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The Empirical Investigation of Relationship between Return, Volume and Volatility Dynamics in Indian Stock Market

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Abstract

This paper examines the empirical relationship between return, volume and volatility dynamics of stock market by using daily data of the Sensitive Index (SENSEX) during the period from October 1996 to March 2006. The empirical analysis provides evidence of positive and significant correlation between volume and return volatility that is indicative of the both mixture of distribution and sequential arrival hypothesis of information flow. Causality from volatility to volume can be seen as some evidence that new information arrival might follow a sequential rather than a simultaneous process. In addition, GARCH (1,1) documents the small declines in persistence of variance over time if one includes trading volume as a proxy for information arrivals in the equation of conditional volatility and ARCH and GARCH effects remain significant, which highlights the inefficiency in the market. This finding supports the proposition that volume provides information on the precision and dispersion of information signals, rather than serving as a proxy for the information signal itself.

Keywords: *contemporaneous relationship, causal relationship, linear Granger causality, GARCH (1,1) and EGARCH.*

***JEL Classification Codes**:* C32, G14.

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Introduction

The emergence of informational efficient financial markets is an important facet of any country's economic modernization, with far-reaching implication for its macroeconomic stability and performance (Stefano, B. et al., (2006)). Thus, it is in the interest of the economy to achieve efficiency in the dynamics of the stock markets. Return and volume are two major pillars, around which entire stock market revolves. While return can be interpreted as the evaluation of new information, volume is an indicator to which the investors disagree about this information. Moreover, it is observed from the prior literature[1] that stock prices are noisy which can't convey all available information to market dynamics of stock prices and trading volume. Therefore, studying the joint dynamics of stock prices and trading volume is essential to improve the understanding of the microstructure of stock markets (Mestal et al., (2003)).

Return-volume relationships are of common interest as they may unearth dependencies that can form the basis of profitable trading strategies, and this has implications for market efficiency (Chen, Firth and Yu (2004)). Karpoff (1987) cited four reasons for discussing price-volume relation. **First,** it provides insight into the structure of financial markets, such as the rate of information flow to the market, how the information is disseminated, the extent to which market prices convey the information, and the existence of short sales constraints. **Second**, the relationship between price and volume can be used to examine the usefulness of technical analysis. For example, Murphy (1985) and DeMark (1994) emphasized that both volume and price incorporate valuable information. A technical analyst gives less significance to a price increase with low trading volume than to a similar price increase with substantial volume.

Third, some researchers, such as Peck (1981), Garcia et al., (1986) and Weiner (2002) have investigated the role of speculation to price volatility (stabilizing or destabilizing), where speculation is closely related to trading volume. **Finally**, as Cornell (1981) pointed out, the volume-price variability relationship may have important implications for fashioning new contracts. A positive volume-price variability relationship means that a new futures contract will be successful only to the extent that there is enough price uncertainty associated with the underlying asset.

Thus, to improve the understanding of the microstructure of stock market, the relationship between return, volume and volatility has received substantial attention in the market microstructure for a number of years. In addition, the return-volume relationship sheds light on the efficiency of stock markets.

[1] See Karpoff (1987), Cetin Ciner (2003), Mestal et al.,(2005), Otavio(2006) Gallant et al., (1992), Blume et al., (1994), Suominen (2001) and Lee and Rui (2002).

Financial literature has documented the various flavors of the return-volume relationship especially in US stock markets (see survey in karpoff (1987)). By contrast, relatively little attention has been devoted to this relationship in India. Some researchers have made attempts to evaluate return-volume relationship in Indian stock market but these are elementary efforts and moreover, the studies have failed to take the phenomena of volatility persistence/volatility clustering in return-volume relationship. As cited in Huson Joher et al., (2005), financial time series behave in such a way that does not conform to the normality distribution. Hence, the volatility observed in the market is a natural application for the autoregressive conditional heteroscedasticity (ARCH). To observe this phenomena, ARCH model introduced by Engle (1982) and Bollerslev's (1986) generalized ARCH (GARCH) model is used in many studies (for e.g. Schwert (1990), Lamoureux and Lastrapes (1990) and Kim and Kon (1994)). The GARCH specification allows the current conditional variance to be a function of past conditional variances. Therefore, the current study investigates return, volume and volatility relationship in Indian stock market using symmetric and asymmetric GARCH models. The remainder of the paper is as follows. Section I reviews the literature. In section II, the methodology and data employed are presented. In section III, the key results from the empirical investigation are reported and in section IV conclusions are drawn.

2. Review of Literature

A detailed analysis of return-volume dynamics is important to have knowledge of issues relating to market efficiency and information flow in the market. The contemporaneous relationship between return and volume reveals information about asymmetry of trading volume in market. Table 1 summarizes the previous studies on the contemporaneous relation between volume and return. Table 2 highlights the studies relating to the contemporaneous relation between volume and return volatility/absolute return.

A positive relationship between return and volume is widely acknowledged in the financial literature[2]. Existence of this positive relationship is observed in stock and bond markets only, not in futures markets (for example see Karpoff (1987), kocagail (1999) and Chen, Firth and Yu (2004)).

One explanation for this relationship is derived from the Jennings, Starks, and Fellingham (1981) (JSF's model, hereafter) who extend the Copeland's (1976) sequential information arrival model and incorporate real world margin constraints and short selling. This new alternate theory has found that short positions are

2 See survey in Karpoff (1987).

possible but are more costly than long positions[3]. Their argument is that when a previously uninformed trader interprets the new information pessimistically, the trading volume that results is less than when the trader is an optimist. In other words, volume is relatively higher when price increases than price decreases. Thus, JSF's model shed light on institutional rules that raise the cost of selling short for explaining positive correlation between return and volume.

JSF's theory is subject to some criticisms as it relies on a peculiar interpretation of heterogeneity across investors and prohibits uninformed investors from learning from the trades of investors who are early in the information queue, which is unreal. However, it suggested costly short sales hypothesis to explain return-volume correlation. The absence of positive relationship between return and volume in futures markets, where the costs of taking long and short positions are symmetric, supports that the differential costs of short sales is one key to a theory of return-volume correlation.

The above-mentioned key (differential costs of short sales) is further supported by Karpoff (1988) Suominen (1996), Kocagail and Shachmurove (1998), David Mcmillen (2002) and Chen, Firth and Yu (2004). These studies covered the futures market and found no significant contemporaneous relationship between return and volume, thus confirming the symmetry of trading in futures markets.

Further, the contemporaneous relationship between volume and volatility shed light on information arrival pattern and quality and dispersion of such information (Blume et al., (1994)). Majority of empirical evidences in financial literature supports the positive relationship between absolute return and volume[4]. Different researchers have given different reasons for this positive relationship. One of the leading hypothesis to explain this relationship is mixture of distribution hypothesis (MDH Clark (1973)[5]. This model is associated with Clark (1973), Epps and Epps (1976), Tauchen and Pitts (1983) and Harris (1986), Lamoureux and Lastrapes (1990) and Andersen (1996). The mixture of distribution hypothesis (MDH) suggests only a contemporaneous relationship between volume and price volatility. Thus, under the MDH, there should be no information content in past volatility data that

3 It implies that the quantity demanded of an investor with short positions is less responsive to price changes than the quantity demanded of an investor with a long holding (See karpoff (1987) and Chen, firth and Rui (2001)).

4 Ying (1966), Crouch (1970), Clark (1973), Epps (1976), Cornell (1981), Harris (1983) Tauchen and Pitts (1983), Rutledge (1984), Jain and Joh (1986) Gallant et al., (1992), Bessembinder and seguin (1993), Brailsford (1994), Jones, Kaul and Lipson (1994), Ragunathan (1997), Daigler and Wiley (1999), Cetin Ciner (2002), Gurgul et al., (2005) and Otavio et al., (2006).

5 Under the MDH, asset prices are modelled as a subordinate stochastic process with prices evolving at different rates during identical intervals of time according to the flow of information, and evolving faster when unexpected information flows into the market. The interpretation of volume as a proxy for the unobservable directing process thus explains the observed positive correlation between the variance of price changes and volume (David Mcmillen (2002)).

can be used to forecast volume (or vice-versa) since these variables contemporaneously change in response to the arrival of new information.

Another popular hypothesis advocated to explain the volume-volatility/absolute return relationship is sequential information arrival hypothesis (SIAH). This model suggests the gradual dissemination of information that means a series of intermediate equilibria exists before arrival of final equilibria (Copeland (1976), Morse (1980), Jennings et al., (1981), and Smirlock and Starks (1985)). In other words, new information is disseminated sequentially to traders, and traders who are not yet informed can't perfectly infer the presence of informed trading. The sequential arrival of new information to the market generates both trading volume and price movements, with both increasing during periods characterized by numerous information shocks (Nguyen and Diagler (2006)). Thus, where MDH implies only contemporaneous relationship, the SIAH further suggest a dynamic relationship whereby lagged values of volatility may have the ability to predict current trading volume, and vice-versa (Darrat et al., (2003)).

Table 1: Empirical Evidence on the Contemporaneous Relationship between Trading Volume (V) and Return (∆p)

	Author(s)	**Year of Study**	**Sample Data**	**Sample Period**	**Differencing Interval**	**Support Positive (∆p.V) Correlation**
1	Granger and Morgenstern	1963	Stock market aggregates, 2 common stocks	1939-61	Weekly	No
2	Godfrey et al.,	1964	Stock market aggregates, 3 common stocks	1959-62, 1951-53	Weekly, Daily	No
3	Ying	1966	S&P 500composite stock price index of NYSE	1957-62	Daily	Yes
4	Epps	1975	20 NYSE bonds	Jan, 1971	Transactions	Yes
5	Morgan	1976	17 common stocks, 44 common stocks	1962-65 1926-68	4 days, Monthly	Yes
6	Epps	1977	20 common stocks	Jan, 1971	Daily	Yes
7	Hanna	1978	20 NYSE bonds	May, 1971	Transactions	Yes
8	Rogalski	1978	10 common stocks & 10 associated warrants	1968-73	Monthly	Yes
9	James and Edmister	1983	500 common stocks	1975, 77-79	Daily	No
10	Comiskey et al.,	1984	211 common stocks	1976-79	Yearly	Yes
11	Harris	1984	50 common stocks	1981-83	Daily	Yes
12	Smirlock and Starks	1985	131 common stocks	1981	Transactions	Yes
13	Wood et al.,	1985	946 common stocks 1138 common stocks	1971-72 1982	Minutes	No

14	Richardson et al.,	1987	106 common stocks	1973-82	Weekly	Yes
15	Jain and Joh	1988	NYSE	1979-83	Hourly	Yes
16	Kocagil and Shachmurove	1998	16 major U.S. futures contracts	1998-1995	Daily	No
17	Lee & Rui	2000	SHSE, SZSE	1990-1997	Daily	Yes
18	Chen et al.,	2001	New York, Tokyo, London, Paris, Toronto, Milan, Zurich, Amsterdam and Hong Kong	N.A	Daily	Yes
19	Mcmillen and Speight	2002	FTSE-100 Short sterling contracts Long gilt series	1992-1995	Intra day	No
20	Lee and Rui	2002	S&P 500, TOPIX, FT-SE 100	1973-1999 1974-1999 1986-1999	Daily	Yes
21	Ciner	2002	TSE	1990-2002	Daily	No
22	Ciner	2003	TSE*-2442 KLSE-2246	1993-2002	Daily	No
23	Mestal et al.,	2003	31 common stocks in Austrian Stock market	2000-2003	Daily	No
24	Mishra	2004	7 Co's, CNXIT of NSE	2000-2003	Daily	Yes
25	Tambi	2005	50 Co's of NIFTY	2000-2005	Daily	Yes
26	Gurgul et al.,	2005	WIG20	1995-2005	Daily	No
27	Otavio and Bernardus	2006	Bovespa index	2000-2005	Daily	Yes
28	Mahajan and Singh	2007	Nifty index	2001-2006	Daily	Yes
29	Christos and Dimitrios	2007	FTSE/ASE-20 index FTSE/ASE MID 40 index	1999-2001 2000-2001	Daily	No
30	Mahajan and Singh	2008a	Sensex	1996-2007	Daily	Yes

Where: FT-SE= Financial times-stock exchange, FTSE/ASE 20= Comprises 20 Greek companies, quoted on the Athens stock exchange, FTSE/ASE 40= Comprises 40 mid-capitalisation Greek companies, KLSE= Kuala Lumpur stock exchange, NYSE= New York stock exchange, NSE= National stock exchange, TOPIX= Tokyo stock exchange price Index, TSE= Toronto stock exchange, TSE*= Tokyo stock exchange, WIG 20= The twenty most liquid companies quoted on the primary market of the Warsaw Stock Exchange.
Source: Compiled from various studies.

Table 2: Empirical Evidence on the Contemporaneous Relationship between Trading Volume (v) and Absolute Return/Return Volatility (│Δp│)/(Δp) 2.

	Author(s)	Year of Study	Sample Data	Sample Period	Differencing Interval	Support Positive (│Δp│. V) Correlation
1	Godfrey et al.,	1964	Stock market aggregates, 3 common stocks	1959-1962, 1951-1953	Weekly, Daily	No
2	Ying	1966	Stock market aggregates	1957-1962	Daily	Yes
3	Crouch	1970	5 common stocks	1963-1967	Daily	Yes
4	Crouch	1970	Stock market aggregates, 3 common stocks	1966-1968	Hourly and Daily	Yes
5	Clark	1973	Cotton futures market	1945-1958	Daily	Yes
6	Epps	1976	20 common stocks	Jan, 1971	Transactions	Yes
7	Morgan	1976	17 common stocks, 44 common stocks	1962-1965 1926-1968	4 days, Monthly	Yes
8	Westerfield	1977	315 common stocks	1968-1969	Daily	Yes
9	Cornell	1981	Futures contracts for 17 commodities	1968-1979	Daily	Yes
10	Harris	1983	16 common stocks	1968-1969	Daily	Yes
11	Tauchen and Pitts	1983	T-bill Futures contracts	1976-1979	Daily	Yes
12	Comiskey et al.,	1984	211 common stocks	1976-79	Yearly	Yes
13	Harris	1984	50 common stocks	1981-83	Daily	Yes
14	Rutledge	1984	Futures contracts for 13 commodities	1973-1976	Daily	Yes
15	Wood et al.,	1985	946 common stocks 1138comon stocks	1971-72 1982	Minutes	Yes
16	Grammatikos and Saunders	1986	Futures contracts for 5 foreign currencies	1978-1983	Daily	Yes
17	Harris	1986	479 common stocks	1976-77	Daily	Yes
18	Jain and Joh	1986	Stock market aggregates	1979-83	Hourly	Yes
19	Richardson et al.,	1987	106 common stocks	1973-82	Weekly	Yes
20	Gallant et al.,	1992	S&P 500 index	1928-1987	Daily	Yes
21	Bessembinder and Seguin	1993	8 futures contracts	1982-1990	Daily	Yes
22	Jones et al.,	1994	NASDAQ	1986-1991	Daily	Yes
23	Brailsford	1996	AOI	1989-1993	Daily	Yes
24	Ragunathan	1997	Sydney futures exchange	1992-1994	Daily	Yes

25	Kocagil and Shachmurove	1998	16 major U.S. futures contracts	1998-1995	Daily	No
26	Daigler and Wiley	1999	LDB	1986-1988	Daily	Yes
27	Lee and Rui	2000	SHSE, SZSE	1990-1997	Daily	Yes
28	Chan and Fong	2000	NYSE, NASDAQ	1993	Daily	Yes
29	Wang and Yau	2000	CME, COMEX	1990-1994	Daily	Yes
30	Chen et al.,	2001	New York, Tokyo, London, Paris, Toronto, Milan, Zurich, Amsterdam and Hong Kong	N.A	Daily	Yes
31	Ciner	2002	TSE	1990-2002	Daily	Yes
32	Ciner	2003	TSE*, KLSE	1993-2002	Daily	Yes
33	Mestal, R. et al.,	2003	31 common stocks in Austrian Stock market	2000-2003	Daily	No
34	Darrat et al.,	2003	30 DJIA stocks	1998	Intraday	No
35	Chae and Joo	2003	KRW/USD spot foreign exchange market	2001-2002	High frequency (two-minute) data	Yes
36	Gurgul et al.,	2005	WIG20	1995-2005	Daily	Yes
37	Gallagher and Kiely	2005	14 Irish stocks	2000-2003	Daily	Yes
38	Otavio and Bernardus	2006	Bovespa index	2000-2005	Daily	No
39	Long	2007	CBOE	1983-1985	Daily	Yes
40	Mahajan and Singh	2008a	Sensex	1996-2007	Daily	Yes
41	Mahajan and Singh	2008b	Nifty index	2001-2006	Daily	Yes

Where: AOI= All Ordinaries Index, DJIA= Dow Jones Industrial Average, KRW/USD= Spot Korean won against US Dollar Exchange Rate, KLSE= Kuala Lumpur Stock Exchange, LDB= Liquidity Data Bank, NYSE= New York Stock Exchange, NSE= National Stock Exchange, TSE= Toronto Stock Exchange, TSE*= Tokyo Stock Exchange, CBOE= Chicago Board of Option Exchange, WIG20= The Twenty most Liquid Companies quoted on the Primary Market of the Warsaw Stock Exchange.
Source: Compiled from various studies.

In contrast to contemporaneous relationship, analysis of dynamic relationship between return and volume, which entails an examination of potential causality from past values of volume to present returns as well as from past returns to present volume, is concerned with issues relating to informational efficiency of the market[6] (David McMillen (2002)). An indication of causality from past values of

[6] The finding of a causal relationship from past volume to current returns is not consistent with weak-form efficiency, since it carries the implication that an investor is able to make systematic profits. For detailed discussion see, Fama (1965).

volume to returns violates assumptions of the weak-form efficiency hypothesis, since it carries the implication that an investor is able to make systematic profits.

Voluminous literature is available which have reported the evidence of causality either from volume to returns or from returns to volume and bi-directional and thus approve the informational role of volume (Rogalski (1978), Smirlock and Starks (1988), Jain and Joh (1986), Gallant et al., (1992), McCarthy and Najand (1993), Hiemstra and Jones (1994), Datar et al., (1998), Lee and Swaminathan (2000), Lee and Rui (2002), David McMillen (2002), Mestal et al., (2003) and Otavio et al., (2006)).

Blume, Easley, and O'Hara (1994) have come forward with a model in which traders can learn valuable information about a security by observing both past price and past volume information. In their model, volume provides data on the quality or precision of information about past price movements. Thus, traders who include volume measures in their technical analysis perform better in the market than those who do not (Chen, Firth and Rui (2001)).

Wang (1994) analyzed dynamic relations between volume and returns based on a model with information asymmetry. His model showed that volume might provide information about expected future returns. In their study, He and Wang (1995) developed a rational expectations model of stock trading in which investors have different information concerning the underlying value of stock. They examined the way in which trading volume relates to the private information flow in the market, and how investors' trading reveals their private information Chordia and Swaminathan (2000) found that trading volume is a significant determinant of the lead-lag patterns observed in stock returns. Specifically, returns of portfolios containing high trading volume lead returns of portfolios comprised of low trading volume stocks after controlling for size and that this is not explained by nonsynchronous trading or low volume portfolio autocorrelations. Instead, they established that their result is due to the fact that returns on low volume portfolios respond more slowly to information in market returns.

The leading discussion highlights that volume is powerful indicator to predict the market. Stock price changes when new information arrives. Thus, if the trading volume is linked to the information flow entering the markets, a relation of price-volume is obtained. Many studies have adopted the volume as proxy for information arrival and examined its relation with return to predict the market (see Cetin Ciner (2002), Mestal (2003), Darrat et al., (2003), Gurgul et al., (2005), Huson Joher et al., (2005) and Otavio et al., (2006)).

Herbert (1995) and Ciner (2002) found that lagged trading volume contains predictive power for current price volatility. These empirical results provide evidence against the mixture of distributions hypothesis and instead, support the sequential information arrival hypothesis. On the other hand, Mestal et al., (2003), Gurgul et al., (2005), Mishra, V. (2004) all found evidence of unidirectional granger causality from return volatility to volume. Otavio et al., (2006) reported the bi-directional causality between the variables, which implies that that the strong form of market efficiency holds since private information is reflected on stock prices.

In nutshell, on the basis of above-mentioned studies it can be stated that the significant efforts have been made at the international level to evaluate return, volume and volatility relationship, whereas in India this relationship has not been well investigated. Therefore, the current study is an attempt to fill this gap and sheds light on the informational efficiency of Indian stock market. This paper examines the relationship between return, return volatility and volume in a contemporaneous and dynamic context in Indian stock market and contributes to the literature in several respects. Firstly, it deploys the granger causality test to investigate information flow between the variables instead of ARIMA. In addition, we use the GARCH models (this model allows for time varying variance in a process and can adequately represent return volatility) in the study of return- volume relationship to examine volatility persistence. This study further checks the information asymmetry with EGARCH (1,1) model. Moreover, the time period considered in the study helps to evaluate the impact of introduction of electronic trading (automation) on stock price-volume linkage of Bombay Stock Exchange. The linkage between automation and information content of volume depends on whether automation increases price efficiency. Thus, the study will enhance the understanding of market asymmetry, market efficiency and information processing.

3. Data Base and Research Methodology

Financial time series such as stock prices often exhibit the phenomena of volatility clustering. To observe this phenomena, ARCH model introduced by Engle (1982) and Bollerslev's (1986) generalized ARCH (GARCH) model is used.

The GARCH specification allows the current conditional variance to be a function of past conditional variances, allowing volatility shocks to persist over time (Huson Joher et al., (2005)). In particular, to test whether the positive contemporaneous relationship between trading volume and returns exists, the following GARCH (1,1) model is estimated where volume is included in mean equation.

$$R_t = \alpha + \sum_{i=1}^{p} \beta_i R_{t-i} + \gamma V_t + \varepsilon_t \qquad (1)$$

$$h_t = \omega + \sum_{i=1}^{m} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{n} \beta_j h_{t-j} + e_t \qquad (2)$$

Where h_t represents the conditional variance term in period t, α_i represents the news coefficient and β_j represents a persistence coefficient. Parameters ω and α_i should be higher than 0 and β_j should be positive in order to ensure conditional variance h_t to be non-negative. The sum of parameters α_i and β_j is a measure of the persistence in the variance of the unexpected return ε_t taking values between 0 and 1. The more this sum tends to unity, the greater the persistence of shocks to volatility, which is known as volatility clustering or hysteresis.

GARCH methodology is also instrumental in supporting or refusing the mixture of distribution hypothesis (MDH). According to the MDH, a serially correlated mixing variable measuring the rate at which information arrives to the market explains the GARCH effect in the returns. This relationship has been documented for the U.S. stock market by Lamoureux and Lastrapes (1990), Andersen (1996) and Gallo and Pacini (2000), and the UK stock market by Omran and McKenzie (2000). In general, the bulk of empirical studies has found evidence that the inclusion of trading volume in GARCH models for returns results in a decrease of the estimated persistence or even causes it to vanish. This finding, generally interpreted as empirical evidence in favor of the MDH (see Sharma, Mougoue and Kamath (1996) and Brailsford (1996)). Thus, to investigate whether trading volume explains the GARCH effects for returns, GARCH (1,1) model with a volume parameter in the variance equation is estimated.

$$h_t = \omega + \sum_{i=1}^{m} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{n} \beta_j \; h_{t-j} + \gamma_i V_t + e_t \qquad (3)$$

However the results based upon GARCH (1,1) may again be doubtful because it doesn’t take into account for asymmetry and non-linearity in the conditional variance. Thus it would be more appropriate to apply asymmetric GARCH model. Engle and Ng (1993) developed an asymmetric GARCH model, which allows for asymmetric shocks to volatility. Thus, among the specifications, which allow for asymmetric shocks to volatility, we estimate the EGARCH (1,1) or exponential GARCH (1,1) model, which was proposed by Nelson (1991) and results are reported in table 4.

$$h_t = \Upsilon_1 + \Upsilon_2 \left| \frac{\varepsilon_{t-1}}{h_{t-1}} \right| + \Upsilon_3 \frac{\varepsilon_{t-1}}{h_{t-1}} + \Upsilon_4 h_{t-1} + \Upsilon_5 V_t + e_t \qquad (4)$$

In this model specification γ_2 is the ARCH term that measures the effect of news about volatility from the previous period on current period volatility. γ_3 measures the leverage effect. Ideally γ_3 is expected to be negative implying that bad news has a bigger impact on volatility than good news of same magnitude. A positive γ_4 indicates volatility clustering implying that positive stock price changes are associated with further positive changes and vice-versa. The parameter γ5 measures the impact of volume on volatility.

Further to examine dynamic relationship between variables, linear granger causality test is applied with the help of E-Views software following the approach of Mestal (2003) and Otavio and Bernardas (2006). To test for Granger Causality, we use a bi-variate VAR model of order p of the form.

$$R_t = \mu_R + \sum_{i=1}^{p} \alpha_i . R_{t-i} + \sum_{i=1}^{p} \beta_i . V_{t-i} + \varepsilon_t \,, \quad (5)$$

$$V_t = \mu_v + \sum_{i=1}^{p} \alpha_i . V_{t-i} + \sum_{i=1}^{p} \beta_i . R_{t-i} + \xi_t \,. \quad (6)$$

The null hypothesis of return not to granger cause volume and vice-versa implies that βi (i=1,.....,P) are all equal to 0. To test the null hypothesis we calculate F-statistic as used in Mestal (2003).

$$F = \frac{SSE_0 - SSE}{SSE} . \frac{N - 2p - 1}{p} \quad (7)$$

Where SSEo stands for the sum of squared residuals of the restricted regression (i.e. β1=------βP=0), SSE is the sum of squared residuals of the unrestricted equation, and N denotes the number of observations. Lag length for granger causality has been determined on the basis of Schwartz criterion. The bivariate regressions in (5) and (6) are re-estimated with squared values of stock returns (i.e. volatility) instead of returns.

The series of stock return is computed from daily closing prices for the Sensitive Index (SENSEX) of Bombay Stock Exchange for a period of more than 9 years from 29th Oct 1996 till 31stMarch 2006. The SENSEX index of BSE captures all the events in the most judicial manner. One can identify the booms and busts of the Indian stock market through SENSEX. This has been the period when electronic trading was introduced in the Bombay Stock Exchange. Introduction of automation has affected the movement of the index and volume trades in the market in different ways. So the current study attempts to evaluate the return–volume relationship after the introduction of electronic trading. The daily stock returns are continuous rates of return, computed as log of ratio of present day's price to previous day's price (i.e. Rt = ln (Pt /Pt-1)). Data are obtained from website of BSE (www.bseindia.com).

4. Results and Analysis

The examination of relationship between return, return volatility and volume provides significant information regarding the price discovery efficiency of the asset. Prior to discussing the lead-lag relationships, table 3 discusses the descriptive statistics to assess the distribution properties of return and volume series. Significant Jarque Bera statistics clearly rejects the hypothesis, which implies that pattern of all variables does not conform to normal distribution, which is the precondition for any market to be efficient in the weak form (Fama (1965), Stevenson and Bear (1970), Reddy (1997) and Kamath (1998)).

Table 3: Descriptive Statistics

	Volume	Return	Volatility
Mean	16.79586	0.000533	0.000260
Median	16.79217	0.001106	8.32E-05
Std. Dev.	0.435985	0.016113	0.000613
Skewness	-0.311909	-0.407756	8.752611
Kurtosis	7.851873	6.631728	136.4036
Jarque-Bera	2332.161	1350.237	1764284.
Probability	0.000000	0.000000	0.000000

Further, skewness and excess kurtosis enshrine the evidence of the nature of departure from normality. The empirical distribution of the volatility series is positively skewed, indicating a right tail of distribution, which shows asymmetry. On the other side, negative skewness is observed for return and volume, which has led the returns to be asymmetric and non-normal and it can be verified from p value of Jarque-Bera test. This table also reports that returns are asymmetric and highly volatile. Risk averse nature of the traders in the market may be prominent cause for the asymmetric returns (Moolman (2004)). Moreover, the excess kurtosis estimated for trading volume is large, clearly a sign of peaked (leptokurtic) end relative to the normal distribution which may result into positive correlation between volume and return volatility as observed by Tauchen and Pitts (1983), Karpoff (1987), Gallant et al., (1992), McCarthy and Najand (1993) and Suominen (1996). Tauchen and Pitts (1983) stated that correlation between volume and return volatility increases with the variance of the daily rate of information flow.

Table 4: Correlation Results

Variables	Volume	Return
Volume	1.000	.037** (.075)
Return	.037** (.075)	1.000
Volatility	.154* (.000)	-----------

Note: * and ** Correlation is significant at the 0.01 level and 10%level (2-tailed).
Figures in parentheses show p values

Table 4 discusses the correlation results, which clearly shows that volume and return volatility are positively correlated. This is first indication that there might exist a causal relationship between trading volume and return volatility because a latent, exogenous variable, representing the rate of information arrival to the market, affects both volume and stock price variance, causing simultaneous movements. Prior research generally does not find a contemporaneous relation between volume and returns on equity markets, see Karpoff (1987), Lee and Rui (2002) and Ciner (2002). In this study, a weak correlation is detected between return and volume implying that forecasts of one of these variables cannot be improved by knowledge of the other.

Table 5: Unit Root Results

Variables	Augmented Dicky Fuller		Philips Perron	
	With constant	With constant and trend	With constant	With constant and trend
Volume	-7.939229*	-7.942309*	-30.37678*	-30.39678*
Return	-45.38914*	-45.41937*	-45.36679*	-45.42177*
Return volatility	-16.37367*	-27.01837*	-40.45979*	-39.79592*

* Significant at 1% significance level.

Thus, in the light of information asymmetry as observed in descriptive statistics, it will be interesting venture to test whether the contemporaneous relationship between return and volume exist using GARCH (1,1) model with a volume parameter in the mean equation and the results are reported in table 6.

Table 6: GARCH (1,1) Estimates for Return-Volume

$$h_t = \omega + \sum_{i=1}^{m} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{n} \beta_j h_{t-j} + e_t$$

Volume-Return Relationship

Parameter	Coefficient	P-value
γ	0.001551	0.0177
ω	9.25E-06	0.0000
α_i	0.142200	0.0000
β_j	0.828274	0.0000
$\alpha_{i+}\ \beta_j$	0.970474	0.0000

Note: * γ is a parameter of volume, which is included in mean equation.

As reported in table 6, coefficient of trading volume is positive and significant (i.e. there exists a positive contemporaneous relationship between trading volume and returns). Further, significant αi and βj coefficients clearly indicate that conditional variance is predominantly affected by lagged variance, which implies that previous information shock significantly affect current returns. These evidences imply that Indian stock market is not efficient in weak form. Moreover, the table 6 shows that there is volatility clustering as measured by sum of αi and βj (0.970), which further supports the asymmetry and inefficiency in market after the introduction of automation.

Further, to investigate whether trading volume explains the GARCH effects for returns, GARCH (1,1) model with a volume parameter in the variance equation is estimated and results are shown in table 7.

Table 7: GARCH (1,1) Estimates for Volume –Volatility Relationship

$$h_t = \omega + \sum_{i=1}^{m} \alpha_i \varepsilon_{t-i}^2 \; + \sum_{j=1}^{n} \beta_j \; h_{t-j} + \gamma_i V_t + e_t$$

Volume-Volatility Relationship

Parameter	Coefficient	P-value
ω	-0.000270	0.0000
α_i	0.163108	0.0000
β_j	0.767751	0.0000
γ_i	1.72E-05	0.0000
$\alpha_{i+}\,\beta_j$	0.930	------

Note: * γ_i is a parameter of volume, which is included in variance equation.

The study finds parameters αi and βj to be positive and significant in table 7 where trading volume is included in the variance equation of GARCH model. The coefficient on the volume γi is significant and indicates positive impact on volatility. Further, the study shows a small decline in the persistence of volatility when trading volume is included in the variance equation, since the sum (□i+□j) falls to 0.93 in the table 7 as compared to sum of αi and βj (0.97) in table 6 where volume is not included in variance equation of GARCH model. It means small degree of persistence is absorbed by the volume series. Therefore, our results for Indian stock market show weak support for the MDH model.

As significant asymmetry is observed in the returns of Nifty index, thus it would be more informative if we examine the return-volume-volatility relation through EGARCH (1,1) model to take into account impact of good and bad news on the volatility knowing the fact that both types of news have different kinds of effect on market. The results of EGARCH (1,1) are shown in table 8 and 9.

Table 8: EGARCH (1,1) Estimates for Return-Volume

$$h_t = \Upsilon_1 + \Upsilon_2 \left| \frac{\varepsilon_{t-1}}{h_{t-1}} \right| + \Upsilon_3 \frac{\varepsilon_{t-1}}{h_{t-1}} + \Upsilon_4 h_{t-1} + e_t$$

Return-Volume Relationship

Parameter	Coefficient	P-value
γ_0	0.001849	0.0038
γ_1	-1.469986	0.0000
γ_2	0.258060	0.0000
γ_3	-0.215193	0.0000
γ_4	0.861218	0.0000

Note: * γ_0 is parameter of volume included in mean equation

The presence of leverage effect can be seen in table 8 and 9, which implies that every price change responds asymmetrically to the positive and negative news in the market. Coefficient γ0 (which is a parameter of volume) shows a positive impact of volume on return. The parameter γ2 is statistically significant, which supports the previous evidences of asymmetric distribution

of returns in descriptive statistics and significant γ3 indicates mean reverting behavior of returns because the value of γ3 is negative, which implies that every price change responds asymmetrically to the positive and negative news in the market (see table 8 and 9). Coefficient γ4 (which is a parameter of lagged conditional volatility) is significant in both cases of EGARCH (1,1) which implies that Indian market is informationally inefficient.

Table 9: EGARCH (1,1) Estimates for Volume-Volatility Relationship

$$h_t = \Upsilon_1 + \Upsilon_2 \left| \frac{\varepsilon_{t-1}}{h_{t-1}} \right| + \Upsilon_3 \frac{\varepsilon_{t-1}}{h_{t-1}} + \Upsilon_4 h_{t-1} + \Upsilon_5 V_t + e_t$$

Volume-Volatility Relationship

Parameter	Coefficient	P-value
γ_1	-2.537025	0.0000
γ_2	0.280519	0.0000
γ_3	-0.113468	0.0000
γ_4	0.911711	0.0000
γ_5	0.093501	0.0000

Note:*γ5 is parameter of volume included in variance equation

After checking for the contemporaneous relationship and ARCH and GARCH effect in stock returns, this paper further verify the robustness of relationship between trading volume, return and return volatility and study the direction of information flow between these variables. For this purpose granger causality and VAR methodologies have been applied. Unit root test results in table 5 shows that trading volume, return and return volatility are stationary at levels, on the basis of both the ADF and PP tests. Lag length for granger causality and VAR has been determined on the basis of Schwartz Information Criterion (see table 10).

Table 10: Lag Structure as per Schwartz Information Criterion

Relationship	Return-Volume	Volume -Volatility
Lags	5	5

Granger causality results in table 11 provide very important information regarding the direction of information transmission. Causality has been observed from return to volume and volatility to volume, however volume causes neither of these. Thus, from granger causality results, it can be inferred that returns contain significant information for volume. This finding is consistent with the observations of Rogalski

(1978), Smirlock and Starks (1988), Jain and Joh (1986), Hiemstra and Jones (1994), Kocagil and Shachmurove (1998), Lee and Rui (2002), Griffin et al., (2004) and Nguyen and Diagler (2006). Moreover, preceding return volatility can be seen as some evidence that new information arrival might follow a sequential rather than a simultaneous process. This implies that the strong form of market efficiency does not hold since some private information exists that is not reflected in stock prices.

Table 11 Linear Granger Causality Test Results

Null Hypothesis	F. Statistic	P-value
Trading Volume does not cause Return	1.41970	0.21387
Return does not cause Trading Volume	3.35106*	0.00509
Trading Volume does not cause Volatility	1.15576	0.32870
Volatility does not cause Trading Volume	8.42084*	6.6E-08

Note: * Significant at 1% level

Granger causality results have been verified through VAR results, because if one variable cause other variable, significant lead-lag relationship must exist between two. VAR results in table 12 (see appendix) indicate no lead-lag relationship between return and volume because both cause each other up to 1 lag. While, Leading role of volatility for volume can be seen in table 13(see appendix).

5. Conclusion

The movement in stock market can't be decided only on the basis of prices. Stock prices without associated with trading volume convey vague information about market activity. It is well established in the literature that prices react to the arrival of new information and trading volume is viewed as the critical piece of information, which signals where prices will go next. Thus, this paper examines the empirical relationship between return, volume and volatility dynamics of stock market by using daily data for the Sensitive Index (SENSEX) of Bombay Stock Exchange, India's premier stock exchange. A main issue has been whether information about trading volume is useful in improving the forecasts of return and return volatility in dynamic context.

The empirical analysis provides evidence of positive and significant correlation between volume and return volatility that is indicative of the both mixture of distribution and sequential arrival hypothesis of information flow. Positive correlation between volatility and trading volume arises because trading by informed traders reveals private information to markets and affects prices (Suominen (2001)). It implies that the informed traders trade only when they receive private information, and that their trading carries information and affects prices.

The study has further re-examined the finding of Lamoureux and Lastrapes (1990) that heteroscedasticity in stock returns can be explained by introducing volume as mixing variable. Using GARCH (1,1), the paper documents small decline in persistence of variance over time with the inclusion of trading volume as a proxy for information arrivals in the equation of conditional volatility, inconsistent with Lamoureux and Lastrapes (1990) who founds that persistence of shock become negligible with the inclusion of trading volume as a proxy for information. Moreover, in contrast to Lamoureux and Lastrapes (1990), ARCH and GARCH effects remain significant as observed in Liam and Daniel (2005), which highlights the inefficiency in the market. This finding leaves the possibility that there may be other variables besides volume, which contribute, to the heteroscedasticity in returns. We can attribute this finding to low level of market depth in India.

Next, in the light of Information asymmetry, the study has used the EGARCH (1,1) or exponential GARCH (1,1) model, which allows for asymmetric shocks to volatility. It indicates the presence of leverage effect and positive impact of volume on volatility. The differential cost of taking long and short positions is main reason for information asymmetry (leverage effect).

Finally, this paper records the evidence of a significant relationship of causality following from volatility to trading volume, which contradicts the mixture of distributions hypothesis and supports the sequential information arrival hypothesis. Preceding return volatility can be seen as some evidence that new information arrival might follow a sequential rather than a simultaneous process(Mestal (2003)). This implies that the strong form of market efficiency does not hold since some private information exists that is not reflected in stock prices. This study also detects one-way causality from return to volume that is indicative of noise trading model of return volume interaction in this market.

In nutshell, it can be stated that volume provides information on the precision and dispersion of information signals, rather than serving as a proxy for the information signal itself (Blume, Easley and O'Hara (1994)). Moreover, new information is absorbed sequentially and the intermediate informational equilibrium is reached before the final equilibrium is found in Indian stock market. These results might be largely attributed to the existence of substantial speculative trading, low level of market depth and price limits observed in Indian market.

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Appendix

Table 12: Lead-Lag Relationship between Return and Volume

Vector Autoregression Estimates		
Standard errors in ( ) & t-statistics in [ ]		
	RETURN	**VOLUME**
RETURN(-1)	0.063482	1.386195
	(0.02074)	(0.36384)
	[3.06066]	[3.80991]
RETURN(-2)	-0.030569	-0.138793
	(0.02079)	(0.36465)
	[-1.47053]	[-0.38062]
RETURN(-3)	0.013798	0.336775
	(0.02079)	(0.36461)
	[0.66381]	[0.92365]
RETURN(-4)	0.050069	-0.175649
	(0.02076)	(0.36425)
	[2.41126]	[-0.48222]
RETURN(-5)	-0.042676	0.386140
	(0.02074)	(0.36383)
	[-2.05756]	[1.06131]
VOLUME(-1)	0.002649	0.425436
	(0.00117)	(0.02059)
	[2.25721]	[20.6629]
VOLUME(-2)	-0.000234	0.157793
	(0.00127)	(0.02233)
	[-0.18393]	[7.06676]
VOLUME(-3)	-0.000325	0.065752
	(0.00129)	(0.02256)
	[-0.25280]	[2.91448]
VOLUME(-4)	-0.001770	0.087733
	(0.00127)	(0.02234)
	[-1.38936]	[3.92634]
VOLUME(-5)	-0.000286	0.137100
	(0.00117)	(0.02060)
	[-0.24356]	[6.65500]
C	-5.01E-05	2.119199
	(0.01506)	(0.26415)
	[-0.00333]	[8.02272]
R-squared	0.012253	0.585307
Adj. R-squared	0.008001	0.583522
Sum sq. resids	0.598674	184.2205
S.E. equation	0.016054	0.281608
F-statistic	2.881696	327.8734
Log likelihood	6337.393	-348.5500
Akaike AIC	-5.421074	0.308098
Schwarz SC	-5.393949	0.335222
Mean dependent	0.000559	16.79625
S.D. dependent	0.016118	0.436363

Table 13 Lead-Lag Relationship between Volatility and Volume

Vector Autoregression Estimates
Standard errors in ( ) & t-statistics in [ ]

	VOLUME	VOLATILITY
VOLUME(-1)	0.413027	-7.81E-07
	(0.02068)	(4.3E-05)
	[19.9758]	[-0.01822]
VOLUME(-2)	0.166380	3.13E-05
	(0.02233)	(4.6E-05)
	[7.45147]	[0.67587]
VOLUME(-3)	0.067592	-4.50E-05
	(0.02257)	(4.7E-05)
	[2.99458]	[-0.96138]
VOLUME(-4)	0.096193	3.42E-05
	(0.02236)	(4.6E-05)
	[4.30216]	[0.73708]
VOLUME(-5)	0.136560	4.47E-05
	(0.02056)	(4.3E-05)
	[6.64160]	[1.04812]
VOLATILITY(-1)	50.89837	0.270086
	(10.0534)	(0.02084)
	[5.06280]	[12.9618]
VOLATILITY(-2)	-9.205823	0.045840
	(10.4259)	(0.02161)
	[-0.88298]	[2.12133]
VOLATILITY(-3)	-20.84912	0.032336
	(10.4284)	(0.02161)
	[-1.99926]	[1.49606]
VOLATILITY(-4)	3.323866	0.041807
	(10.4317)	(0.02162)
	[0.31863]	[1.93362]
VOLATILITY(-5)	-37.40672	0.062812
	(10.1020)	(0.02094)
	[-3.70290]	[2.99995]
C	2.023912	-0.000938
	(0.26721)	(0.00055)
	[7.57421]	[-1.69453]
R-squared	0.589752	0.109619
Adj. R-squared	0.587986	0.105786
Sum sq. resids	182.2461	0.000783
S.E. equation	0.280094	0.000581
F-statistic	333.9423	28.59950
Log likelihood	-335.9747	14085.66
Akaike AIC	0.297322	-12.06055
Schwarz SC	0.324446	-12.03343
Mean dependent	16.79625	0.000260
S.D. dependent	0.436363	0.000614