15*	0.06*	0.07*	0.015*	0.001	-0.010*	0.000	-0.010*
NTPC	0.09	0.04	-0.08*	-0.03	-0.01	-0.02	-0.71*	0.59*	-0.52*	0.24	0.16	-0.004	0.68*	-0.08**	0.18*	0.00	0.16*	0.012**	-0.002	-0.001	0.007	0.001
ONGC	0.067	0.091*	-0.069*	-0.004	0.019	0.003	-0.02	0.03	-0.04	-0.11	0.04	0.003	0.51*	0.08*	0.13*	0.10*	0.09*	0.009	-0.002	-0.005	0.002	-0.011*
PNB	0.16**	0.02	-0.02	-0.04	0.00	-0.05	0.02	0.22	-0.33	0.13	-0.12	-0.001	0.53*	0.19*	0.01	0.11*	0.04	0.010**	0.003	-0.008	0.002	0.003
POWER&G	-0.09	0.15*	-0.11	-0.05	-0.07	-0.05	-0.24	-0.23	0.70	0.25	0.05	-0.027	0.69*	-0.24	0.28*	0.08	0.08	0.003	-0.001	0.005	0.000	0.006
RANBAXY	-0.01	0.05**	-0.01	0.02	0.01	0.01	-0.21*	0.12	-0.02	0.04	-0.01	0.00	0.59*	0.08*	0.00	0.04	0.10*	0.01	-0.02*	-0.01	0.01	-0.01
RCOMM	-0.06	-0.08**	-0.01	0.04	-0.10*	0.01	0.34	-0.07	0.01	-0.51**	-0.04	-0.005	0.45*	0.09**	0.15*	0.01	0.11*	0.000	-0.005	-0.017*	-0.014	0.001
RELIANC	0.062	0.035	-0.005	-0.037	-0.005	0.003	-0.27*	0.21	0.08	-0.19	0.06	0.002	0.51*	0.02	0.14*	0.14*	0.12*	-0.004	0.005	0.010	-0.004	0.000
RPOWER	-0.39	0.16*	-0.04	0.16**	-0.08	-0.01	0.58	0.07	0.39	-0.49	-0.74	0.111*	0.22*	0.20*	0.11	0.19*	0.61*	0.003	-0.004	-0.001	0.009	0.000
RINFRA	0.05	0.06*	-0.07*	0.03	-0.04**	-0.01	0.00	-0.37	-0.51**	0.80	0.04	0.003	0.61*	0.13*	0.09*	-0.02	0.16*	-0.004	0.001	-0.004	0.003	0.001
RPETRO	0.02	0.12*	-0.03	-0.06	0.00	0.03	0.05	0.05	-0.59**	0.25	0.12	0.000	0.60*	0.01	0.18*	-0.05	0.18*	-0.003	0.014**	0.014	0.006	0.009
SAIL	0.08	0.05*	-0.04	0.01	0.01	0.01	-0.35**	0.03	0.05	-0.03	0.20	0.000	0.58*	0.06*	0.14*	0.02	0.13*	0.011*	0.003	0.006**	-0.002	-0.002
SATYAM	-0.02	0.05**	-0.04	-0.01	0.00	-0.03	0.22	-0.07	-0.10	-0.22	0.12	0.010	0.38*	0.17*	0.04	0.14*	0.24*	-0.011*	-0.001	0.001	-0.011*	-0.013*
SBI	0.075	0.056*	-0.043	-0.001	0.005	-0.046**	-0.23	0.18	-0.03	-0.17	0.21	0.004	0.47*	0.10*	0.16*	0.10*	0.13*	0.000	0.009**	-0.004	-0.006	-0.011*
SIEMENS	0.07	0.05*	-0.02	0.01	0.01	0.04	-0.09	-0.04	0.00	0.02	-0.02	0.00	0.64*	0.03	0.05	0.06**	0.09*	0.01*	0.00	0.01	0.00	-0.01*
STERLIT	0.04	0.07*	-0.01	0.04	0.00	0.02	-0.03	-0.02	0.38	-2.24*	1.27*	0.001	0.62*	0.02	0.13*	0.02	0.15*	0.002	0.004*	-0.001	0.004*	-0.002
SUNPHAR	0.10	0.02	-0.01	0.00	-0.04	-0.03	0.00	-0.16	0.13	0.11	-0.19*	0.00	0.51*	0.05	0.12*	0.00	0.14*	0.02*	-0.01	-0.01	0.00	-0.01
SUZLON	-0.09	0.04	0.01	0.02	0.06	0.03	-0.19	1.42*	-0.65	-0.71	-0.12	0.002	0.59*	-0.01	0.30*	-0.06	0.13*	-0.007**	0.007**	-0.003	-0.001	-0.011*
TATACOM	-0.01	0.08*	-0.04	-0.02	-0.02	-0.03	0.03	0.01	-0.18	0.33**	-0.17	0.000	0.58*	0.05**	0.03	0.11*	0.12*	0.006	0.005	0.002	0.000	0.002
TATAMOT	-0.02	0.10*	-0.04	-0.02	-0.03	0.03	0.11	-0.03	0.09	-0.15	-0.03	0.001	0.54*	0.09*	0.09*	0.08*	0.13*	0.007**	-0.005	0.002	-0.003	-0.009*
TATAPOW	-0.001	0.014*	-0.001	0.006	-0.007**	0.005	-0.30**	0.12	-0.39*	0.66*	-0.18	0.02	0.58*	0.05	0.09*	0.12*	0.09*	0.07*	-0.03	0.02	0.00	0.02
TATASTE	0.003	-0.007	0.013*	-0.001	-0.002	-0.004	-0.04	-0.02	-0.07	-0.05	0.06	-0.01	0.54*	0.09*	0.09*	0.06*	0.17*	0.03	-0.10*	-0.11*	-0.10*	0.04
TCS	-0.01	-0.02*	0.01	-0.02*	0.01	-0.01	0.02	-0.02	-0.07	0.08	-0.10	0.21**	0.52*	0.05	0.07**	-0.01	0.10*	-0.02	0.00	0.03	0.05**	0.05**
UNITECH	0.21**	-0.02	0.00	0.03	0.05**	0.05**	0.14	0.37	-0.57**	-0.50	0.34	0.011	0.51*	0.09*	0.14*	0.08*	0.13*	-0.013*	0.006*	-0.012*	-0.001	-0.003
WIPRO	-0.03	0.05*	0.02	-0.01	0.01	0.00	0.09	0.11	-0.40	0.23	-0.11	0.000	0.51*	0.11*	0.08*	0.09*	0.17*	-0.003	0.002	-0.009*	-0.004	-0.003
ZEE	-0.09	0.05*	-0.01	-0.01	-0.04	-0.02	-0.12	0.04	-0.07	0.10	-0.17	-0.003	0.52*	0.13*	0.09*	0.10*	0.10*	-0.002	-0.003	-0.004	-0.004	-0.007*

b. VAR model with returns and the daily number of shares traded as volume measure

$$r_t = \alpha_0 + \sum_{i=1}^5 \alpha_i r_{t-i} + \sum_{j=1}^5 \beta_j V_{t-j}$$

$$V_t = \gamma_0 + \sum_{i=1}^5 \gamma_i V_{t-i} + \sum_{j=1}^5 \delta_j r_{t-j}$$

Company	α_0	α_1	α_2	α_3	α_4	α_5	β_1	β_2	β_3	β_4	β_5	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	δ_1	δ_2	δ_3	δ_4	δ_5
ABB	0.09	0.06*	0.00	0.00	0.00	-0.01	0.07	0.00	-0.12	0.03	-0.10	0.001	0.39*	0.15*	0.08*	0.14*	0.00	-0.002	-0.003	-0.003	-0.006	-0.001
ACC	0.03	0.01	-0.04	-0.01	0.03	-0.01	0.12	-0.04	0.02	-0.14	0.06	-0.002	0.42*	0.16*	0.13*	0.10*	0.11*	0.017*	-0.007	0.003	-0.002	-0.003
AMBUJA	0.03	0.02	-0.06*	0.00	0.04	-0.01	0.01	-0.04	0.05	-0.06	-0.06	0.000	0.05*	0.03	0.12*	0.03	0.03	-0.002	-0.007	-0.008	0.012	0.002
BHARTI	0.18*	-0.01	-0.06*	-0.02	-0.03	0.02	-0.04	-0.06	-0.14**	0.08	-0.01	-0.005	0.03	0.02	0.03	0.03	0.02	0.003	0.003	0.011	0.007	0.000
BHEL	0.12	0.04	-0.06*	0.00	0.02	-0.02	0.03	-0.07	0.10	-0.06	-0.05	0.002	0.50*	0.15*	0.09*	0.12*	0.05**	-0.002	-0.015*	-0.007	0.002	-0.004
BPCL	0.03	0.08*	0.01	0.01	-0.01	-0.04	-0.27*	0.09	0.06	0.11	-0.07	0.000	0.52*	0.02	0.09*	0.12*	0.08*	0.009	-0.001	0.003	-0.002	-0.002
CIPLA	0.03	0.08*	-0.01	-0.05*	0.00	0.01	-0.05	-0.04	0.10	-0.04	-0.01	0.000	0.40*	0.13*	0.10*	0.05**	0.09*	0.016**	0.004	-0.002	0.003	0.000
CAIRN	0.05	0.02	0.02	-0.07	-0.15*	0.00	0.23	-0.34	0.37	0.05	-0.25	-0.01	0.58*	-0.11**	0.21*	0.05	0.08	0.01**	-0.01	0.00	0.00	-0.01**
DLF	-0.15	0.01	-0.05	0.07	-0.02	-0.01	0.58	0.15	-0.31	0.52	-0.86	-0.011	0.34*	0.31*	0.00	0.18*	0.03	-0.003	-0.003	0.001	-0.001	-0.004
GAIL	0.06	-0.01	-0.07*	0.01	0.01	-0.07*	0.00	0.12	-0.07	0.05	-0.18	0.001	0.51*	0.11*	0.12*	0.07*	0.10*	-0.001	-0.003	-0.004	-0.004	-0.001
GRASIM	0.03	0.05*	-0.04	0.06*	0.02	0.04	0.17	0.05	-0.09	-0.08	-0.04	0.000	0.48*	0.18*	0.12*	0.00	0.16*	0.003	-0.006	-0.005	-0.009**	-0.006
HCL	-0.07	0.07*	-0.02	-0.06*	-0.02	-0.10*	-0.24	0.28	-0.35**	0.44	-0.08	-0.001	0.49*	0.15*	0.11*	0.02	0.12*	-0.017*	-0.004	0.010*	-0.007**	0.001
HDFC	0.09	-0.02	-0.05*	-0.02	-0.05*	-0.03	-0.04	0.04	-0.02	0.01	0.00	-0.002	0.03	0.01	0.02	0.01	0.02	0.004	0.012	0.008	0.001	-0.001
HDFCORP	0.13*	0.03	-0.09*	-0.06*	-0.02	-0.09*	0.02	-0.06	0.02	0.03	-0.11**	-0.01	0.03	0.02	0.04**	0.03	0.03	0.01	0.00	0.02*	0.00	-0.01
HINDALC	-0.02	0.12*	-0.01	-0.07*	0.02	0.01	0.12	0.04	0.18	-0.25*	-0.11	0.001	0.46*	0.04	0.38*	-0.04	0.03	-0.003	-0.010	-0.028*	-0.004	-0.014*
HLL	0.00	0.04	-0.02	-0.04	0.01	-0.06	-0.01	0.04	0.01	-0.06	0.03	0.00	0.26*	0.15*	0.11*	0.10*	0.11*	0.00	-0.02**	-0.02	0.00	-0.01
HONDA	0.06	0.04	-0.10	-0.05	-0.03	0.01	-0.02	0.07	-0.02	-0.04	0.02	0.00	0.42*	0.08*	0.08*	0.05*	0.08*	0.00	-0.02*	-0.01	-0.01	-0.01
ICICI	0.08	0.12*	-0.06*	0.02	-0.03	-0.01	0.05	0.05	0.00	-0.12	-0.02	0.002	0.08*	0.07*	0.05*	0.05*	0.05*	-0.009	0.002	-0.005	-0.009	0.002
IDEA	-0.12	0.10**	0.00	0.00	0.03	0.01	-0.14	-0.47	0.57	0.13	-0.17	-0.030	0.30*	0.16*	0.11**	-0.05	0.11*	0.001	-0.006	-0.001	0.010	0.002
INFOSYS	0.01	0.08*	-0.06*	-0.01	-0.03	-0.03	-0.02	0.07	-0.21*	0.08	0.02	0.001	0.39*	0.14*	0.08*	0.06*	0.06*	-0.031*	-0.006	-0.004	-0.002	0.005
ITC	0.05	-0.02	-0.01	0.01	0.01	0.00	0.03	-0.08	0.05	-0.10	0.01	-0.001	0.47*	0.15*	0.09*	0.04	0.10*	0.010	0.001	-0.006	-0.002	-0.001
L&T	0.02	0.08*	-0.04	0.02	0.01	-0.03	-0.11	-0.14	0.35*	-0.03	-0.14	-0.001	0.54*	0.10*	0.10*	0.09*	0.09*	0.003	-0.009*	-0.003	0.000	-0.005
M&M	0.00	0.13*	-0.05*	-0.01	0.01	-0.05	0.09	0.13	-0.07	0.01	-0.13	0.000	0.36*	0.12*	0.11*	0.14*	0.12*	0.011**	-0.002	0.000	-0.001	0.000
MARUTI	0.08	0.04	-0.05	-0.01	0.01	-0.04	-0.13	0.14	0.06	0.08	-0.07	-0.001	0.59*	0.03	0.15*	-0.01	0.19*	-0.016*	0.004	-0.002	-0.006	-0.004
NALCO	0.04	0.04	0.01	-0.03	-0.01	0.02	-0.02	0.03	0.03	-0.03	-0.08	0.000	0.27*	0.14*	0.10*	0.09*	0.07*	0.016*	0.002	-0.006	0.002	-0.008
NTPC	0.08	0.02	-0.07*	-0.03	-0.01	-0.02	-0.16	0.04	-0.30	-0.11	0.20	-0.010	0.45*	0.04	0.12*	0.06	0.16*	0.010*	-0.004	0.000	0.004	-0.001
ONGC	0.07	0.09*	-0.07*	0.00	0.02	0.00	0.15**	-0.08	-0.03	-0.05	-0.02	0.001	0.33*	0.12*	0.10*	0.15*	0.08*	0.007	-0.003	-0.002	0.003	-0.008
PNB	0.16**	0.02	-0.03	-0.04	0.00	-0.05	0.15	0.27	-0.48*	0.25	-0.17	-0.003	0.42*	0.27*	0.01	0.17*	0.02	0.011*	0.004	-0.009	0.001	0.003
POWER&G	-0.07	0.14*	-0.11	-0.06	-0.07	-0.06	-0.05	-0.50	1.06**	0.24	0.03	-0.027	0.70*	-0.28*	0.34*	0.04	0.08	0.003	0.001	0.005	0.000	0.006
RANBAXY	-0.01	0.04**	-0.01	0.02	0.01	0.01	-0.18*	0.03	0.00	0.00	0.06	-0.002	0.49*	0.08*	0.02	0.05**	0.11*	0.001	-0.020*	-0.007	0.005	-0.009

company	α_0	α_1	α_2	α_3	α_4	α_5	β_1	β_2	β_3	β_4	β_5	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	δ_1	δ_2	δ_3	δ_4	δ_5
RELIANC	0.062	0.039	-0.004	-0.039	-0.004	0.008	-0.10	0.11	0.04	-0.08	0.02	-0.01	0.41*	0.09*	0.16*	0.16*	-0.01	0.02*	0.00	0.00	-0.01	0.00
RPOWER	-0.40	0.17*	-0.04	0.15	-0.07	-0.01	0.63	0.01	0.30	-0.35	-0.91	0.146*	0.09	0.25*	0.13	0.21*	0.87*	0.001	-0.001	-0.001	0.005	0.001
RINFRA	0.05	0.06*	-0.07*	0.03	-0.04	-0.01	0.12	-0.06	-0.19	0.22	-0.01	0.003	0.33*	0.21*	0.12*	0.09*	0.14*	0.002	-0.007	-0.007	-0.004	0.003
RPETRO	0.02	0.11*	-0.02	-0.06	0.00	0.03	0.19	-0.09	-0.41	0.08	0.15	-0.004	0.54*	0.01	0.16*	-0.05	0.22*	-0.001	0.016**	0.016**	0.007	0.010
SAIL	0.076	0.047**	-0.038	-0.002	0.003	0.008	-0.10	-0.18	0.37**	-0.19	0.12	-0.003	0.55*	0.00	0.17*	0.01	0.18*	0.020*	0.004	0.005	0.006	-0.003
SATYAM	-0.02	0.05**	-0.04	-0.01	0.00	-0.03	0.37*	-0.23	-0.16	-0.15	0.12	0.005	0.44*	0.19*	0.01	0.15*	0.17*	-0.009*	-0.002	0.004	-0.009*	-0.011
SBI	0.07	0.05*	-0.04	0.00	0.01	-0.04**	-0.08	0.01	-0.05	-0.04	0.08	0.00	0.47*	0.11*	0.12*	0.11*	0.07*	0.02*	0.01	-0.01	-0.01	0.00
SIEMENS	0.07	0.05*	-0.02	0.01	0.01	0.04	-0.13	-0.05	0.05	-0.07	-0.02	-0.002	0.46*	0.09*	0.04	0.12*	0.06*	0.015*	-0.004	0.004	0.000	-0.010
STERLIT	0.04	0.06*	-0.01	0.04**	-0.01	0.02	0.13	0.17	0.06	-1.89*	0.90*	0.000	0.46*	0.09*	0.09*	0.14*	0.16*	0.003	0.004**	-0.005*	0.005*	-0.002
SUNPHAR	0.10	0.02	-0.02	0.00	-0.03	-0.03	-0.11	-0.05	0.06	0.00	0.03	0.000	0.15*	0.01	0.06*	0.06*	0.05*	0.014	-0.002	0.001	-0.010	-0.001
SUZLON	-0.10	0.03	0.02	0.03	0.06	0.04	0.34	1.58*	-0.77	-0.95**	-0.27	0.007	0.67*	-0.09**	0.31*	-0.16*	0.25*	-0.005	0.006	-0.006	0.000	-0.011*
TATACOM	-0.01	0.08*	-0.04	-0.02	-0.02	-0.03	-0.01	0.09	-0.19	0.24	-0.06	0.000	0.46*	0.22*	-0.04	0.12*	0.09*	0.007	-0.001	-0.003	0.001	-0.002
TATAMOT	-0.02	0.10*	-0.04	-0.02	-0.03	0.03	0.13	0.06	-0.03	-0.02	-0.16	0.00	0.56*	0.08*	0.07*	0.07*	0.13*	0.01	-0.01	0.00	-0.01	-0.01
TATAPOW	0.09	0.08*	-0.10*	0.00	0.01	0.01	-0.07	0.29**	-0.27**	0.40*	-0.40*	0.00	0.39*	0.20*	0.15*	0.11*	0.08*	0.02*	-0.01	0.01	-0.01	0.00
TATASTE	0.02	0.07*	-0.03	0.02	-0.01	0.02	0.12	0.03	-0.17	0.22	-0.21	-0.001	0.43*	0.12*	0.12*	0.06*	0.18*	-0.002	0.009**	0.003	0.000	-0.005
TCS	-0.01	0.03	-0.10*	-0.11*	-0.10*	0.04	-0.04	-0.07	-0.02	-0.01	0.02	-0.02	0.09*	0.04	0.03	0.03	0.03	-0.01	-0.01	-0.01	-0.01	-0.01
UNITECH	0.21**	-0.01	0.01	0.03	0.05*	0.04	0.39	0.07	-0.41	-0.56	0.55**	0.015	0.57*	0.01	0.33*	-0.09*	0.18*	-0.015*	0.002	-0.009*	0.001	-0.006*
WIPRO	-0.03	0.05*	0.02	-0.02	0.01	0.00	0.09	-0.05	-0.04	0.08	-0.12	0.001	0.38*	0.11*	0.07*	0.10*	0.15*	-0.002	0.001	-0.010**	-0.004	-0.001
ZEE	-0.09	0.05*	-0.01	-0.01	-0.03	-0.02	-0.02	0.03	-0.18	-0.01	-0.06	-0.003	0.40*	0.21*	0.05**	0.16*	0.11*	-0.003	-0.002	-0.005	-0.002	-0.009*

c. VAR model with returns and the daily value of shares traded as volume measure

	$r_t = \alpha_0 + \sum_{i=1}^5 \alpha_i r_{t-i} + \sum_{j=1}^5 \beta_j V_{t-j}$											$V_t = \gamma_0 + \sum_{i=1}^5 \gamma_i V_{t-i} + \sum_{j=1}^5 \delta_j r_{t-j}$										
Company	α_0	α_1	α_2	α_3	α_4	α_5	β_1	β_2	β_3	β_4	β_5	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	δ_1	δ_2	δ_3	δ_4	δ_5
ABB	0.090	0.064*	-0.001	0.002	0.001	-0.014	0.02	0.02	-0.07	-0.06	0.04	-0.001	0.36*	0.21*	0.11*	0.13*	0.01	0.009	0.009	-0.001	-0.003	0.001
ACC	0.03	0.02	-0.03	-0.01	0.03	-0.01	-0.04	0.01	0.05	-0.15	0.07	0.00	0.38*	0.15*	0.11*	0.12*	0.11*	0.02*	0.00	0.01	0.00	0.01
AMBUJA	0.03	0.02	-0.06*	0.00	0.04	-0.01	-0.01	-0.05	0.04	-0.06	-0.06	0.000	0.05	0.03	0.06*	0.03	0.03	0.000	-0.003	-0.004	0.014	0.005
BHARTI	0.18*	-0.01	-0.06*	-0.03	-0.03	0.02	-0.07	-0.07	-0.15**	0.04	-0.04	0.001	0.07*	0.06*	0.05**	0.05	0.04	-0.005	0.000	0.003	0.003	-0.004
BHEL	0.12	0.04	-0.07*	-0.01	0.02	-0.02	-0.09	0.05	0.21	-0.29	0.03	0.00	0.58*	0.07*	0.15*	0.06*	0.06*	0.00	-0.01*	-0.01*	0.01	-0.01
BPCL	0.03	0.08*	0.02	0.01	-0.01	-0.04	-0.33*	0.07	0.06	0.10	-0.06	0.000	0.47*	0.06*	0.07*	0.10*	0.09*	0.015	0.000	0.004	0.001	-0.002
CIPLA	0.03	0.08*	0.00	-0.05*	0.00	0.01	-0.05	-0.04	0.08	-0.07	0.01	-0.002	0.42*	0.09*	0.12*	0.08*	0.06*	0.033	0.001	0.004	0.010	-0.004
CAIRN	0.04	0.03	0.02	-0.07	-0.15*	0.00	0.11	-0.30	0.40	-0.01	-0.26	-0.01	0.68*	-0.19*	0.30*	-0.01	0.10**	0.02*	-0.01	0.00	-0.01	-0.01
DLF	-0.16	0.01	-0.04	0.06	-0.01	-0.01	0.20	-0.22	0.07	0.20	-0.38	-0.017	0.24*	0.18*	0.02	0.17*	0.03	0.003	0.000	0.004	0.002	-0.001
GAIL	0.06	-0.01	-0.07*	0.00	0.01	-0.07*	0.03	0.06	0.03	-0.06	-0.22	0.000	0.48*	0.12*	0.13*	0.09*	0.11*	0.008	0.001	-0.003	-0.002	0.000
GRASIM	0.03	0.06*	-0.04	0.06*	0.02	0.04	-0.04	0.14	-0.07	-0.06	0.02	0.00	0.36*	0.15*	0.09*	0.09*	0.14*	0.02*	0.00	-0.01	-0.01	-0.01
HCL	-0.07	0.07*	-0.02	-0.06*	-0.02	-0.10*	-0.12	0.09	-0.25	0.29*	-0.06	-0.005	0.35*	0.19*	0.12*	0.06*	0.10*	-0.003	0.000	0.005	-0.003	-0.002
HDFC	0.09	-0.02	-0.05*	-0.02	-0.05*	-0.03	-0.03	0.02	-0.04	0.00	-0.01	0.000	0.06*	0.05*	0.05*	0.05*	0.06*	0.003	0.008	0.003	0.000	-0.005
HDFCORP	0.13**	0.03	-0.09*	-0.06*	-0.02	-0.08*	-0.01	-0.18*	0.01	0.07	-0.10	0.00	0.11*	0.09*	0.09*	0.05**	0.05*	0.01	0.00	0.02*	0.00	-0.01
HINDALC	-0.02	0.12*	-0.01	-0.06*	0.03	0.01	0.15	-0.16	-0.01	-0.21**	0.10	0.00	0.47*	0.14*	0.14*	0.04	0.05*	0.01	0.00	-0.02*	0.00	-0.01
HLL	0.00	0.04	-0.02	-0.04	0.01	-0.06*	0.03	0.02	-0.02	-0.07	0.04	0.00	0.28*	0.15*	0.11*	0.11*	0.10*	0.01	-0.01	-0.01	0.00	-0.01
HONDA	0.06	0.04	-0.10*	-0.05*	-0.03	0.01	-0.08	0.10	-0.03	-0.05	0.00	0.002	0.36*	0.06*	0.09*	0.06*	0.10*	0.011	-0.013	-0.003	0.000	-0.010
ICICI	0.08	0.12*	-0.06*	0.01	-0.03	-0.01	-0.02	0.12	-0.02	-0.25*	-0.03	0.003	0.27*	0.21*	0.08*	0.09*	0.14*	-0.010	0.003	0.000	-0.005	0.003
IDEA	-0.11	0.10	0.00	0.00	0.03	0.01	-0.03	-0.32	0.46	0.00	-0.18	-0.02	0.35*	0.14*	0.14	-0.07	0.12*	0.01	0.00	0.00	0.01	0.00
INFOSYS	0.01	0.09*	-0.07*	0.00	-0.04	-0.03	-0.14	0.19	-0.41*	0.18	0.04	-0.001	0.47*	0.17*	0.12*	0.06*	0.09*	-0.011*	0.001	0.000	-0.001	0.007
ITC	0.05	-0.02	-0.01	0.01	0.02	0.00	-0.01	-0.10	0.03	-0.16	0.05	-0.01	0.45*	0.06*	0.13*	0.05	0.10*	0.03*	0.01	0.00	0.00	0.01
L&T	0.02	0.08*	-0.05	0.02	0.01	-0.03	-0.02	-0.02	0.12	-0.06	-0.17	-0.001	0.48*	0.10*	0.11*	0.14*	0.06*	0.005	-0.008	-0.004	0.000	-0.008
M&M	0.00	0.14*	-0.05**	-0.01	0.01	-0.05**	0.07	0.09	-0.12	0.02	-0.10	0.000	0.24*	0.16*	0.12*	0.11*	0.15*	0.013**	0.002	0.001	0.002	0.000
MARUTI	0.08	0.04	-0.05	-0.01	0.01	-0.04	-0.14	0.17	0.07	-0.05	-0.06	0.000	0.55*	0.08*	0.15*	-0.03	0.19*	-0.011**	0.006	0.000	-0.002	-0.005
NALCO	0.04	0.04	0.01	-0.02	-0.01	0.03	-0.03	0.05	-0.05	-0.03	-0.11	0.000	0.37*	0.12*	0.09*	0.11*	0.07*	0.019	0.005	-0.003	0.004	-0.006
NTPC	0.09	0.01	-0.08*	-0.03	-0.01	-0.02	-0.21	0.09	-0.36**	-0.08	0.24	-0.01	0.55*	0.02	0.06	0.11*	0.16*	0.03*	0.00	0.01	0.01	0.00
ONGC	0.067	0.089*	-0.069*	-0.003	0.017	0.003	0.14	-0.07	-0.04	-0.10	-0.02	0.001	0.32*	0.11*	0.10*	0.16*	0.08*	0.009	0.002	-0.001	0.003	-0.006
PNB	0.16**	0.02	-0.03	-0.04	0.01	-0.05	0.00	0.20	-0.30*	0.07	-0.14	0.00	0.49*	0.16*	-0.01	0.10*	0.07*	0.02*	0.01	-0.01	0.01	0.00
POWER&G	-0.09	0.15*	-0.10	-0.05	-0.07	-0.06	-0.12	-0.44	1.00	0.22	-0.06	-0.023	0.71*	-0.26*	0.28*	0.07	0.08	0.008	0.001	0.007	0.000	0.009
RANBAXY	-0.01	0.05	-0.01	0.02	0.01	0.01	-0.20*	0.00	0.00	0.05	0.02	0.00	0.48*	0.08*	0.02	0.06*	0.15*	0.01	-0.01*	0.00	0.01	-0.01
RCOMM	-0.06	-0.08**	-0.02	0.03	-0.10*	0.01	0.11	0.12	-0.10	-0.28	-0.14	-0.011	0.45*	0.08	0.12*	-0.03	0.12*	0.010	0.003	-0.005	-0.003	0.003

company	α_0	α_1	α_2	α_3	α_4	α_5	β_1	β_2	β_3	β_4	β_5	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	δ_1	δ_2	δ_3	δ_4	δ_5
RELIANC	0.062	0.036	-0.004	-0.038	-0.004	0.008	-0.15**	0.09	0.00	-0.06	0.00	0.00	0.41*	0.01	0.22*	0.14*	-0.02	0.01**	0.01	0.01**	0.00	0.00
RPOWER	-0.35	0.16**	-0.04	0.16**	-0.08	-0.01	0.56	0.13	0.42	-0.54	-0.56	0.097	0.23*	0.24*	0.04	0.30*	0.46*	0.003	-0.003	-0.006	0.004	0.001
RINFRA	0.05	0.06*	-0.06*	0.03	-0.04	-0.01	0.03	-0.31	-0.26	0.49*	0.06	0.001	0.46*	0.19*	0.09*	0.04	0.16*	0.005	0.000	-0.001	0.001	0.004
RPETRO	0.02	0.12	-0.03	-0.06	0.01	0.03	0.06	0.09	-0.59*	0.25	0.05	0.00	0.52*	0.04	0.23*	-0.11*	0.20*	0.01	0.02	0.02	0.01	0.01
SAIL	0.07	0.05*	-0.03	0.01	0.01	0.01	-0.27	-0.09	0.17	-0.08	0.15	0.00	0.53*	0.03	0.17*	0.01	0.14*	0.02*	0.00	0.01**	0.00	0.00
SATYAM	-0.02	0.04	-0.04	-0.01	0.00	-0.03	0.20	-0.31	-0.29	0.29	-0.02	0.00	0.45*	0.13*	0.09*	0.15*	0.12*	0.01*	0.00	0.01*	-0.01*	0.00
SBI	0.07	0.06*	-0.04	0.00	0.00	-0.04**	-0.17	0.10	-0.01	-0.04	0.05	0.00	0.40*	0.14*	0.14*	0.13*	0.10*	0.01*	0.02*	0.00	0.00	-0.01
SIEMENS	0.07	0.06*	-0.02	0.01	0.01	0.04	-0.10	-0.06	0.07	-0.06	0.00	-0.002	0.67*	-0.04	0.06*	0.05**	0.07*	0.014*	0.000	0.005	0.004	-0.004
STERLIT	0.04	0.05**	-0.02	0.02	0.03	0.02	0.47	0.16	0.07	-3.29*	1.61*	-0.002	0.45*	0.08*	0.18*	0.04	0.19*	0.013*	0.010*	0.002	0.005*	0.000
SUNPHAR	0.10	0.02	-0.01	0.00	-0.03	-0.03	-0.17*	-0.07	0.05	-0.02	0.05	-0.002	0.15*	0.03	0.11*	0.08*	0.11*	0.019*	0.003	0.002	-0.004	0.005
SUZLON	-0.10	0.05	0.00	0.01	0.07	0.04	-0.18	0.51	-0.43	-0.38	0.07	-0.01	0.41*	0.09**	0.13*	0.04	0.05	0.00	0.01**	-0.01	0.00	-0.01
TATACOM	-0.01	0.08**	-0.04	-0.02	-0.02	-0.03	-0.05	0.09	-0.19	0.25	-0.07	0.000	0.44*	0.24*	-0.06*	0.15*	0.08*	0.008**	-0.001	-0.003	0.002	-0.001
TATAMOT	-0.02	0.11*	-0.03	-0.02	-0.03	0.03	-0.03	0.06	0.07	-0.03	-0.05	-0.001	0.49*	0.09*	0.12*	0.10*	0.14*	0.010*	0.000	0.000	-0.003	-0.006
TATAPOW	0.09	0.08*	-0.08*	0.01	0.02	0.00	-0.30*	0.03	-0.21	0.60*	-0.24*	-0.01	0.48*	0.05**	0.01	0.24*	0.12*	0.03*	0.00	0.01*	0.00	0.02*
TATASTE	0.02	0.07*	-0.03	0.02	-0.01	0.02	0.02	0.03	-0.19	0.19	-0.14	0.00	0.40*	0.13*	0.13*	0.08*	0.18*	0.01	0.01*	0.01	0.00	0.00
TCS	0.00	0.03	-0.10*	-0.10*	-0.10*	0.04	-0.01	-0.06	0.00	0.01	0.02	-0.017	0.09*	0.04	0.02	0.02	0.02	-0.003	0.000	-0.001	-0.001	-0.003
UNITECH	0.21**	-0.02	0.00	0.03	0.06*	0.05**	0.07	-0.10	-0.14	-0.11	0.05	0.008	0.42*	0.06*	0.19*	0.07*	0.14*	-0.002	0.000	-0.008*	0.006**	-0.002
WIPRO	-0.03	0.05*	0.02	-0.01	0.01	0.00	0.19	0.11	-0.43**	0.30	-0.31	0.000	0.50*	0.14*	0.04	0.15*	0.12*	0.005	0.003	-0.004	0.000	-0.002
ZEE	-0.09	0.04	-0.01	-0.01	-0.04	-0.02	0.36	-0.16	-0.29	0.01	-0.21	-0.003	0.40*	0.17*	0.11*	0.19*	0.08*	0.006*	0.003	-0.001	-0.003	0.005**

4.2.1 Variance Decomposition and Impulse Response Function

We carry out impulse response function and variance decomposition analysis in addition to the Granger causality tests and VAR modeling. Such an analysis explains economic significance in addition to statistical significance. The results are reported only for volume as the proxy for trading volume as value and trade show similar results. From the variance decomposition (Table 9), it is evident that any variation in returns is explained by its own lagged returns (>99%) itself than by the lagged volume. In approximately 8% of the stocks, lagged volume explains more than 1% variation in stock returns. From the results of variance decomposition, volume is highly autoregressive i.e. variation in volume is mainly explained by its lagged volume (>95%) than by the lagged returns. However, it is important to note that the lagged returns are able to explain more than 5% variation in volume in case of 4 stocks, more than 3% variation in case of 5 stocks and more than 1% variation in case of 17 stocks. These results support the findings of Granger causality test that in emerging markets returns to some extent lead the trading.

The impulse response of returns to shocks in returns and volume series is given in Appendix A. It can be seen that for most of the stocks, the returns are not affected by volume shock at any lag. Hence even though we have statistical significance of volume affecting returns at one lag, it is not economically significant. Similar to the result found under VAR, returns are found to be autoregressive but effective for one day. The impulse response of volume to shocks in returns and volume is presented in Appendix B. As can be seen from the results, the volume is more autoregressive in nature than the returns. For most stocks, the effect of volume shock to volume is persistent up to many lags (more than 12). The exceptions are BHARTI, HDFC, HDFC Corp., ICICI, SUNPHARMA and TCS where the effect of any shock in volume affects the volume only the next day. It is also interesting to note that for some stocks (HCL, HINDALCO, CAIRN, INFOSYS, RANBAXY, RELIANCE COM., RELIANCE POWER, SUZLON and UNITECH) the effect of returns shock at higher lags on volume is negative. This may mean that trading volume responds to positive change in prices contemporaneously but with overreaction. With lagged returns, this overreaction corrects itself and the volume eventually reduces.

4.3 Trading Volume and Unconditional Volatility

The relationship between unconditional volatility and trading volume and its asymmetric behavior i.e. stronger relationship between trading volume and volatility when price ticks up than downtick, is estimated through OLS using equation [2]. The results are presented in Table 10. The estimates of β_1 , which measures the contemporaneous correlation between unconditional volatility and volume irrespective of the direction of price change, are significant and positive at 1% level in most of the stocks and are consistent for all the three measures of volume. In all the cases, the coefficients are positive. The asymmetric relationship between unconditional volatility and trading volume is also prominent in most of the cases (33 stocks when value, 31 when volume and 38 when number of trades is taken as measure of trading volume). When returns are negative, the relation between trading volume and volatility is lower as compared to when the returns are positive. Similar to the findings in case of returns and trading volume relationship, the asymmetric behavior is more prominent when the daily number of transactions is taken as the proxy of daily trading volume. This can be interpreted that the number of transactions may be more accurate proxy of information than the other two measures. Harris (1987) also argued that the transaction data may be a better proxy of information.

4.4. Trading Volume and Conditional Volatility

In order to investigate the effect of trading volume and conditional volatility, we first model the time series of all the stock returns using GARCH (1,1) model. The parameter estimates of GARCH (1,1) are presented in Table 11. It is found that for all stocks the conditional volatility is time varying and shows persistence. The persistence of the conditional variance process, which we measure by $\alpha_1 + \beta_1$, is high (>0.9) except for DLF and is often close to unity.

Table 9: Proportions of Variation in Returns and Volume due to shock s in Returns and Volume

This table gives the variance decomposition of returns and volume by shocks in returns and volume. In other words, it gives the proportion of variation of returns explained by returns itself and the proportion by volume and vice versa. The lags that are reported are 1, 5, 10, 15 and 20. The proportions are given in percentage form.

Proportions of Prediction Error Covariances																				
Lag	Returns										Volume									
	1	5	10	15	20	1	5	10	15	20	1	5	10	15	20	1	5	10	15	20
Company	Returns					Volume					Returns					Volume				
ABB	100.0%	99.9%	99.6%	99.6%	99.6%	0.0%	0.1%	0.4%	0.4%	0.4%	1.2%	1.0%	0.9%	0.9%	0.9%	98.8%	99.0%	99.1%	99.1%	99.1%
ACC	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	4.1%	6.0%	6.0%	6.0%	6.0%	95.9%	94.0%	94.0%	94.0%	94.0%
AMBUJA	100.0%	99.9%	99.8%	99.8%	99.8%	0.0%	0.1%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	99.8%	99.7%	99.7%	99.7%	99.7%
BHARTI	100.0%	99.6%	99.6%	99.6%	99.6%	0.0%	0.4%	0.4%	0.4%	0.4%	0.0%	0.2%	0.2%	0.2%	0.2%	100.0%	99.8%	99.8%	99.8%	99.8%
BHEL	100.0%	100.0%	99.9%	99.9%	99.9%	0.0%	0.0%	0.1%	0.1%	0.1%	2.2%	1.6%	1.2%	1.0%	1.0%	97.8%	98.4%	98.8%	99.0%	99.0%
BPCL	100.0%	99.5%	99.5%	99.5%	99.5%	0.0%	0.5%	0.5%	0.5%	0.5%	1.7%	2.5%	2.5%	2.5%	2.5%	98.3%	97.5%	97.5%	97.5%	97.5%
CIPLA	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.3%	0.3%	0.3%	0.3%	100.0%	99.7%	99.7%	99.7%	99.7%
CAIRN	100.0%	99.7%	99.6%	99.6%	99.6%	0.0%	0.3%	0.4%	0.4%	0.4%	2.9%	4.5%	4.1%	3.9%	3.9%	97.1%	95.5%	95.9%	96.1%	96.1%
DLF	100.0%	99.5%	99.4%	99.4%	99.4%	0.0%	0.5%	0.6%	0.6%	0.6%	2.8%	2.0%	1.7%	1.5%	1.4%	97.2%	98.0%	98.4%	98.5%	98.6%
GAIL	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.2%	1.6%	1.2%	0.9%	0.8%	0.8%	98.4%	98.8%	99.1%	99.2%	99.2%
GRASIM	100.0%	99.8%	99.8%	99.8%	99.8%	0.0%	0.2%	0.2%	0.2%	0.2%	2.5%	2.2%	1.6%	1.3%	1.2%	97.5%	97.8%	98.4%	98.7%	98.8%
HCL	100.0%	99.4%	99.4%	99.4%	99.4%	0.0%	0.6%	0.6%	0.6%	0.6%	0.1%	1.1%	0.9%	0.8%	0.8%	99.9%	98.9%	99.1%	99.2%	99.2%
HDFC	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.3%	0.3%	0.3%	0.3%	99.8%	99.7%	99.7%	99.7%	99.7%
HDFCORP	100.0%	99.9%	99.8%	99.8%	99.8%	0.0%	0.1%	0.2%	0.2%	0.2%	0.1%	0.6%	0.6%	0.6%	0.6%	99.9%	99.4%	99.4%	99.4%	99.4%
HINDALC	100.0%	99.5%	99.4%	99.4%	99.4%	0.0%	0.5%	0.6%	0.6%	0.6%	0.1%	1.6%	3.5%	4.1%	4.3%	99.9%	98.4%	96.5%	95.9%	95.7%
HLL	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	1.7%	1.6%	1.5%	1.4%	1.4%	98.3%	98.4%	98.6%	98.6%	98.6%
HONDA	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	1.2%	1.3%	1.3%	1.3%	1.3%	98.8%	98.7%	98.7%	98.7%	98.7%
ICICI	100.0%	99.8%	99.8%	99.8%	99.8%	0.0%	0.2%	0.2%	0.2%	0.2%	0.0%	0.2%	0.2%	0.2%	0.2%	100.0%	99.8%	99.8%	99.8%	99.8%
IDEA	100.0%	99.2%	99.1%	99.1%	99.1%	0.0%	0.8%	0.9%	0.9%	0.9%	0.9%	1.3%	1.6%	1.6%	1.6%	99.1%	98.7%	98.4%	98.4%	98.4%
INFOSYS	100.0%	99.7%	99.7%	99.7%	99.7%	0.0%	0.3%	0.3%	0.3%	0.3%	0.0%	2.0%	2.0%	2.0%	2.0%	100.0%	98.0%	98.0%	98.0%	98.0%
ITC	100.0%	99.9%	99.8%	99.8%	99.8%	0.0%	0.1%	0.2%	0.2%	0.2%	0.5%	0.7%	0.6%	0.6%	0.6%	99.5%	99.3%	99.4%	99.4%	99.4%
L&T	100.0%	99.7%	99.6%	99.6%	99.6%	0.0%	0.3%	0.4%	0.4%	0.4%	1.9%	1.6%	1.2%	1.1%	1.0%	98.1%	98.4%	98.8%	98.9%	99.0%
M&M	100.0%	99.8%	99.7%	99.7%	99.7%	0.0%	0.2%	0.3%	0.3%	0.3%	2.7%	3.5%	3.6%	3.6%	3.6%	97.3%	96.5%	96.4%	96.4%	96.4%
MARUTI	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	2.1%	1.3%	0.9%	0.7%	0.7%	97.9%	98.7%	99.1%	99.3%	99.3%
NALCO	100.0%	100.0%	99.9%	99.9%	99.9%	0.0%	0.0%	0.1%	0.1%	0.1%	1.9%	2.7%	2.6%	2.6%	2.6%	98.1%	97.3%	97.4%	97.4%	97.4%

NTPC	100.0%	99.6%	99.6%	99.6%	99.5%	0.0%	0.4%	0.4%	0.4%	0.5%	0.3%	1.2%	1.2%	1.2%	1.2%	99.7%	98.8%	98.8%	98.8%	98.8%
ONGC	100.0%	99.8%	99.7%	99.7%	99.7%	0.0%	0.2%	0.3%	0.3%	0.3%	0.2%	0.4%	0.3%	0.3%	0.3%	99.8%	99.6%	99.7%	99.7%	99.7%
PNB	100.0%	99.2%	99.1%	99.1%	99.1%	0.0%	0.8%	0.9%	0.9%	0.9%	8.4%	10.2%	10.7%	10.8%	10.8%	91.6%	89.8%	89.3%	89.2%	89.2%
POWER&G	100.0%	99.0%	98.8%	98.7%	98.7%	0.0%	1.0%	1.2%	1.3%	1.3%	0.3%	1.3%	2.5%	2.7%	2.9%	99.7%	98.7%	97.5%	97.3%	97.1%
RANBAXY	100.0%	99.7%	99.7%	99.6%	99.6%	0.0%	0.3%	0.4%	0.4%	0.4%	0.4%	0.6%	0.7%	0.7%	0.7%	99.6%	99.4%	99.3%	99.3%	99.3%
RCOMM	100.0%	99.4%	99.3%	99.3%	99.3%	0.0%	0.6%	0.7%	0.7%	0.7%	0.1%	1.1%	1.3%	1.3%	1.3%	99.9%	98.9%	98.7%	98.7%	98.7%
RELIANC	100.0%	99.8%	99.8%	99.8%	99.8%	0.0%	0.2%	0.2%	0.2%	0.2%	0.0%	0.4%	0.4%	0.4%	0.4%	100.0%	99.6%	99.6%	99.6%	99.7%
RPOWER	100.0%	98.6%	96.9%	96.1%	95.6%	0.0%	1.4%	3.1%	3.9%	4.4%	0.3%	0.3%	0.2%	0.1%	0.1%	99.7%	99.7%	99.8%	99.9%	99.9%
RINFRA	100.0%	99.7%	99.7%	99.7%	99.7%	0.0%	0.3%	0.3%	0.3%	0.3%	1.2%	1.0%	0.9%	0.8%	0.7%	98.8%	99.0%	99.1%	99.2%	99.3%
RPETRO	100.0%	99.3%	99.2%	99.2%	99.2%	0.0%	0.7%	0.8%	0.8%	0.8%	0.2%	3.4%	5.5%	6.3%	6.7%	99.8%	96.6%	94.5%	93.7%	93.3%
SAIL	100.0%	99.8%	99.7%	99.7%	99.7%	0.0%	0.2%	0.3%	0.3%	0.3%	5.6%	13.0%	14.5%	15.2%	15.6%	94.4%	87.0%	85.5%	84.8%	84.4%
SATYAM	100.0%	99.6%	99.6%	99.6%	99.6%	0.0%	0.4%	0.4%	0.4%	0.4%	0.0%	0.7%	1.9%	2.3%	2.4%	100.0%	99.3%	98.1%	97.7%	97.6%
SBI	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	1.5%	3.1%	3.0%	2.9%	2.9%	98.5%	96.9%	97.0%	97.1%	97.1%
SIEMENS	100.0%	99.7%	99.5%	99.4%	99.4%	0.0%	0.3%	0.5%	0.6%	0.6%	0.1%	0.5%	0.4%	0.4%	0.4%	99.9%	99.5%	99.6%	99.6%	99.6%
STERLIT	100.0%	97.7%	97.5%	97.3%	97.2%	0.0%	2.3%	2.5%	2.7%	2.8%	0.4%	1.3%	1.4%	1.4%	1.4%	99.6%	98.7%	98.6%	98.6%	98.6%
SUNPHAR	100.0%	99.7%	99.7%	99.7%	99.7%	0.0%	0.3%	0.3%	0.3%	0.3%	0.5%	0.8%	0.8%	0.8%	0.8%	99.5%	99.2%	99.2%	99.2%	99.2%
SUZLON	100.0%	96.7%	96.7%	96.6%	96.6%	0.0%	3.3%	3.3%	3.4%	3.4%	0.0%	0.3%	1.9%	2.4%	2.8%	100.0%	99.7%	98.1%	97.6%	97.2%
TATACOM	100.0%	99.8%	99.8%	99.8%	99.8%	0.0%	0.2%	0.2%	0.2%	0.2%	2.5%	3.1%	3.0%	3.0%	3.0%	97.5%	96.9%	97.0%	97.0%	97.0%
TATAMOT	100.0%	99.9%	99.8%	99.8%	99.8%	0.0%	0.1%	0.2%	0.2%	0.2%	2.3%	3.2%	2.6%	2.3%	2.2%	97.7%	96.8%	97.4%	97.7%	97.8%
TATAPOW	100.0%	99.4%	99.2%	99.2%	99.2%	0.0%	0.6%	0.8%	0.8%	0.8%	1.7%	4.1%	4.4%	4.5%	4.5%	98.3%	95.9%	95.6%	95.5%	95.5%
TATASTE	100.0%	99.7%	99.7%	99.7%	99.7%	0.0%	0.3%	0.3%	0.3%	0.3%	1.3%	1.8%	1.8%	1.8%	1.8%	98.7%	98.2%	98.2%	98.2%	98.2%
TCS	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	0.0%	0.2%	0.3%	0.3%	0.3%	100.0%	99.8%	99.7%	99.7%	99.7%
UNITECH	100.0%	99.6%	99.5%	99.5%	99.5%	0.0%	0.5%	0.5%	0.5%	0.5%	0.0%	3.7%	6.5%	7.8%	8.6%	100.0%	96.3%	93.5%	92.2%	91.4%
WIPRO	100.0%	99.9%	99.9%	99.9%	99.9%	0.0%	0.1%	0.1%	0.1%	0.1%	0.4%	0.5%	0.4%	0.4%	0.4%	99.6%	99.5%	99.6%	99.6%	99.6%
ZEE	100.0%	99.9%	99.9%	99.8%	99.8%	0.0%	0.1%	0.1%	0.2%	0.2%	3.7%	2.9%	2.2%	1.8%	1.7%	96.3%	97.1%	97.8%	98.2%	98.4%

Table 10: Relationship between Standardized Trading Volume and Unconditional Volatility

This table provides the coefficient estimates from regressions of trading volume against unconditional volatility and asymmetric coefficient of the OLS equation $V_t = \alpha + \beta_1 r_t^2 + \beta_2 D_t r_t^2$, where V_t = standardized trading volume at time t , r_t is the return at time t and $D_t=1$ when $r_t < 0$ and $D_t=0$ when $r_t \geq 0$. Three measures of trading volume, the daily total dollar value of shares traded (value), the daily number of shares traded (volume) and the daily number of equity trades (trade) are considered. Parameter estimates of all 50 companies are presented.

Company	Value				Volume				Trade			
	α	β_1	β_2	RSQ	α	β_1	β_2	RSQ	α	β_1	β_2	RSQ
ABB	-0.06*	1.38*	-0.78*	0.019	-0.12*	2.77*	-1.42*	0.083	-0.11*	2.48*	-1.15*	0.071
ACC	-0.10*	2.01*	-1.32*	0.053	-0.11*	2.34*	-1.74*	0.067	-0.12*	2.48*	-1.64*	0.081
AMBUJA	-0.02	0.50**	-0.38	0.002	-0.02	0.46**	-0.33	0.002	-0.12*	2.28*	-0.74*	0.067
BHARTI	-0.04	0.33	0.41	0.007	-0.04	0.44**	0.10	0.006	-0.17*	1.83*	0.86*	0.125
BHEL	-0.09*	1.45*	-0.72*	0.049	-0.12*	1.87*	-0.97*	0.080	-0.10*	1.44*	-0.52*	0.056
BPCL	-0.12*	1.65*	-0.75*	0.080	-0.13*	1.62*	-0.44*	0.095	-0.13*	1.58*	-0.44*	0.089
CIPLA	-0.15*	3.43*	-1.36*	0.135	-0.11*	1.85*	0.39	0.087	-0.15*	2.85*	-0.28	0.138
CAIRN	-0.10*	1.20*	-1.02*	0.056	-0.10*	0.99*	-0.79*	0.065	-0.12*	1.25*	-0.90*	0.068
DLF	-0.03	0.00	-0.02	0.000	-0.04	0.00	0.11	0.004	-0.04	0.00	0.18	0.006
GAIL	-0.04*	0.78*	-0.56*	0.033	-0.05**	0.98*	-0.76*	0.048	-0.06*	1.02*	-0.77*	0.053
GRASIM	-0.07*	1.62*	-1.10*	0.034	-0.08*	1.69*	-0.95*	0.040	-0.12*	2.44*	-1.28*	0.085
HCL	-0.14*	1.16*	-0.45*	0.099	-0.14*	1.03*	-0.19	0.095	-0.15*	1.08*	-0.16	0.108
HDFC	-0.02	0.37**	-0.16	0.003	-0.01	0.35**	-0.23	0.003	-0.07*	1.21*	-0.08	0.051
HDFCORP	-0.06*	0.76*	0.26	0.019	-0.05**	0.70*	0.04	0.013	-0.18*	2.43*	0.52**	0.175
HINDALC	-0.14*	2.59*	-1.00*	0.140	-0.21*	3.75*	-1.42*	0.295	-0.19*	3.04*	-0.61*	0.246
HLL	-0.14*	4.09*	-2.64*	0.120	-0.09*	2.75*	-1.80*	0.054	-0.14*	3.82*	-1.82*	0.118
HONDA	-0.05*	0.98*	-0.35	0.014	-0.09*	1.84*	-0.78*	0.048	-0.11*	1.65*	0.07	0.051
ICICI	-0.10*	0.82*	0.20	0.056	-0.06**	0.49*	0.09	0.019	-0.15*	1.17*	0.48*	0.136
IDEA	-0.04	0.23	-0.37	0.005	-0.07**	0.38**	-0.25	0.011	-0.08*	0.63*	-0.44	0.025
INFOSYS	-0.10*	1.55*	-0.89*	0.070	-0.10*	1.48*	-0.63*	0.085	-0.12*	1.77*	-0.82*	-0.12
ITC	-0.18*	3.70*	-0.49	0.161	-0.11*	2.25*	-0.37	0.058	-0.16*	3.35*	-0.68**	-0.16
L&T	-0.12*	3.08*	-3.05*	0.116	-0.10*	2.48*	-2.46*	0.075	-0.10*	2.60*	-2.57*	-0.10
M&M	-0.01	0.37**	-0.55*	0.004	-0.04	0.76*	-0.70*	0.014	-0.06*	1.06*	-0.81*	0.028
MARUTI	-0.11*	2.03*	-1.04*	0.053	-0.10*	1.85*	-1.01*	0.048	-0.12*	2.13*	-0.96*	0.062
NALCO	-0.07*	1.04*	-0.80*	0.038	-0.07*	1.07*	-0.80*	0.041	-0.10*	1.28*	-0.66*	0.073
NTPC	-0.16*	2.47*	0.15	0.194	-0.09*	1.15*	0.01	0.096	-0.21*	3.52*	0.22	0.299
ONGC	-0.04	0.59*	0.14	0.014	-0.06**	0.89*	0.05	0.026	-0.08*	1.11*	0.16*	0.044
PNB	-0.14*	2.04*	-1.44*	0.113	-0.18*	2.58*	-1.70*	0.187	-0.17*	2.37*	-1.44*	0.164
POWER&G	-0.16	2.00	-1.82	0.139	-0.18*	2.07*	-1.83*	0.179	-0.19*	2.28*	-1.93*	0.168
RANBAXY	-0.13*	2.69*	-1.38*	0.110	-0.15*	3.05*	-1.30*	0.158	-0.15*	3.14*	-1.39*	0.162
RCOMM	-0.08**	0.68	-0.39	0.030	-0.14*	1.14*	-0.52*	0.113	-0.16*	1.42*	-0.58*	0.160
RELIANC	-0.11*	1.93*	-0.43**	0.144	-0.11*	2.38*	-1.19*	0.123	-0.13*	2.49*	-0.87*	0.184
RPOWER	-0.02	0.02	0.19	0.002	-0.02	-0.01	0.30	0.003	-0.03	0.06	0.22	0.003
RINFRA	-0.11*	1.40*	-0.75*	0.102	-0.12*	1.74*	-1.07*	0.141	-0.12*	1.47*	-0.69*	0.124
RPETRO	-0.17*	2.08*	-0.77*	0.215	-0.20*	2.43*	-1.04*	0.294	-0.18*	2.28*	-0.94*	0.238
SAIL	-0.09*	0.75*	-0.10	0.062	-0.12*	0.98*	-0.21	0.102	-0.11*	0.75*	0.17	0.082
SATYAM	-0.11*	1.23*	-0.75*	0.077	-0.12*	1.20*	-0.53*	0.098	-0.16*	1.34*	-0.32*	0.174
SBI	-0.12*	2.29*	-0.80*	0.069	-0.13*	2.48*	-1.04*	0.074	-0.14*	2.62*	-0.79*	0.096
SIEMENS	-0.10*	1.68*	-0.56*	0.064	-0.16*	1.75*	0.79*	0.166	-0.14*	1.78*	0.25	0.122
STERLIT	-0.07*	0.89*	-0.88*	0.045	-0.07*	0.94*	-0.94*	0.057	-0.06*	0.83*	-0.83*	0.041
SUNPHAR	-0.05**	0.80*	-0.25	0.011	-0.05**	0.87*	-0.42	0.012	-0.15*	2.43*	-0.54**	0.110
SUZLON	-0.12*	1.14*	-1.02*	0.162	-0.13*	1.29*	-1.04*	0.164	-0.15*	1.37*	-1.06*	0.221
TATACOM	-0.05**	0.76*	-0.73*	0.026	-0.05**	0.75*	-0.67*	0.026	-0.06*	0.82*	-0.70*	0.032
TATAMOT	-0.03	0.60*	-0.57*	0.005	-0.10*	1.83*	-1.32*	0.046	-0.08*	1.33*	-0.66*	0.031
TATAPOW	-0.13*	1.72*	-0.48*	0.128	-0.09*	1.25*	-0.43*	0.063	-0.11*	1.42*	-0.26	0.097
TATASTE	-0.09*	1.41*	-0.68*	0.042	-0.12*	1.90*	-1.01*	0.072	-0.17*	2.29*	-0.63*	0.149
TCS	-0.05	0.68**	-0.05	0.008	-0.08**	1.25*	-0.11	0.028	-0.16*	2.38*	0.48	0.173
UNITECH	-0.06**	0.48*	-0.42*	0.034	-0.09	0.75	-0.59	0.104	-0.09*	0.73*	-0.59*	0.093
WIPRO	-0.10*	0.95*	-0.39*	0.059	-0.09	0.88	-0.36	0.051	-0.12*	1.08*	-0.32*	0.087
ZEE	-0.08*	0.74*	-0.47*	0.035	-0.11	1.15	-0.81	0.075	-0.11*	1.19*	-0.81*	0.083

*(**) represents significance of the parameter at 1 % (5%) significance level.

Table 11: GARCH parameters estimate

This table provides the GARCH (1,1) parameters estimate for returns of the equation

$$r_t = a + \sum_{i=1}^5 b_i r_{t-i} + \varepsilon_t \text{ where, } \varepsilon_t | \psi_{t-1} \sim N(0, \sigma_t^2) \text{ and } \sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 . r_t \text{ is the return at}$$

time t.

Company	α	$\alpha 1$	$\beta 1$	$\alpha 1 + \beta 1$
ABB	0.824*	0.214*	0.651*	0.865
ACC	0.197*	0.136*	0.847*	0.982
AMBUJA	0.145*	0.112*	0.868*	0.980
BHARTI	0.297*	0.090*	0.873*	0.963
BHEL	0.238*	0.128*	0.849*	0.977
BPCL	0.201*	0.069*	0.911*	0.980
CIPLA	0.333*	0.104*	0.836*	0.941
CAIRN	0.609*	0.179*	0.774*	0.952
DLF	33.821*	0.000	0.000	0.000
GAIL	0.190*	0.131*	0.860*	0.991
GRASIM	0.116*	0.104*	0.881*	0.986
HCL	0.144*	0.093*	0.900*	0.993
HDFC	0.437*	0.251*	0.699*	0.950
HDFCORP	0.243*	0.126*	0.839*	0.965
HINDALC	0.278*	0.140*	0.821*	0.961
HLL	0.342*	0.107*	0.823*	0.930
HONDA	0.660*	0.177*	0.727*	0.905
ICICI	0.216*	0.101*	0.879*	0.980
IDEA	0.573*	0.150*	0.805*	0.954
INFOSYS	0.131*	0.109*	0.885*	0.994
ITC	0.282*	0.118*	0.827*	0.944
L&T	1.850*	0.106*	0.729*	0.835
M&M	0.314*	0.134*	0.831*	0.965
MARUTI	0.199*	0.109*	0.865*	0.974
NALCO	0.340*	0.151*	0.828*	0.980
NTPC	0.171*	0.124*	0.845*	0.969
ONGC	0.112*	0.098*	0.891*	0.990
PNB	0.242*	0.130*	0.851*	0.982
POWER&G	1.011**	0.400*	0.582*	0.982
RANBAXY	0.338*	0.148*	0.802*	0.950
RCOMM	0.400*	0.132*	0.845*	0.977
RELIANC	0.848*	0.312*	0.572*	0.884
RPOWER	2.887	0.227*	0.594*	0.821
RINFRA	0.264*	0.155*	0.827*	0.982
RPETRO	0.058*	0.091*	0.911*	1.002
SAIL	0.748*	0.191*	0.767*	0.957
SATYAM	0.055*	0.062*	0.937*	0.999
SBI	0.160*	0.093*	0.884*	0.977
SIEMENS	0.630*	0.234*	0.697*	0.931
STERLIT	3.955*	1.884*	0.119*	2.003
SUNPHAR	0.132*	0.112*	0.871*	0.983
SUZLON	0.862*	0.120*	0.834*	0.954
TATACOM	0.404*	0.057*	0.915*	0.972
TATAMOT	0.249*	0.104*	0.867*	0.971
TATAPOW	0.173*	0.111*	0.873*	0.983
TATASTE	0.448*	0.156*	0.793*	0.949
TCS	0.217*	0.149*	0.810*	0.959
UNITECH	2.189*	0.197*	0.691*	0.888
WIPRO	0.325*	0.151*	0.832*	0.982
ZEE	0.928*	0.143*	0.802*	0.945

*(**) indicates significance at 1%(5%) level.

In most of the cases, the autoregressive parameter of conditional volatility is higher than the return innovations (except for STERLITE). The mixed distribution hypothesis or the relationship between conditional volatility and trading volume is then estimated by modifying GARCH equation as explained in equation [5]. The MDH model predicts that if trading volume is a proxy of information and if daily volume is serially correlated then the parameter $\chi > 0$ and $(\alpha_1 + \beta_1)$ will become either small or statistically insignificant. The persistence of variance as measured by $(\alpha_1 + \beta_1)$ should become negligible if accounting for the uneven flow of information (V) explains the presence of ARCH effect in the data. The contemporaneous trading volume (V) is assumed as the proxy of information⁵. The parameter estimates of equation [5] are presented in Table 12. In most cases, the inclusion of trading volume as an explanatory variable in the conditional variance equation results in a substantial reduction of volatility persistence in daily returns. Hence, serially correlated news arrival processes proxied by trading volume as a source of ARCH effect is indicated by results in the Indian stock market. It is found that around 80% of the companies have trading volume as significant explanatory variable (across all three measures).

In approximately 34% of the stocks the GARCH parameters become statistically insignificant and in case of another 44%, the persistence reduces dramatically when volume is used as an explanatory variable in the conditional volatility equation. In 18 stocks, the explanatory power of GARCH is not reduced by the inclusion of trading volume as explanatory variable. When value is used, the GARCH effect becomes insignificant in 16% cases only and when trade is used, 54% stocks show insignificant GARCH effect. However, in all stocks the volume parameter is positive and significant at 1% significant level. This result supports strong relationship between contemporaneous trading volume and conditional volatility. However, our results provide mixed conclusions, not entirely rejecting the MDH nor giving it an unconditional support in case of Indian stock market. Similar results have been reported by Ane and Ureche-Rangau (2008). Ane and Ureche-Rangau (2008) analyzed the temporal dependence of volatility and volume on 50 LSE stocks and found mixed results. They found that in some stocks the effect of volume is very strong, in some moderate and in some cases it has negligible effect. They tried to explain these differences by understanding the long term behavior of volume and volatility and found that the stocks for which the trading volume has negligible explanatory power as compared to the ARCH effect, have highest difference in the fractional differencing parameter of volume and volatility. It is possible that these two variables do share common short-term movements, but they may have fundamentally different long-term behavior.

Other results which support MDH over ARCH effect for most of the stocks are in line with the findings of Lamoureux and Lastrapes (1990), Kim & Kon, (1994), Gallo & Pacini, (2000), and Omran & McKenzie (2000) in developed markets and Pyun, Lee, and Nam (2000) and Bohl and Henke (2003) in emerging market. Pyun, Lee, and Nam (2000) studied 15 individual shares of the Korean stock market and found that all stocks show high statistically significant positive correlation with contemporaneous volume. They found that as the volume is used in GARCH equation as an exogenous variable the return volatility persistence reduces dramatically. Bohl and Henke (2003) investigated 20 Polish stocks and found that in majority of cases volatility persistence tends to disappear when trading volume is included in the conditional variance equation.

⁵ In most of the stocks and across all three measures of trading volume, we found very high autocorrelation. This fact validates one of the assumption of MDH.

Table 11: GARCH parameters estimate with trading volatility as one of the exogenous variable of the GARCH equation

This table provides the GARCH (1,1) parameters estimate for returns of the equation

$$r_t = a + \sum_{i=1}^5 b_i r_{t-i} + \varepsilon_t \text{ where, } \varepsilon_t | \psi_{t-1} \sim N(0, \sigma_t^2) \text{ and } \sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 + \chi V_t. r_t \text{ is the}$$

return at time t and V_t is standardized trading volume at time t. Three measures of trading volume, the daily total dollar value of shares traded (value), the daily number of shares traded (volume) and the daily number of equity trades (trade) are considered.

Company	Value					Volume					Trade				
	α	β_1	β_1	β_1	χ	α	β_1	β_1	β_1	χ	α	β_1	β_1	β_1	χ
ABB	1.131*	0.258*	0.560*	0.818	0.34*	5.015*	0.209*	0.000	0.209	5.80*	5.208*	0.229*	0.000	0.229	5.52*
ACC	0.573*	0.161*	0.771*	0.932	0.47*	3.569*	0.253*	0.310*	0.564	3.38*	6.235*	0.196*	0.001	0.197	5.04*
AMBUJA	0.174*	0.117*	0.858*	0.975	0.11	0.171*	0.116*	0.859*	0.975	0.10**	4.429*	0.297*	0.068**	0.365	4.05*
BHARTI	1.949*	0.215*	0.555*	0.770	2.67*	8.439*	0.153*	0.000	0.153	33.59*	6.581*	0.144*	0.000	0.144	4.92*
BHEL	5.237*	0.333*	0.151*	0.485	4.95*	8.495*	0.176*	0.000	0.176	11.84*	8.650*	0.216*	0.000	0.216	11.73*
BPCL	2.329*	0.255*	0.511*	0.766	1.36*	6.127*	0.282*	0.088**	0.370	4.41*	6.304*	0.293*	0.068	0.361	4.617*
CIPLA	4.364*	0.215*	0.054*	0.269	5.29*	4.389*	0.281*	0.047*	0.327	4.85*	4.254*	0.230*	0.032*	0.262	4.65*
CAIRN	4.744*	0.384*	0.305*	0.689	5.86*	5.877*	0.381*	0.222*	0.603	7.95*	10.46*	0.310*	0.000	0.310	13.35*
DLF	32.67*	0.000	0.002	0.002	0.00	33.84*	0.000	0.000	0.000	1.25	33.83*	0.000	0.000	0.000	0.00
GAIL	5.781*	0.351*	0.165*	0.516	6.17*	6.219*	0.145*	0.830*	0.975	0.30*	5.575*	0.162*	0.790*	0.953	0.55*
GRASIM	0.230*	0.120*	0.847*	0.967	0.16*	0.548*	0.170*	0.761*	0.932	0.66*	4.381*	0.271*	0.116*	0.387	4.09*
HCL	4.797*	0.415*	0.325*	0.740	5.41*	1.152*	0.189*	0.746*	0.935	1.64*	2.689*	0.263*	0.583*	0.846	3.29*
HDFC	1.248*	0.295*	0.550*	0.845	2.85*	5.877*	0.230*	0.013	0.242	18.85*	5.530*	0.191*	0.000	0.191	8.33*
HDFCORP	4.139*	0.230*	0.269*	0.499	9.41*	6.219*	0.139*	0.089*	0.228	15.85*	6.288*	0.108*	0.000	0.108	9.95*
HINDALC	3.928*	0.296*	0.150*	0.445	3.86*	0.807*	0.183*	0.700*	0.883	0.64*	5.123*	0.279*	0.040	0.319	5.61*
HLL	4.301*	0.149*	0.025	0.173	4.38*	1.983*	0.259*	0.348*	0.608	1.25*	3.867*	0.157*	0.005	0.162	3.05*
HONDA	0.790*	0.197*	0.689*	0.886	0.21*	1.032*	0.204*	0.645*	0.849	0.49*	4.888*	0.245*	0.000	0.245	2.94*
ICICI	0.283*	0.094*	0.879*	0.973	0.20*	0.335*	0.099*	0.869*	0.968	0.64*	5.323*	0.099*	0.870*	0.969	0.21*
IDEA	0.468*	0.216*	0.761*	0.978	0.34	0.684*	0.180*	0.771*	0.951	0.56	0.605*	0.170*	0.786*	0.955	0.20
INFOSYS	5.538*	0.301*	0.146*	0.447	6.20*	5.281*	0.184*	0.172*	0.356	4.47*	4.844*	0.203*	0.149*	0.353	3.50*
ITC	3.418*	0.231*	0.135*	0.366	3.60*	2.694*	0.297*	0.236*	0.533	2.38*	3.765*	0.249*	0.018	0.267	3.11*
L&T	12.75*	0.044*	0.000	0.044	14.71*	9.298*	0.067*	0.013	0.081	3.50*	11.06*	0.000	0.000	0.000	9.25*
M&M	0.340*	0.143*	0.819*	0.961	0.05	0.453*	0.148*	0.799*	0.947	0.19*	0.464*	0.154*	0.793*	0.947	0.12*
MARUTI	0.256*	0.117*	0.849*	0.966	0.08	0.239*	0.112*	0.856*	0.969	0.05	6.340*	0.119*	0.000	0.119	3.91*
NALCO	0.490*	0.222*	0.764*	0.985	0.20*	0.551*	0.206*	0.765*	0.972	0.37*	0.760*	0.216*	0.738*	0.954	0.41*
NTPC	5.180*	0.102*	0.000	0.102	6.76*	5.347*	0.090*	0.000	0.090	10.41*	5.267*	0.021	0.000	0.021	5.90*
ONGC	0.134*	0.108*	0.879*	0.988	0.06*	0.134*	0.108*	0.875*	0.986	0.07*	0.141*	0.107*	0.880*	0.987	0.03*
PNB	1.142*	0.224*	0.669*	0.893	0.86*	8.464*	0.206*	0.000	0.206	9.31*	7.709*	0.202*	0.000	0.202	6.35*
POWER&G	1.508*	0.488*	0.497*	0.985	1.57	2.412*	0.474*	0.466*	0.939	4.20**	10.65*	0.319*	0.000	0.319	14.61*
RANBAXY	5.352*	0.225*	0.011	0.236	7.33*	5.601*	0.141*	0.000	0.141	7.82*	5.129*	0.166*	0.000	0.166	6.52*
RCOMM	9.976*	0.243*	0.085*	0.328	8.42*	9.449*	0.074**	0.155**	0.229	8.33*	9.652*	0.394*	0.001	0.395	7.55*
RELIANC	3.673*	0.334*	0.063*	0.397	3.03*	2.385*	0.381*	0.267*	0.648	1.97*	4.427*	0.262*	0.000	0.262	4.14*
RPOWER	2.698	0.225*	0.609*	0.834	0.95	3.087	0.230*	0.580*	0.810	0.86	2.984	0.221*	0.597*	0.817	1.12
RINFRA	4.509*	0.306*	0.337*	0.642	7.42*	8.659*	0.206*	0.000	0.206	12.70*	11.10*	0.251*	0.000	0.251	19.43*
RPETRO	6.956*	0.269*	0.090	0.359	9.87*	8.566*	0.065	0.007	0.072	10.27*	10.09*	0.077	0.000	0.077	11.24*
SAIL	1.106*	0.215*	0.717*	0.933	0.46*	10.783*	0.290*	0.000	0.290	11.65*	1.832*	0.239*	0.640*	0.879	0.83*
SATYAM	5.890*	0.313*	0.301*	0.614	5.66*	1.930*	0.226*	0.648*	0.875	1.59*	6.960*	0.286*	0.186*	0.472	5.73*
SBI	4.804*	0.223*	0.024	0.247	2.47*	0.336*	0.113*	0.837*	0.950	0.15*	5.186*	0.210*	0.000	0.210	3.53*
SIEMENS	1.904*	0.314*	0.450*	0.764	1.72*	5.764*	0.231*	0.017	0.248	7.14*	5.321*	0.291*	0.038	0.328	5.92*
STERLIT	14.15*	0.673*	0.003	0.676	10.97*	22.911*	0.256*	0.000	0.256	32.01*	14.81*	0.143*	0.418*	0.562	20.40*
SUNPHAR	0.744*	0.257*	0.646*	0.903	0.83*	1.188*	0.298*	0.545	0.843	1.70*	3.996*	0.329*	0.082*	0.411	3.78*
SUZLON	14.69*	0.17*	0.009	0.184	16.3*	25.286*	0.084**	0.000	0.084	51.98*	18.54*	0.058	0.002	0.059	24.74*
TATACOM	9.35*	0.35*	0.09*	0.448	11.0*	6.530*	0.426*	0.203*	0.629	6.60*	7.564*	0.432*	0.169*	0.602	8.57*
TATAMOT	0.26*	0.10*	0.86*	0.969	0.00	0.286*	0.107*	0.859*	0.966	0.04	0.249*	0.104*	0.867*	0.971	0.00
TATAPOW	1.29*	0.21*	0.64*	0.856	0.7*	0.308*	0.114*	0.853*	0.967	0.20*	5.378*	0.274*	0.104*	0.378	4.20*
TATASTE	0.95*	0.207*	0.682*	0.889	0.36*	1.543*	0.245*	0.576*	0.821	0.73*	1.522*	0.234*	0.589*	0.823	0.67*
TCS	0.211*	0.154*	0.808*	0.961	0.01	3.699*	0.274*	0.107*	0.382	6.27*	3.950*	0.126*	0.052	0.178	3.74*
UNITECH	11.1*	0.292*	0.144**	0.436	5.19*	6.035*	0.228*	0.470*	0.698	6.29*	4.071*	0.233*	0.556*	0.790	1.57*
WIPRO	5.632*	0.366*	0.311*	0.677	7.08*	3.615*	0.397*	0.366*	0.763	3.72*	4.652*	0.375*	0.312*	0.687	4.60*
ZEE	7.99*	0.30*	0.247*	0.547	8.42*	11.543*	0.281*	0.031	0.313	10.79*	12.02*	0.259*	0.000	0.259	9.96*

*indicates significance at the 1% level.

In line with such empirical evidence in other emerging markets, our result partially supports the implications of the MDH which provides, to a large extent, a valid theoretical explanation for behavior of volatility. However, our results are mixed as opposed to the findings of Sharma et al. (1996), Chen (2001) Argo and Nieto (2005) who found that the total trading volume is unable to eliminate the ARCH effect.

5. Conclusions

Understanding the relationship between returns, volatility and trading volume in financial markets is equally important for traders, researchers and policy makers. The distribution of returns has implications for various financial models and risk management practices. The dynamic relationship between returns and trading volume helps to understand the market clearing process and frictions in the market. Also, implications of trading volume in forecasting volatility helps agents like traders, with a very short-term investment horizon and many portfolio managers that have a medium- to long-term investment horizon. In emerging markets generally and in Indian stock market context specifically, very few empirical studies has been reported on aforementioned issues. This paper reports an empirical study for Indian Stock market.

Using 50 Indian stocks, we analyze the returns and volume relationship, focusing on the contemporaneous relation between absolute returns and trading volume, the asymmetric behavior of trading volume in response to price changes and dynamic (lead-lag) relationship between returns and trading volume. We model the dynamic relationship using VAR model. This study also investigates the contemporaneous relationship between volatility and trading volume. In this study we generalize the work of Lamoureux and Lastrapes (1990) which supports the influence of trading volume on the persistence of GARCH effects on the returns of the financial assets.

Our findings indicate evidence of positive contemporaneous correlation between absolute price changes and trading volume in Indian stock markets. However, we get mixed result on asymmetric relationship between trading volume and returns. Most of the stocks show asymmetric behavior which is in line with the findings of Assogbavi et al. (1995) and Brailsford (1996). Some of the stocks, where we do not find asymmetric behavior, are consistent with the findings of Assogbavi (2007) that clearly indicated the absence of asymmetric relationship in emerging markets. The results of dynamic relationship between returns and trading volume show very interesting results. We find strong evidence that in Indian market, past returns Granger cause trading volume, which can easily conceived in an emerging market (Assogbavi, 2007) where the state of development of the market possibly does not allow instantaneous information dissemination. Our results are further supported by the variance decomposition. However, in most of the cases the relationship lacks economic significance even when statistically significant. The results of impulse response analysis indicate that both returns and volume are mostly affected by their own lag and the volume is more autoregressive than returns i.e. any shock in either returns or volume does not affect the return series beyond one lag.

In case of unconditional volatility and trading volume, we find positive contemporaneous relationship between trading volume and unconditional volatility. However, the results on asymmetric relationship are mixed. In most of the cases, there exists asymmetric relationship and relationship is stronger when prices move up than when prices go down. In some stocks, we do

not find such asymmetric relationship. The results of relation between trading volume and conditional volatility support strong contemporaneous relationship between trading volume and conditional volatility. However, our results are mixed. They do not entirely reject the MDH nor give it an unconditional support. In more than 70% of the stocks, ARCH effect is either reduced or becomes insignificant when trading volume is included in GARCH equation. It indicates that the trading volume is a better proxy of information than the volatility itself. However for some stocks the GARCH parameters do not reduce. Similar kind of mixed results have been found for LSE stocks by Ane and Ureche-Rangau (2008). Our results also indicate that in Indian stock markets, the daily number of transactions may be a better proxy of information than the total number of shares traded or the total value of shares traded.

References

- Abdullah, D.A. and P.C. Rangazas (1988). "Money and the Business Cycle: Another Look", *Review of Economics and Statistics*, 70, 680-85.
- Admati, A.R. and Pfleiderer, P., (1988). "A Theory of Intraday Trading Patterns: Volume and Price Variability", *Review of Financial Studies*, 1,3-40.
- Andersen, T. (1996). "Return volatility and trading volume: An information flow interpretation of stochastic volatility", *Journal of Finance*, 51, 169–204.
- Ane, T. and Ureche-Rangau, L. (2008). "Does trading volume really explain stock returns volatility?", *Journal of International Financial Markets, Institutions, and Money*, 18, 216–235.
- Argo, V. and Nieto, L. (2005). "Heteroskedasticity in the returns of the main world stock exchange indices: volume versus GARCH effects", *Journal of International Financial Markets, Institutions, and Money*, 15, 271–384.
- Assogbavi, T. (2007) "Equity Price-Volume Relationship On The Russian Stock Exchange", *International Business & Economics Research Journal*, Vol 6, 9, 107-116.
- Assogbavi, T., Khoury, N., and Yourougou, P. (1995). "Short interest and the asymmetry of the price-volume relationship in the Canadian Stock market", *Journal of Banking & Finance* 19 1341-1358
- Bhagat, S., Bhatia, S. (1996). "Trading Volume and Price Variability: Evidence on Lead-Lag Relations for Granger-Causality Tests", Working paper, University of Colorado at Boulder.
- Bohl, M. T., and Henke, H. (2003). "Trading volume and stock market volatility: The Polish case", *International Review of Financial Analysis*, 12, 513–525
- Blume, L., Easley, D., and O'Hara, M. (1994). "Market statistics and technical analysis: The role of volume", *Journal of Finance*, 49, 153-182.
- Brailsford, T. (1996). "The empirical relationship between trading volume, returns, and volatility", *Accounting and Finance*, 35, 89–111.
- Chen, K. and Fong W. N., (2000). "Trade size, order imbalance, and the volatility-volume relation", *Journal of Financial Economics*, 57, 247-273.
- Chen, G. M., Firth, M., and Rui, O. M. (2001). "Dynamic relation between stock returns, trading volume, and volatility". *Financial Review*, 36, 153–73.

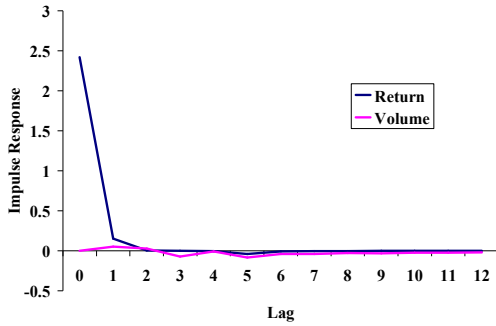
- Chordia, T. and Swaminathan, B. (2000). "Trading volume and cross-autocorrelations in stock returns", *Journal of Finance*, 55,913-935.
- Clark, P.K. (1973). "A subordinated stochastic process model with finite variance for speculative prices", *Econometrica*, 41, 135-55.
- Copeland, T. E. (1976). "A model of asset trading under the assumption of sequential information arrival", *Journal of Finance* 31, 1149-1168.
- Crouch, R. L., (1970). "The volume of transactions and price changes on the New York Stock Exchange", *Financial Analysts Journal*, 26, 104-109.
- Epps, T., Epps, M. (1976). "The stochastic dependence of security price changes and transaction volumes: Implications for the mixture-of-distributions hypothesis", *Econometrica*, 44, 305-321.
- Foster, F.D. and Viswanathan, S. (1990). "A Theory of Interday Variations in Volume, Variance and Trading Costs in Securities Markets", *Review of Financial Studies*, 3, 593-624.
- Gallo, G., & Pacini, B. (2000). "The effects of trading activity on market volatility", *European Journal of Finance*, 6, 163-175.
- Grundy, B., and McNichols, M. (1989). "Trade and revelation of information through prices and direct disclosure", *Review of Financial Studies*, 2, 495-526.
- Harris, L. (1986). "Cross-security tests of the mixture of distributions hypothesis", *Journal of Financial and Quantitative Analysis*, 21, 39-46.
- Harris, L. (1986). "A Transaction Data Study of Weekly and Intradaily Patterns in Stock Returns", *Journal of Financial Economics*, 16, 99-117.
- Harris, L., (1987), "Transaction Data Tests of the Mixture of Distributions Hypothesis", *Journal of Financial and Quantitative Analysis*, June, 22, 127-141.
- Harris, M., Raviv, A. (1993). "Differences of opinion make a horse race", *Review of Financial Studies*, 6, 473-506.
- He, H., and Wang, J. (1995). "Differential information and dynamic behaviour of stock trading volume", *Review of Financial Studies*, 8:919-72.
- Henry and McKenzie (2006) "The Impact of Short Selling on the Price-Volume Relationship: Evidence from Hong Kong", *Journal of Business*, 2006, 79, 2, 671-691.
- Hiemstra, C., and Jones, J. D. (1994). "Testing for linear and non-linear Granger causality in the stock price-volume relationship". *Journal of Finance* 49:1639-64.

- Jennings, R.H. and Barry, C. (1983). "Information dissemination and portfolio choice", *Journal of Financial and Quantitative Analysis*, 18, 1-19.
- Karpoff, J.M. (1986). "A theory of trading volume", *Journal of Finance*, 41, 1069-1088.
- Karpoff, J.M., (1987). "The relation between price changes and trading volume: A survey", *Journal of Financial and Quantitative Analysis*, 22, 109-126
- Kim, D., & Kon, S. (1994). "Alternative models for the conditional heteroscedasticity of stock returns", *Journal of Business*, 67, 563–588.
- Kim, O., and Verrecchia, R. (1991). "Market reactions to anticipated announcements", *Journal of Financial Economics*, 30, 273-310
- Kyle, A. (1988). "Trading halts and price limits. Review of Futures Markets", 7, 426–434.
- Kyle, A. (1985). "Continuous auctions and insider trading", *Econometrica*, 53, 1315-1335.
- Lamoureux, C.G. and W.D. Lastrapes (1990). "Heteroskedasticity in stock return data: Volume versus GARCH effects", *Journal of Finance*, 45, 221-229.
- Lamoureux, C.G. and W.D. Lastrapes (1994). "Endogenous trading volume and momentum in stock-return volatility", *Journal of Business and Economic Statistics*, 12, 253-260.
- Lange, S. (1999). "Modeling asset market volatility in a small market: Accounting for non-synchronous trading effects", *Journal of International Financial Markets, Institutions, and Money*, 9, 1–18.
- Morse, D. (1980). "Asymmetrical information in securities markets and trading volume", *Journal of Financial and Quantitative Analysis*, 15, 1129-1 148.
- Omran, M., & McKenzie, E. (2000). "Heteroscedasticity in stock returns data revisited: Volume versus GARCH Effects", *Applied Financial Economics*, 10, 553–560.
- Pyun, C., Lee, S., & Nam, K. (2000). "Volatility and information flows in emerging equity markets: A case of the Korean stock exchange", *International Review of Financial Analysis*, 9, 405–420.
- Ratner, M., and Leal, R. P. C. (2001). "Stock returns and trading volume: Evidence from the emerging markets of Latin America and Asia. *Journal of Emerging Markets*, 6, 5–22.
- Rogalski, R.J. (1978). "The dependence of prices and volume", *Review of Economics and Statistics*, 60, 268-274.
- Sharma, J.L., Mougoue, M., and Kamath, R. (1996). "Heteroscedasticity in stock market indicator return data: volume versus GARCH effects", *Applied Financial Economics*, 6, 337–342.

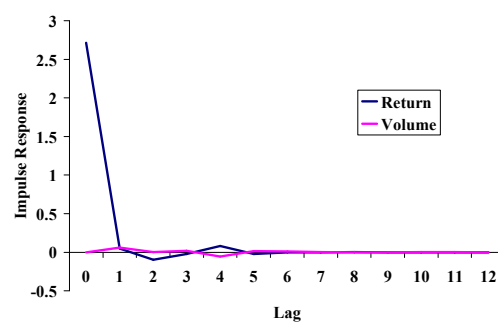
- Sims, C. (1972), "Money, Income, and Causality", *American Economic Review*, 62, 540-52.
- Sims, C. (1980), "Macroeconomics and Reality", *Econometrica* 48, 1-48.
- Smirlock, M., and Starks, L. (1985). "A further examination of stock price changes and transaction volume", *Journal of Financial Research* 8, 217-225.
- Smirlock, M., Starks, L.T. (1988). "An empirical analysis of the stock price-volume relationship", *Journal of Banking Finance*, 12, 1, 31-41.
- Tauchen, G. E. and M. Pitts (1983). "The price variability-volume relationship on speculative markets", *Econometrica*, **51**, 485-505.
- Varian, H. (1985). "Divergence of opinion in complete markets: a note", *Journal of Finance*, 40, 309-317.
- Varian, H. (1989). "Differences of opinion in financial markets. In: Stone, C. (Ed.), *Financial risk: theory, evidence and implications*, Proceedings of the Eleventh Annual Economic Policy Conference of the Federal Reserve Bank of St. Louis. Kluwer, Boston, pp. 3-37.
- Wang, J. (1994). "A model of competitive stock trading volume", *Journal of Political Economy*, 102, 127- 168.
- Holthausen, R., and Verrecchia, R. (1990). "The effect of informedness and consensus on price and volume behavior", *Accounting Review*, 65, 191-208.

Appendix A

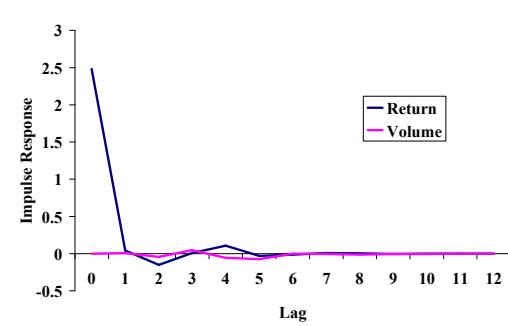
Impulse Response Function of Return (ABB)



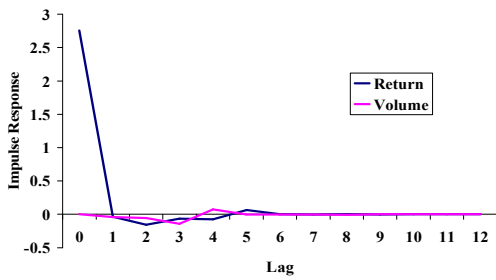
Impulse Response Function of Return (ACC)



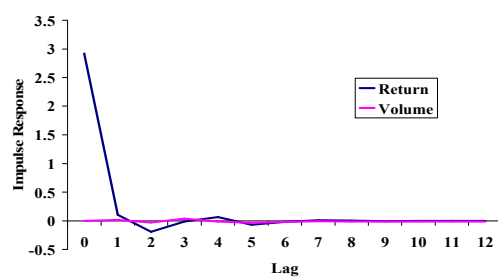
Impulse Response Function of Return (AMBUJA)



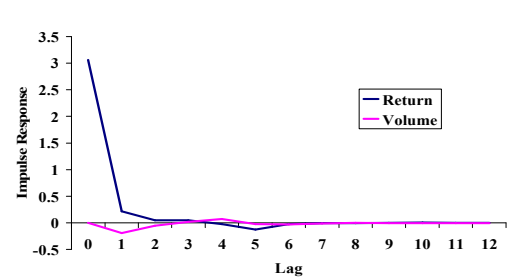
Impulse Response Function of Return (BHARTI)



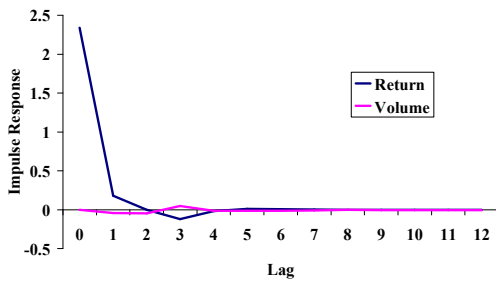
Impulse Response Function of Return (BHEL)



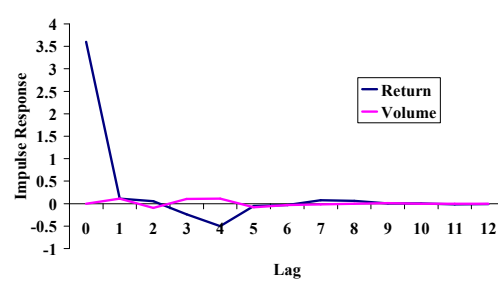
Impulse Response Function of Return (BPCL)



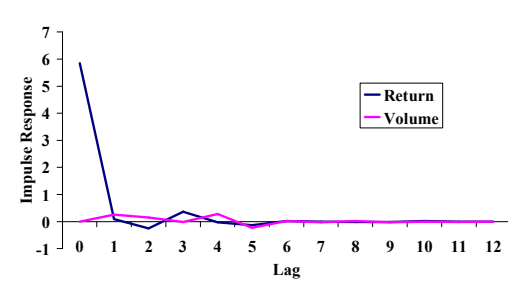
Impulse Response Function of Return (CIPLA)



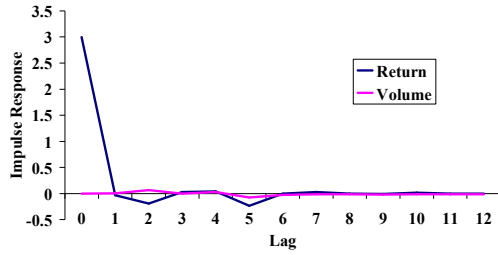
Impulse Response Function of Return (CAIRN)



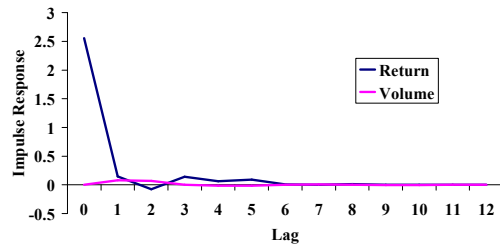
Impulse Response Function of Return (DLF)



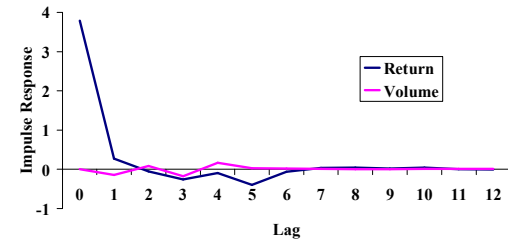
Impulse Response Function of Return (GAIL)



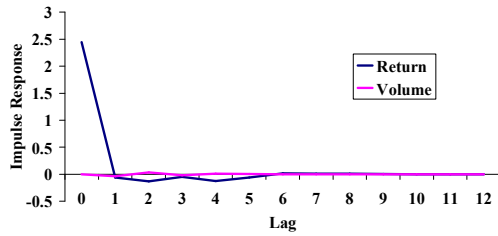
Impulse Response Function of Return (GRASIM)



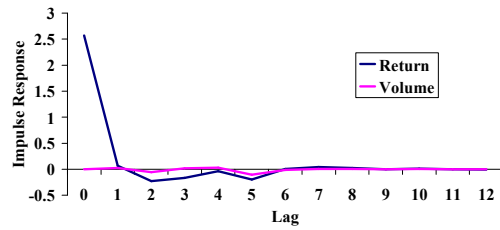
Impulse Response Function of Return (HCL)



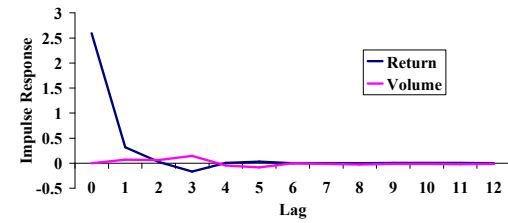
Impulse Response Function of Return (HDFC)



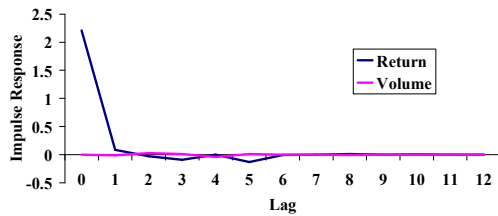
Impulse Response Function of Return (HDFCORP)



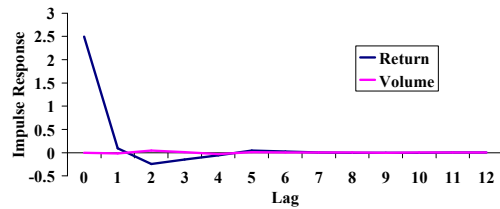
Impulse Response Function of Return (HINDALCO)



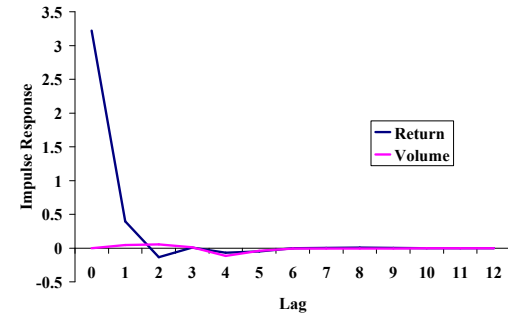
Impulse Response Function of Return (HLL)



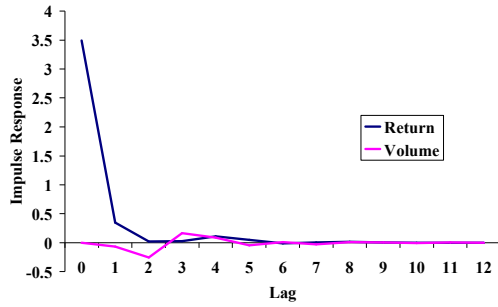
Impulse Response Function of Return (HONDA)



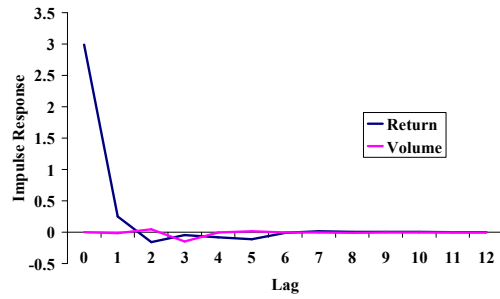
Impulse Response Function of Return (ICICI)



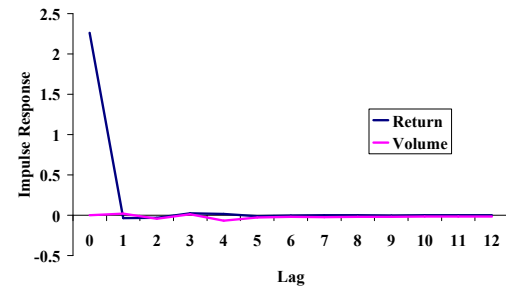
Impulse Response Function of Return (IDEA)



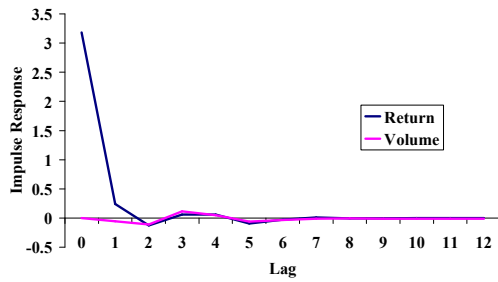
Impulse Response Function of Return (INFOSYS)



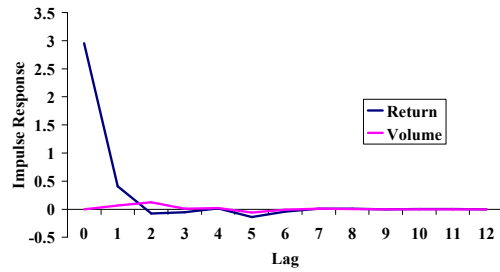
Impulse Response Function of Return (ITC)



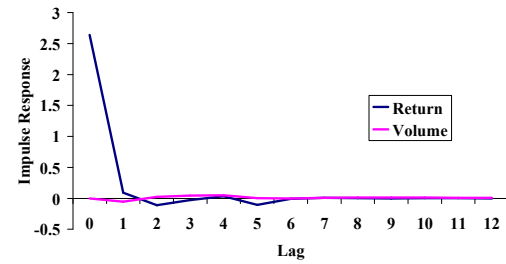
Impulse Response Function of Return (L&T)



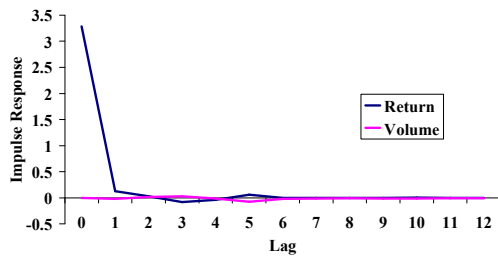
Impulse Response Function of Return (M&M)



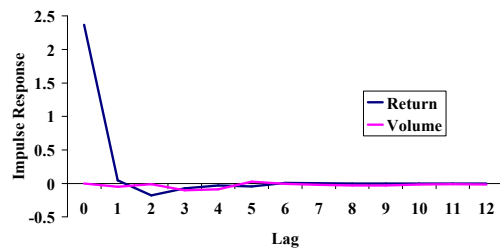
Impulse Response Function of Return (MARUTI)



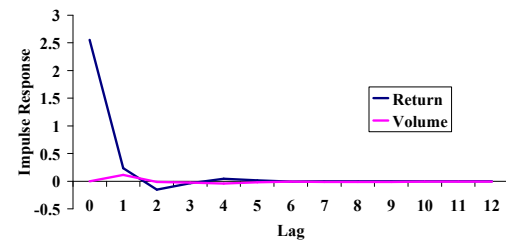
Impulse Response Function of Return (NALCO)



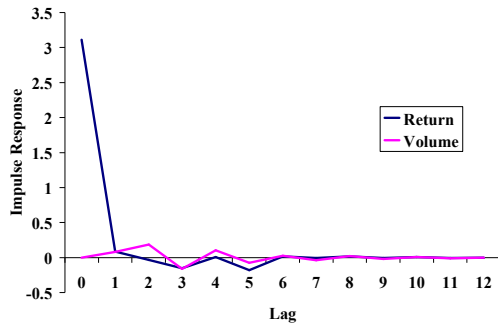
Impulse Response Function of Return (NTPC)



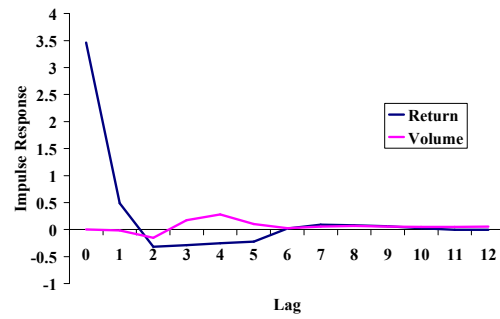
Impulse Response Function of Return (ONGC)



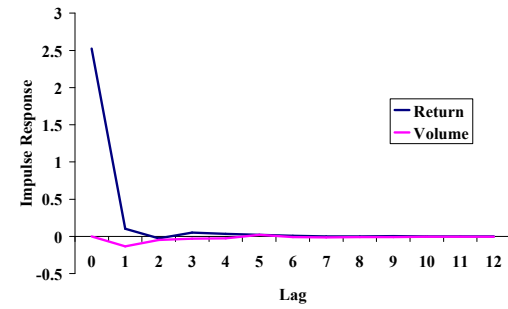
Impulse Response Function of Return (PNB)



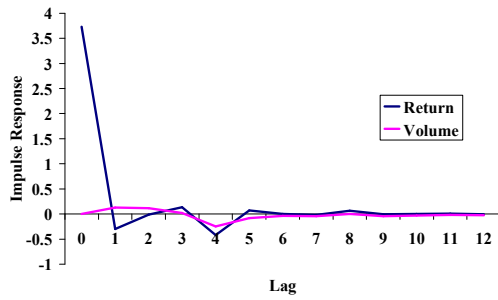
Impulse Response Function of Return (Power Grid)



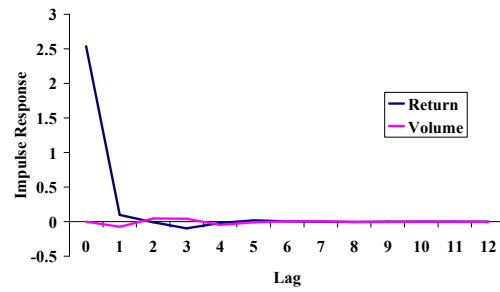
Impulse Response Function of Return (RANBAXY)



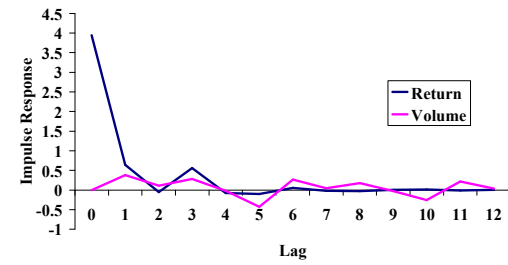
Impulse Response Function of Return (RCOMM)



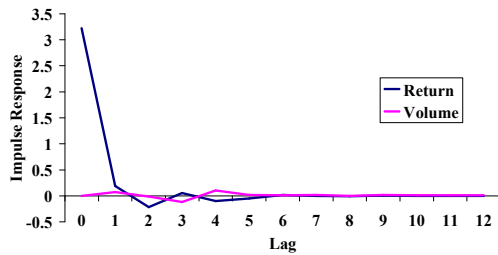
Impulse Response Function of Return (RELIANCE)



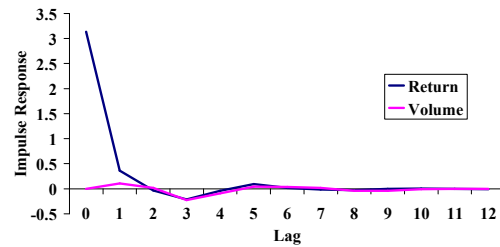
Impulse Response Function of Return (RELIANCE POWER)



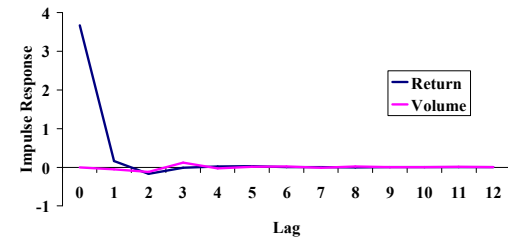
Impulse Response Function of Return (RELIANCE INFRA)



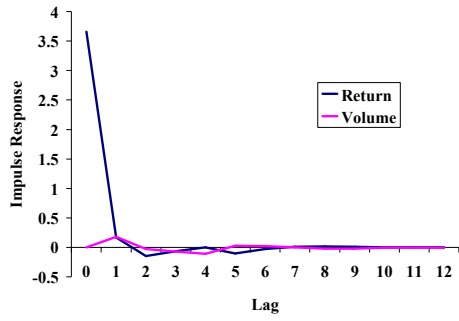
Impulse Response Function of Return (RELIANCE PETRO)



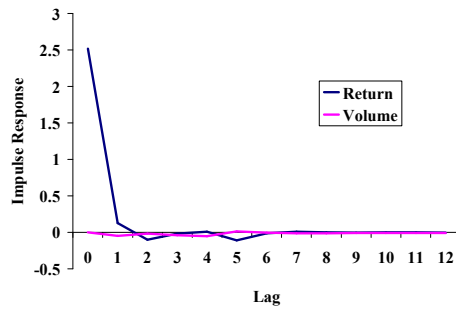
Impulse Response Function of Return (SAIL)



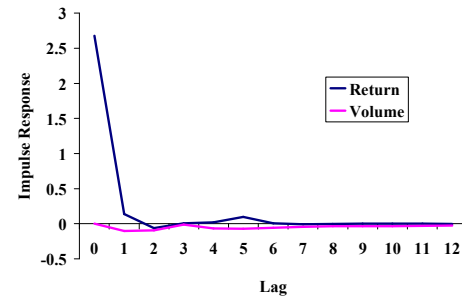
Impulse Response Function of Return (SATYAM)



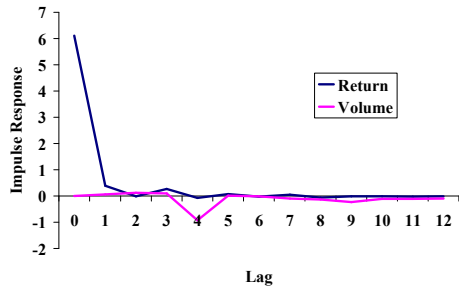
Impulse Response Function of Return (SBI)



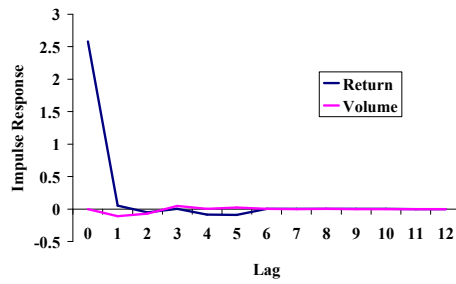
Impulse Response Function of Return (SIEMENS)



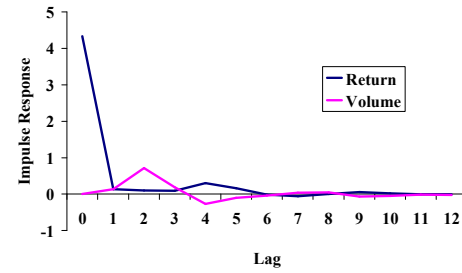
Impulse Response Function of Return (STERLITE)



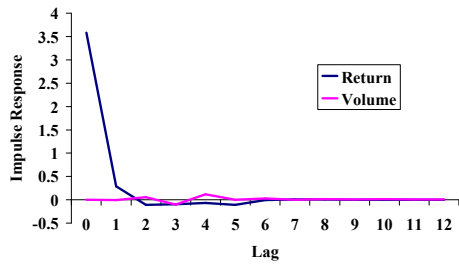
Impulse Response Function of Return (SUN PHARMA)



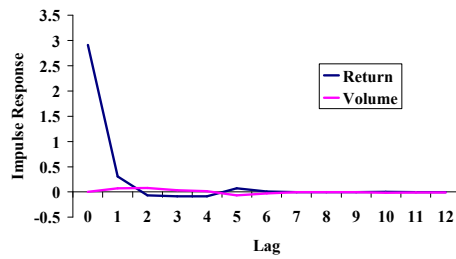
Impulse Response Function of Return (SUZLON)



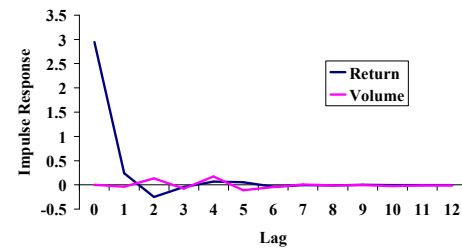
Impulse Response Function of Return (TATACOMM)



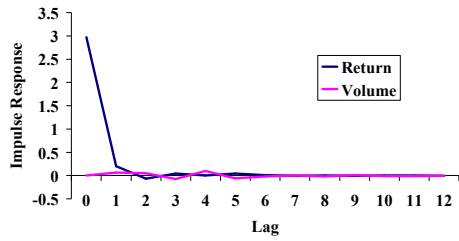
Impulse Response Function of Return (TATA MOTORS)



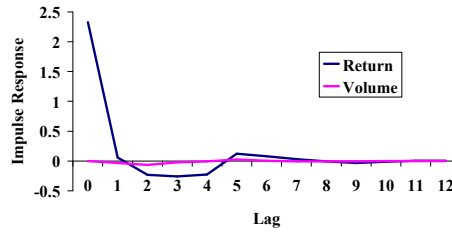
Impulse Response Function of Return (TATA POWER)



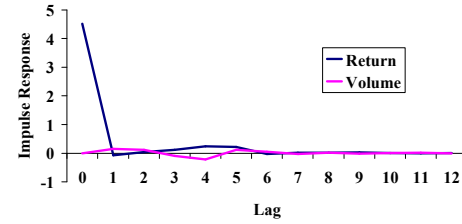
Impulse Response Function of Return (TATA STEEL)



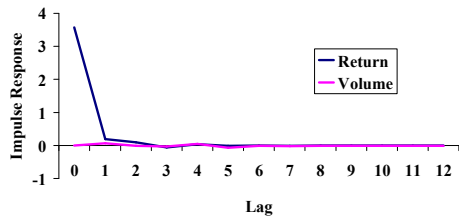
Impulse Response Function of Return (TCS)



Impulse Response Function of Return (UNITECH)



Impulse Response Function of Return (WIPRO)



Impulse Response Function of Return (ZEE)

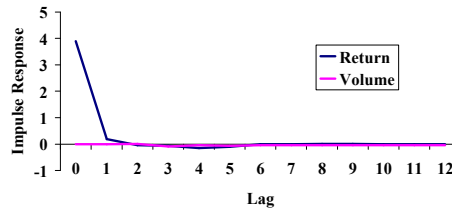
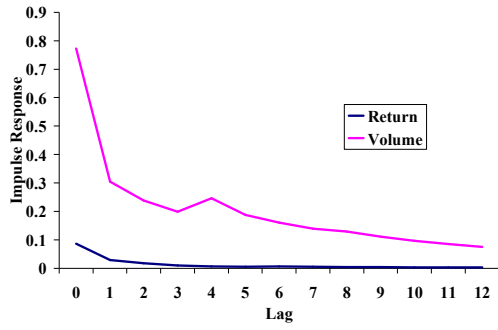


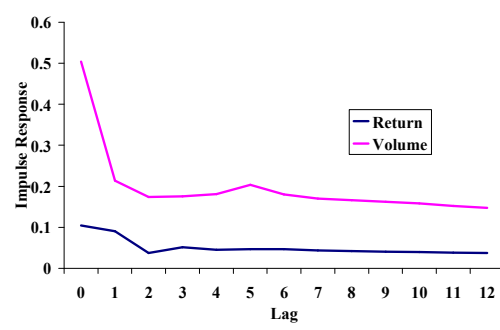
Figure 1: Impulse Response Function of Returns to Shock in Returns and Volume of all the 50 Stocks

Appendix B

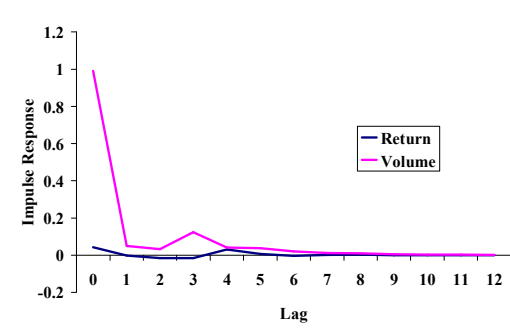
Impulse Response Function of Volume (ABB)



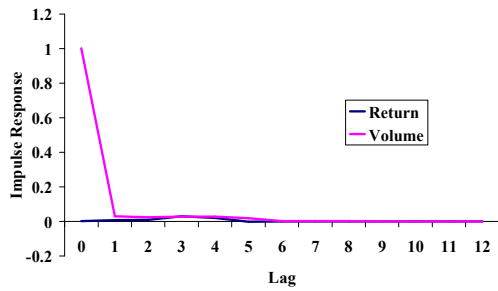
Impulse Response Function of Volume (ACC)



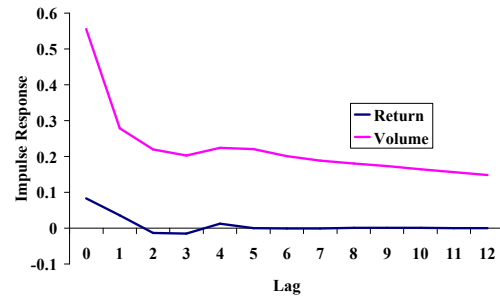
Impulse Response Function of Volume (AMBUJA)



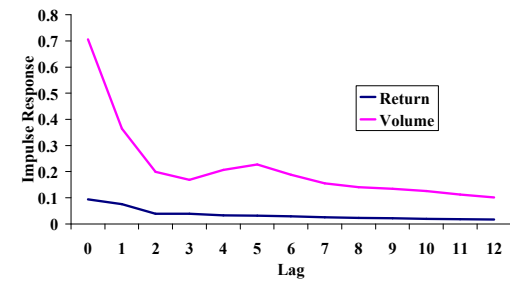
Impulse Response Function of Volume (BHARTI)



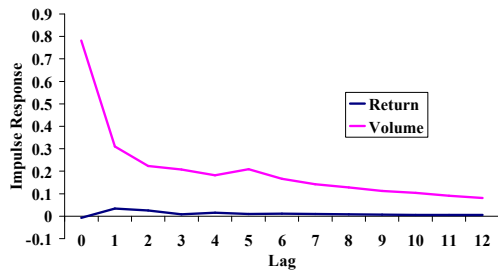
Impulse Response Function of Volume (BHEL)



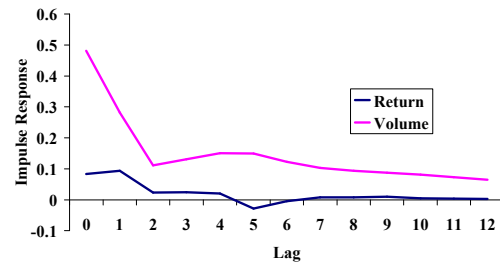
Impulse Response Function of Volume (BPCL)



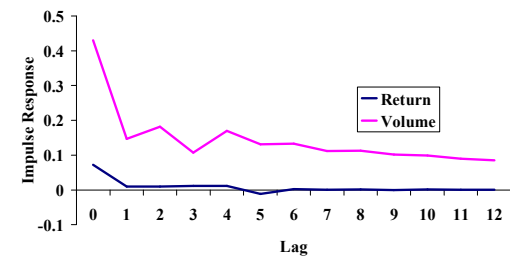
Impulse Response Function of Volume (CIPLA)



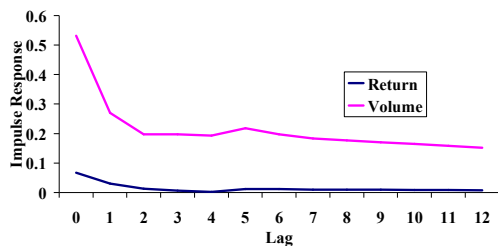
Impulse Response Function of Volume (CAIRN)



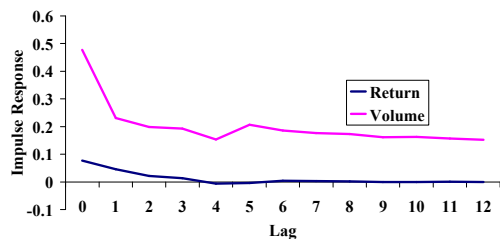
Impulse Response Function of Volume (DLF)



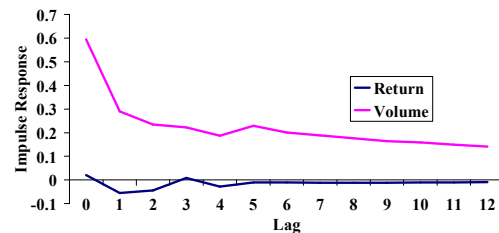
Impulse Response Function of Volume (GAIL)



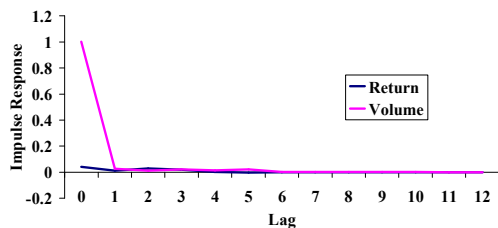
Impulse Response Function of Volume (GRASIM)



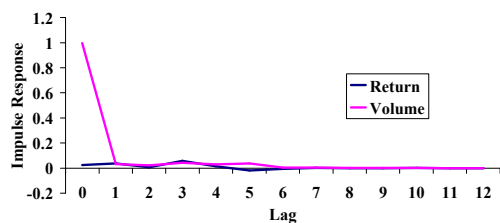
Impulse Response Function of Volume (HCL)



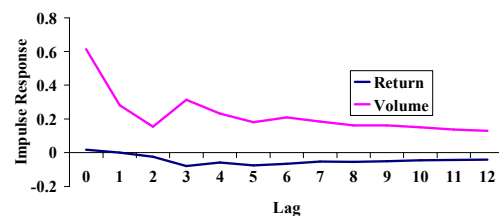
Impulse Response Function of Volume (HDFC)



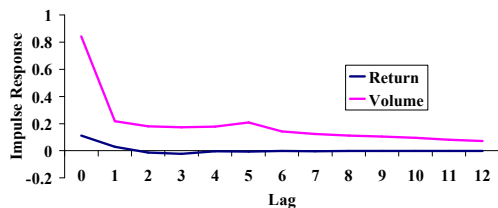
Impulse Response Function of Volume (HDFCORP)



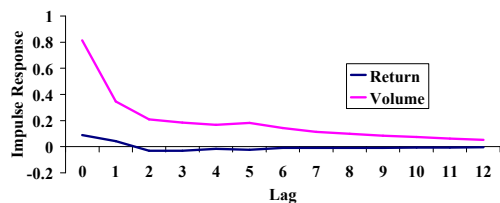
Impulse Response Function of Volume (HINDALCO)



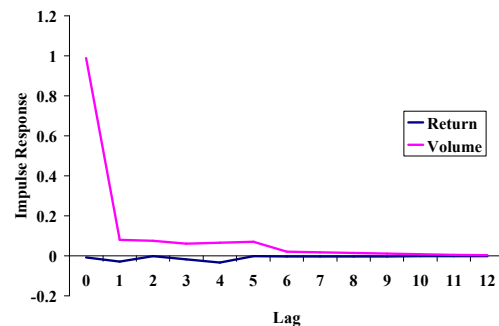
Impulse Response Function of Volume (HLL)



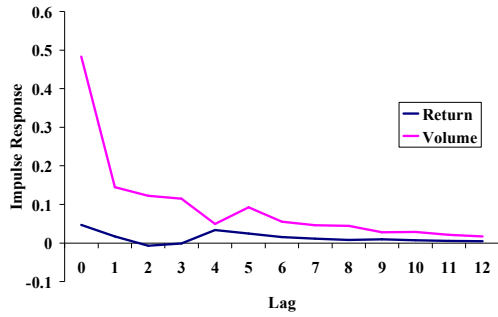
Impulse Response Function of Volume (HONDA)



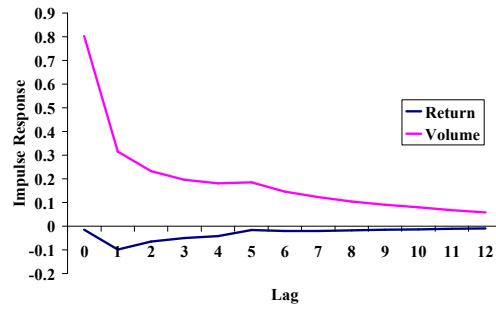
Impulse Response Function of Volume (ICICI)



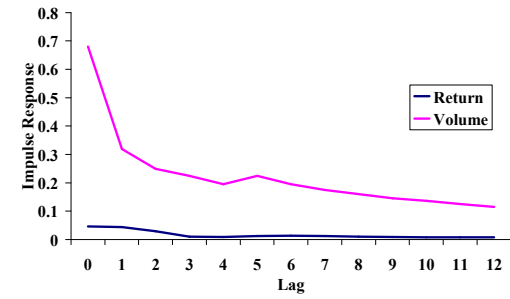
Impulse Response Function of Volume (IDEA)



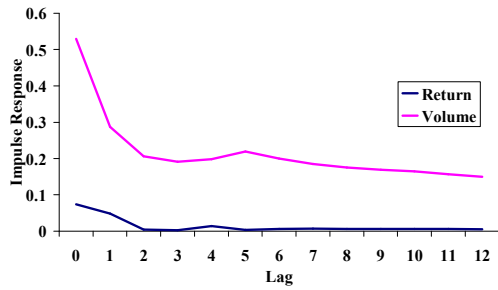
Impulse Response Function of Volume (INFOSYS)



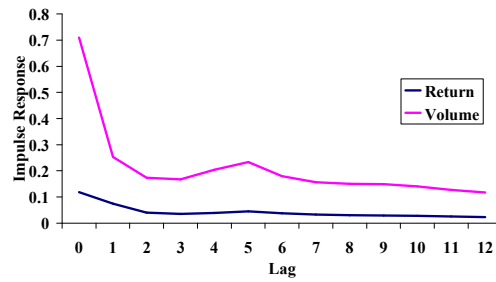
Impulse Response Function of Volume (ITC)



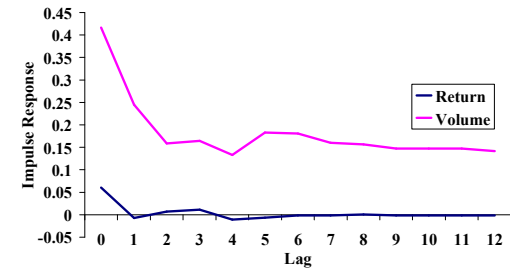
Impulse Response Function of Volume (L&T)



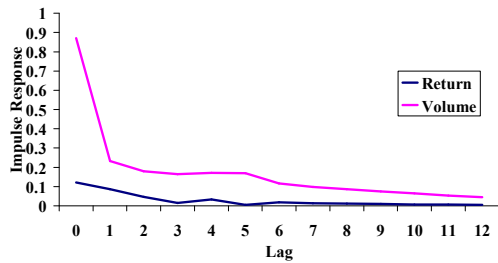
Impulse Response Function of Volume (M&M)



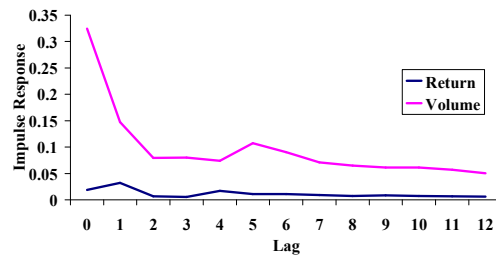
Impulse Response Function of Volume (MARUTI)



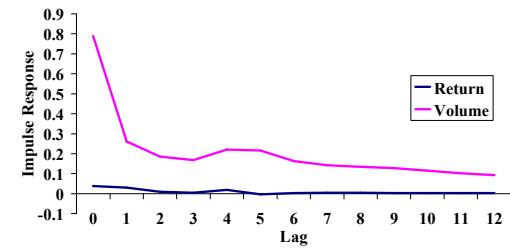
Impulse Response Function of Volume (NALCO)



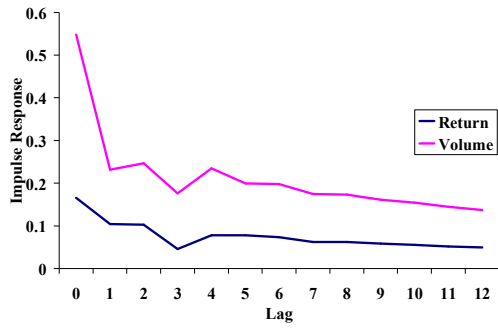
Impulse Response Function of Volume (NTPC)



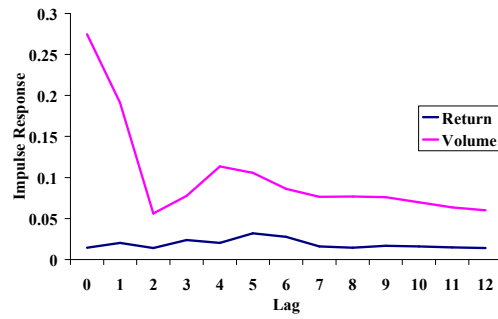
Impulse Response Function of Volume (ONGC)



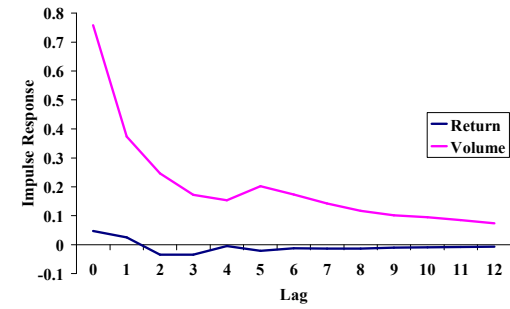
Impulse Response Function of Volume (PNB)



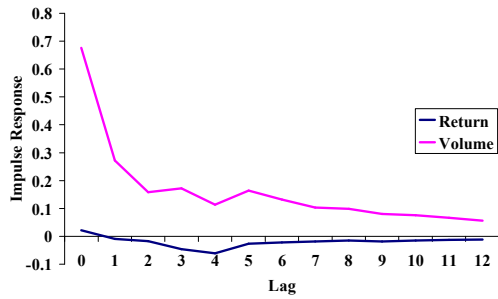
Impulse Response Function of Volume (Power Grid)



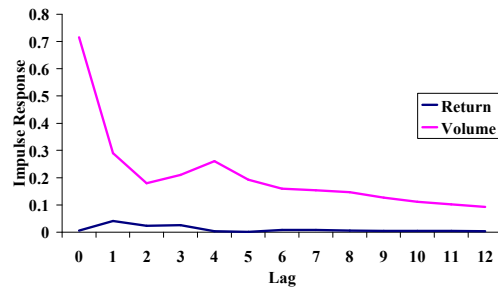
Impulse Response Function of Volume (RANBAXY)



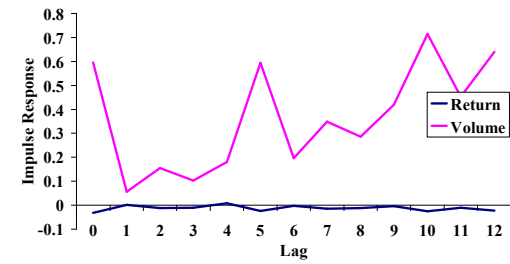
Impulse Response Function of Volume (RCOMM)



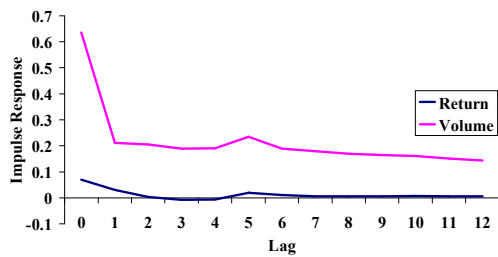
Impulse Response Function of Volume (RELIANCE)



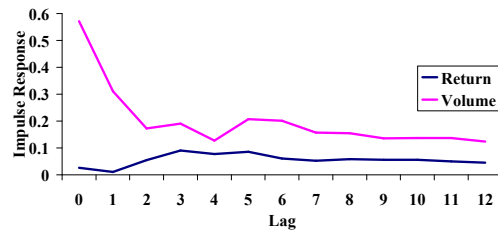
Impulse Response Function of Volume (RELIANCE POWER)



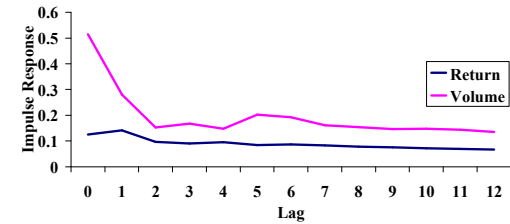
Impulse Response Function of Volume (RELIANCE INFRA)



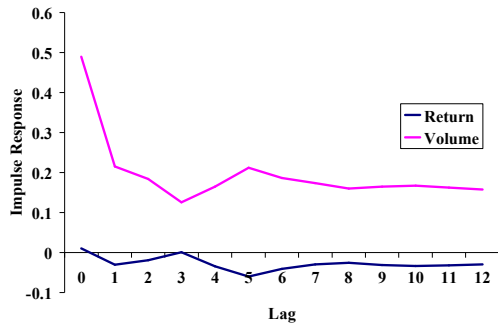
Impulse Response Function of Volume (RELIANCE PETRO)



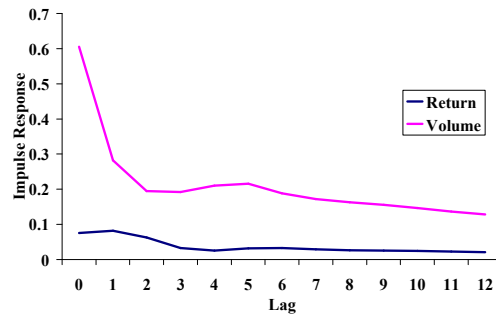
Impulse Response Function of Volume (SAIL)



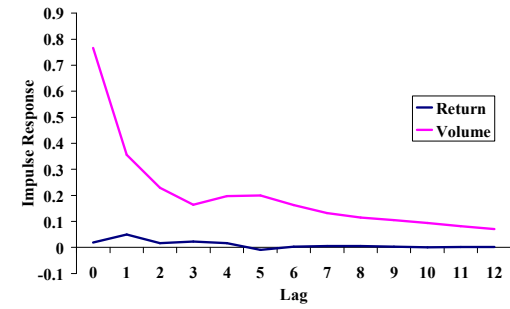
Impulse Response Function of Volume (SATYAM)



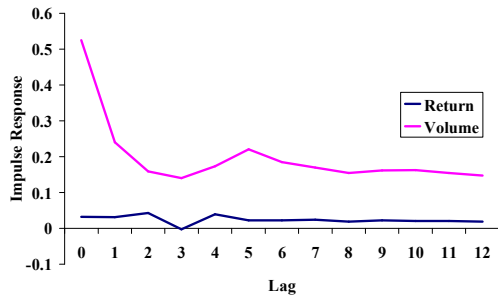
Impulse Response Function of Volume (SBI)



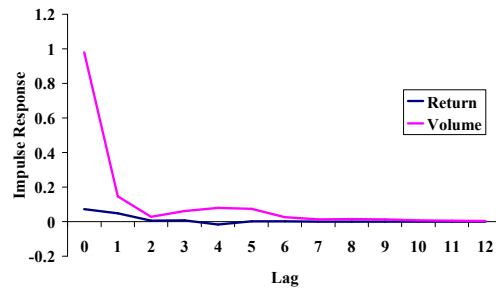
Impulse Response Function of Volume (SIEMENS)



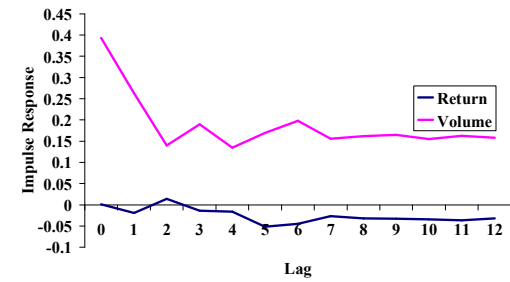
Impulse Response Function of Volume (STERLITE)



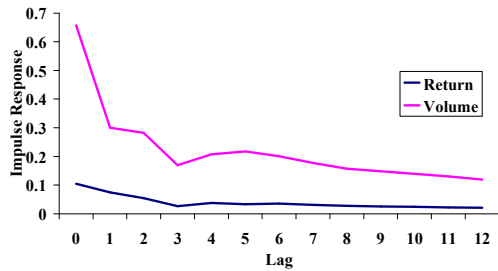
Impulse Response Function of Volume (SUN PHARMA)



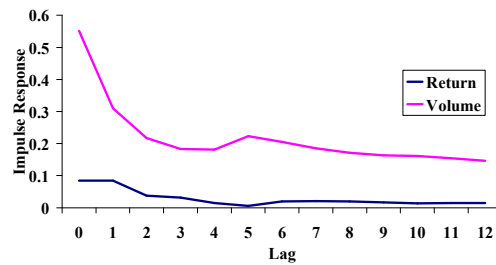
Impulse Response Function of Volume (SUZLON)



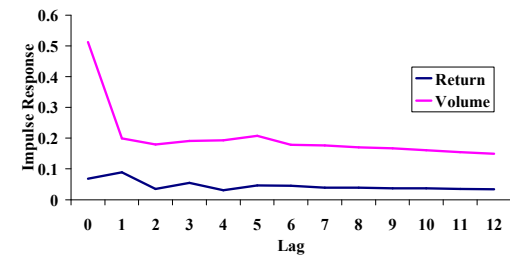
Impulse Response Function of Volume (TATACOMM)



Impulse Response Function of Volume (TATA MOTORS)



Impulse Response Function of Volume (TATA POWER)



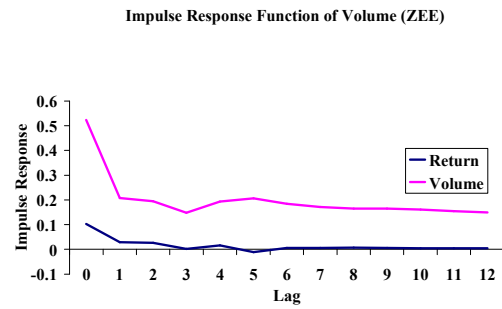
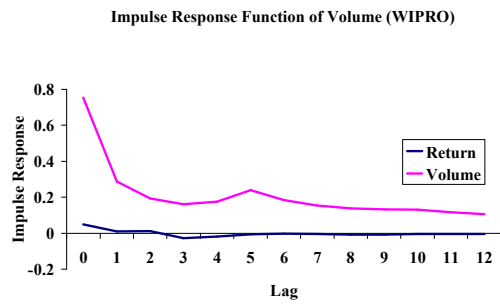
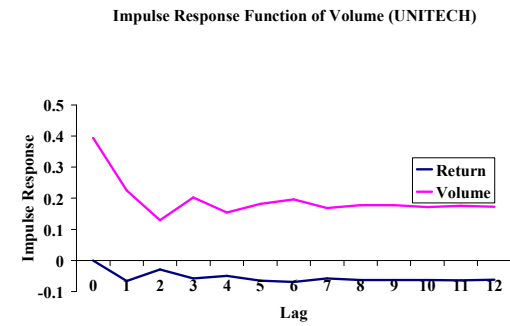
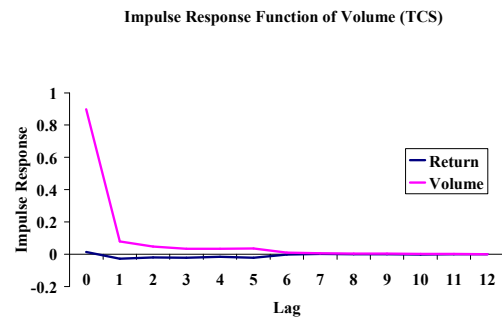
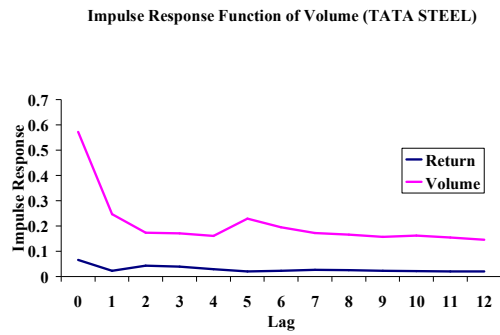


Figure 2: Impulse Response Function of Volume to Shock in Returns and Volume of all the 50 Stocks