ISSN (Print Version) 0975-3931
ISSN (On Line Version) 2278-1277

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

Nupur Gupta- Bhattacharya[1] and Gopal S. Zavar[2]

1. Introduction

Mark Twain once split the world in two different kinds of people – first, who have seen Taj Mahal, a famous Indian monument & those who have not. Same can be said about the investors. There are two kinds of investors: one who knows about the potential of investment opportunities in India and those who do not. Someone from US may see India as a small dot, but after closer inspection, one will find same attributes as found in any other promising market. Since the mid-eighties, the Indian capital market has undergone a metamorphic transformation involving multi-dimensional growth. The magnitude of growth can be assessed in terms of massive jumps in funds mobilization, the turnover on the stock exchanges, the amount of market capitalization, and the expansion of investor population. The popular stock index – Sensex is considered as the barometer of the Indian economy. It was first compiled in 1986 with a value of 100 taking base year as 1978-79, based on the performance of the stocks of 30 financially sound benchmark companies on the basis of market capitalization. In 1990 the BSE crossed the 1000 mark for the first time. The stock market is a remarkably good forecaster of economy. For example, in India during the early 1990s, stock prices rose sharply, in anticipation of doubling the profits in 1994 and another doubling of profits in 1995. The reason for such a huge surge in the stock market was the liberal financial policies announced by the then Finance Minister Dr. Manmohan Singh. From late 1994 onwards, stock prices fell badly. This was in anticipation of big declines in profit: -38%, -22% and -50% from 1996-97 to 1998-99. Similarly, in 2002 -03 and 2003-04, profits grew sharply (India Shining), and the stock market captured this in prices ahead of events.The year 2007 was a landmark year when the Sensex broke all records and crossed 15,000, 16,000, 17,000, 18000, 19,000 and 20,000 mark in a span of just four months. It touched the all-time peak of 30,024 in year March 2015.

[1] Assistant Professor (Senior Scale), Finance: Department, Management, K J Somaiya Institute of Management Studies and Research, Vidyanagar, Vidyavihar(E), Mumbai - 400077, Maharashtra, India. Email: nupur.b@somaiya.edu

[2] MMS 14-16 graduated from K.J. Somaiya Institute of Management and Research, Vidyanagar, Vidyavihar(E), Mumbai - 400077, Maharashtra, India. . Email: gopal.zavar@somaiya.edu

The market capitalization to GDP ratio is an important indicator which confirms heightened stock market activity. It is the same as the market capitalization to sales ratio for individual companies. The share of equity traded was 35.7% of the GDP in financial year 2014-15[3]. Another important indicator is the market liquidity measured as a percentage of turnover velocity to market capitalization.[4]

As per the data released by the World Federation of Exchanges, BSE was tenth among the topmost exchanges of the world in terms of the number of trade in equity shares in the electronic order book form for the calendar year 2014[5]. BSE was regarded tenth position in the top performing broad market index in local currency term in 2014. In terms of the value of shares traded NSE was 11th among the top most exchanges of the world (SEBI Annual Report, 2014-15). The growth in the capital market may be understood from the steady increase in the rate of market capitalization as a percentage of the GDP, volumes traded in the cash segment, the number of intermediaries.

A major portion in Indian stock market trading happens prominently on two exchanges – NSE &BSE. Started in 1875, BSE has been the oldest market in India. On the other hand, NSE is comparatively newer, with founding year as 1992 & trade starting year as 1994. Both of the exchanges follow similar mechanism for trading, same settlement process, same trading hours, etc. BSE has 4700 firms listed while NSE has 1200. In BSE, top 500 firms account almost 90% of the total market capitalization & rest are highly illiquid shares.Nifty & Sensex are the prominent market indices in India. Sensex is oldest index for equities. It includes BSE top 30 firm's shares, which constitutes 45% of the total free float market capitalization. It started in 1986 & gives time series data information from 1979 April onwards.

1.1. Stock Volume:

Stock volume is the number of shares traded in a market in a given period. Simply put, it is the amount of shares trading hands from sellers to the buyers. If a seller sells 100 shares to a buyer, then based on this transaction, the volume would increase by 100 shares for that period. Stock volume is considered as an important indicator in the technical analysis because it can be used to measure a market movement. If a market has made a strong price movement either in upward or in a downward direction, the volume for that time period will decide the strength of the move. If the volume during the price movement is high, the move is considered as significant.

- Support & Resistance – Throw one pebble at a glass window & it may not crack or break, but throw 100 of different sizes & the chances of a break are far greater.

[3]http://data.worldbank.org/indicator/CM.MKT.TRAD.GD.ZS accessed on 13th Jan 2016

[4]World development indicator 2012 report page 299

[5]http://blogs.wsj.com/indiarealtime/2014/11/28/indian-stock-exchange-rises-up-world-rankings-catching-up-with-china/ accessed on 8th Jan, 2016.

Applying this to stocks, if one investor places an order to buy 100 shares of stock at the current Ask price, the stock may not move up. But, if 20 investors all place buy orders of different quantities, the stock is most likely going to move up in price because there are not enough sellers. Bottom line, to break through a key support or resistance level on a stock chart, volume is needed in quantity.

- Average Daily Volume – By knowing the total volume on a day, you can understand the power of influence on a given stock. The greater the volume, the greater the influence for the price to change. This allows the investors to identify accumulation and distribution days on a stock chart which can be used to identify current momentum & predict future price movements.

1.2. Stock Returns:

In the simple words, stock return is the loss or gain of a security in specific period. It consists of the capital gains relative & income on an investment. Mostly, it is quoted in terms of percentages. A general rule suggests that more the risk, higher is the potential for profit & of course for loss also. Stock Returns, as wordings itself suggests are the returns that an investor can generate from the stock market. These returns can be either in the form of dividends given by a company to the shareholders or profit through the trading. Generally, after every quarter, a profit making firm offers a part of their kitty to its shareholders. It is one of the sources of the stock return an investor would expect. Generating returns by trading in the secondary market is most common technique. An investor can make money in the secondary market by buying the stock at a lower price & selling it at a higher price when the price rises.

These Returns aren't fixed & ensured but are subject to the market risks. They can be negative or positive. Returns are also not homogeneous & change from investor to investor. It depends upon the risk an investor is ready to take & also on the quality of the Stock Market Analysis done by him. The returns in bonds are fixed. But at contrast, the nature of returns in the stock market is variable. The main idea behind the stock market returns is to buy cheap & sell dear. But the risk is the parcel of this type of market. An investor must be ready to see the negative returns also if speculations are wrong. An investor can speculate on the basis of technical & fundamental analysis.

1.3. Need for the study of stock market volume and returns

Generally, when there is high demand for a stock & if sufficient volume is not available for the sales in the market, the stock prices rise until there is equilibrium in the supply & demand. It in turn affects the profitability or the returns on that stock. So, it can be seen that there is a very close relationship between return & volumes trading on.

Karpoff (1987) had discussed the importance of studying the price & volume relationship. He points out the four most important reasons being:

- First, the stock price & volume relationship can provide an insight into the structure of the financial markets which can describe about how the information is disseminated in the market
- This relationship has a great significance in the event studies which use a combination of stock volumes & returns data to draw the inferences
- It is also an integral part of the empirical distribution of speculative prices
- Most importantly, it can help in deciding the future market movements

2. Literature Review

The most important study in this field, which brings the results of other earlier studies from different markets together, was done by ***Karpoff*** in 1987. He has classified this study in two different groups. First is the research which studies relationship between the trading volume & absolute price change. Another one studies relation between the trading volume & price changes per se. He found that most of the studies report the positive relation between trading volume & price changes. Also, many studiers have used the linear monotonic model to find the relationship. But he argues that there might be some asymmetry in it. Finally, he mentions two theories which help in explaining this positive price vs. volume variability. They were mixture of distributions hypothesis (MDH), and Sequential Information Flow hypothesis (SIF).

Clark (1973) had an explanation for the positive relation between volume & the price volatility. He assumed that volume & price changes have a joint probability distribution. Then his MDH (mixture of distributions hypothesis) theory argues that both of them should be positively correlated since they are jointly depending upon a common underlying variable. This variable was interpreted as random flow of information in the stock markets. It signifies that both trading volume & price changes simultaneously respond to any new information. Hence, they are contemporaneously correlated. ***Epps & Epps (1976)*** also provided some additional evidences to support this theory. They suggested that changes in the log normal return of stock prices follow a mixture of distributions. Transaction volume was considered as a mixing variable.

Copeland (1976) was the first to propose the Sequential Information flow hypothesis (SIF) in 1976. It was further discussed by ***Jennings et al in 1981***. This model assumes that the information is disseminated to market randomly & sequentially. Hence an informed trader who gets information first takes positions & adjusts the portfolios accordingly. This results in the shift in demand & supply & leads to a series of transitory equilibrium. The equilibrium is restored back after the information was absorbed by both unformed as well as informed traders. This sequential dissemination of the information starts transactions at various price levels during the day. This no. of transactions is directly proportional to the rate of information flow in the market. As a result, both the movement in prices & trading volume increase with the rate of information arrival in market increases. It indicates a positive relation between those variables.

Both SIF & MDH attempt to justify that there exists a positive relation between volume and price changes. But the difference is that MDH assumes that information dissemination is symmetrical and all the traders can view the changes in demand & supply simultaneously, which restores equilibrium immediately. SIF assumes asymmetric dissemination of information & slow restoration of equilibrium.

On the basis of the information content of trading volume, ***Blume et al (1994)*** proposed an alternate theory. They assumed that volume is a proxy for quality & precision of information into the stock market & contains information about the stock prices movements. They suggested that stock volume has a major role in the stock prices formation process. Hence, they proposed that superior results can be produced by technical trading based on both the information in volume as well as price. It implies inefficiency in the process of price determination.

Volume & price volatility study was recently examined in a dynamic framework by ***Lamaoureux and Lastrapes (1990)***. They used GARCH model. They considered the trading volume as a proxy for the information flow rate in the market. They studied this for different stocks in the America in 1990.They used the contemporaneous trading volume as an explanatory variable in the equation of variance. They found that this volume inclusion eliminates the volatility persistence. But they also warned that it may cause the simultaneity bias because trading volume is endogenous to the system. Hence, they also tried to use the lagged volume instead of the contemporaneous one but found the insignificant results.

Foster (1995) tried to investigate the temporal price & volatility relation in the oil futures market by considering simultaneity problem. He estimated time varying variances using GARCH model. He incorporated volatility & volume in a simultaneous equation model. His findings indicate that not only lagged volume is positively related to volatility but also there exists a positive contemporaneous relationship between trading volume & the price volatility.

Alex W H (2010) chose six markets, namely Singapore, Malaysia, Thailand, Mexico, Chile & Argentina. The reason for choosing these countries is that among all the emerging markets they have a relatively long history of trading volume data available. For all six countries, there is strong evidence that a positive relation between price change & volume exists. Although there were significant institutional differences between emerging & mature financial markets, the old adage that it takes volume to move price holds true across different markets. But it lacks a unified theory which can explain this asymmetric relation between volume & return.

Another study by ***Brijesh and Singh (2009)*** empirically examines the relationship between returns, volatility & trading volume for 50 Indian stocks. Three measures of the trading volume, namely number of shares traded, total value of the shares traded & the number of transactions were used. They studied the contemporaneous correlation between trading volume and returns. They also examined the asymmetric relation between returns and level of trading volume. They also investigated a lead lag

relationship between stock volume and stock returns. They found a positive correlation between volume & returns. The results indicate that the level of volume is dependent on the direction of price change only in case of 60% of the stocks in the sample. Further tests indicate that for some stocks, returns cause volume. It can be conceived in the context of emerging markets where the development of market causes sequential information dissemination.

Overall the results from these studies indicate the existence of a positive relationship between the price changes & volume. Additionally, some studies have also reported a causal relationship between the price changes & the trading volume. But the causality direction differs from market to market.

3. Objectives, Data &Research Methodology

3.1. Objectives of the study:

The objective of this study is to test the relationship between returns of equity markets in India (for which Sensex is taken as a proxy) and volumes of the shares traded (represented by – shares traded, number of trades and turnover of stocks). In order to test the impact of volume on returns, the dependent variable taken under the study is Sensex closing value while the other three variables are taken as independent variables.

3.2. Data Sources:

In this paper, daily closing prices of Sensex have been used for investigation for the period between October 2010 and September 2015. The reason behind choosing this time period was to make the results more robust. Since, 2008-09 was a period of worldwide recession time, impacting equity markets, this study has taken the data post this slow down phase. Hence, in order to avoid any structural breaks in between the data, the time period chosen was after 2010. The five year time period can be considered as a good time to make convincing conclusions. A total of 1243 observations are there in each of the category of the four chosen variables - (1) daily Sensex closing value, (2) daily shares traded quantity, (3) daily total number of trades and (4) daily turnover of all the stocks included in Sensex.

3.3. Log Normal Returns

The log of the returns is taken to normalize the data. Sensex closing has been converted to LN returns. Taking log of returns helps to remove unusual variations in the data. Log returns converts them enables a series comparable to the other series. This is the most popularly used method in the stock market industry.

$$u_i = \ln(S_i) - \ln(S_{i-1}) = \ln\left(\frac{S_i}{S_{i-1}}\right)$$

Where, u_i = Log Normal Return on the i^{th} day

& S_i = Closing price of stock on the i^{th} day

If it is assumed that the Sensex closing value is log normally distributed, then LN returns are conveniently normally distributed:

$$1 + r_i = \frac{p_i}{p_j} = \exp^{\log(\frac{p_i}{p_j})}$$

Another advantage of using LN returns is 'approximate raw log equality'. When there are very small returns (generally in daily data), then it is ensured that they are close to the value of the raw returns by-

$$\log(1 + r) \approx r \, , r \ll 1$$

3.4. Stationarity:

The closing Sensex prices are non-stationary. It means that their variances, covariance & means change over time. Therefore, as a rule, the non-stationary data cannot be modeled, forecasted or predicted. The outcome by using a non-stationary time series can be spurious in that they might imply that there is a relation between the two variables when actually there is none. The non-stationary data should be transformed into the stationary data to obtain the reliable outcome. In contrast to the Sensex closing data which has the variable mean & variance which neither returns nor remains closer to the long run mean or variance over a period of time, the LN returns reverts around a constant long term mean. It also has a constant variance which is not dependent on the time. The non-stationary series gives unreliable result which leads to the specious forecasting. The solution to this problem is to transform the time series so that it becomes stationary. So, LN returns are taken into consideration & not the closing Sensex values.

3.5. Research tools:

First of all, the Unit Root Test has been applied to check if there is any unit root in the data. Statistical investigation is proceeded after data has been converted into a stationary series. Thereafter, Granger Causality test and Vector Auto regression test has been applied to investigate long run relationship between stock market returns and trading volumes.

The Augmented Dickey Fuller (hereafter ADF) test is used to check a unit root in the time series sample. The augmented version of the Dickey Fuller test to be used when there is large and more complicated data sets for the time series models. The statistic used in this test is a negative number. A high negative value of the statistics is preferred. It implies the rejection of the null hypothesis with given confidence level.

Once, it is confirmed that there is no unit root in the data, the Granger causality and VAR test can be safely applied.

3.5.1. Granger Causality Test:

This test is a statistical hypothesis testing used to determine if a time series can be used to forecast other one or not. Mostly, a regression reflects a mere correlation. But Granger argued that causality in a time series can be tested by measuring an ability of it to predict

about future values from the past values of some another series. The causality is a philosophical term. Statisticians argue that this test can find only predictive causality because of the post hoc ergo propter hoc fallacy to assume that if a thing precedes another, then it can be used as a proof of causation.
Granger defined this causality based on the two principles:

- The cause happens prior to the effect.
- The cause has some unique info about the future values of effect.

Assuming those two, he advised to test following to identify the causal effect-
Let x & y are 2 stationary time series.
Null Hypothesis: X doesn't granger cause y.

Now, we need to find proper lagged values of y & x which we can include to augment the AR:

$$y_t = a_0 + a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_m y_{t-m} + b_p x_{t-p} + \cdots + b_q x_{t-q} + \text{residual}_t.$$

All the statistically significant lagged values of x are retained in this regression but they should collectively add the explanatory power to the regression which is decided by F-test. Null hypothesis isn't rejected if & only if there are no lagged values of x which are retained in this regression.

Granger Causality test is a statistical hypothesis test used to determine if a there is a unidirectional or bidirectional relationship between each pair of time series. Mostly, a regression reflects a mere correlation. But Granger argued that causality in a time series can be tested by measuring an ability of it to predict about future values from the past values of some another series.

3.5.2. Vector Auto Regression model:

The VAR is an econometric model which is used to capture the linear inter-dependencies among multiple time series. It is a generalized form of the univariate AR model. It allows more than one variable. All of these variables are treated symmetrically, although it is possible that their respective response coefficients might be different. Each of the variables has an equation which explains their evolution that is based on lags of other variables as well as lag of its own. This model doesn't need much information about forces which influence the variables as we need in the case of structural models having simultaneous equations. A list of all the variables that can be hypothesized to affect each other is the only thing that we need in VAR.

A VAR model describes evolution of a variable set over the same sample period like t =1,…,T as a linear function of only their past values.

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t,$$

ISSN (Print Version) 0975-3931
ISSN (On Line Version) 2278-1277

4. Data Analysis and discussion

Analysis of unit root test:

As it can be seen, the probability values for all the parameters in the Unit root test is less than 0.05. It means that the null hypothesis can be rejected. So, the alternate hypothesis is true. There is no unit root in any of the parameters. The time-series is stationary at their first difference. Hence, 'Granger Causality Test' and 'Vector Auto Regression model' can be further applied for analysis.

Table 1: Results of ADF Unit Root Test

S.No.	Variable	Level of differencing	t-Statistic	Prob	Result
1	Sensex close	First difference	-32.34218	0.0000	Data is Stationary
2	Daily Number of trades	First difference	-4.039804	0.0013	Data is Stationary
3	Total shares traded	First difference	-6.185556	0.0000	Data is Stationary
4	Shares Turnover	First difference	-5.369546	0.0000	Data is Stationary

Source: As per Author's calculations

Table 2: Results of pairwise granger causality test

S.No.	Null Hypothesis	F-Statistic	Probability
1	*D(SENSEX_CLOSE) does not Granger Cause NO_TRADES*	*6.84253*	*0.00111*
	NO_TRADES does not Granger Cause D(SENSEX_CLOSE)	0.71279	0.49048
2	SHARES_TRADED does not Granger Cause D(SENSEX_CLOSE)	0.49718	0.60837
	D(SENSEX_CLOSE) does not Granger Cause SHARES_TRADED	2.00588	0.13498
3	TURNOVER does not Granger Cause D(SENSEX_CLOSE)	0.97465	0.37761
	D(SENSEX_CLOSE) does not Granger Cause TURNOVER	0.43262	0.64891
4	*SHARES_TRADED does not Granger Cause NO_TRADES*	*7.20758*	*0.00077*
	NO_TRADES does not Granger Cause SHARES_TRADED	*17.3761*	*3.6E-08*
5	*TURNOVER does not Granger Cause NO_TRADES*	*13.4492*	*1.7E-06*
	NO_TRADES does not Granger Cause TURNOVER	*22.5827*	*2.3E-10*
6	*TURNOVER does not Granger Cause SHARES_TRADED*	*19.4476*	*4.8E-09*
	SHARES_TRADED does not Granger Cause TURNOVER	*48.6550*	*4.6E-21*

Source: As per author's calculations

Analysis of Granger Causality Tests:

If probability is less than 0.05, the null hypothesis is rejected in favor of the alternate hypothesis.

The log normal returns of the Sensex closing value granger causes the number of trades. It means that number of trades is a function of Sensex returns. However, number of trades do not granger because Sensex returns. Hence, there is unidirectional relationship between number of trades and Sensex returns. Similarly, Shares traded and the log normal returns of Sensex closing values do not cause each other because probability is greater than 0.05. So, there is no relationship between them. In the similar way, there is no causal relationship between the turnover & the log normal return of the Sensex closing values.But in the case of shares traded vs. number of trades, it can be seen that there is a bidirectional relationship between both of them, which means that a change in the no. of trades causes the shares traded to change & vice the versa.Similarly, there is a bidirectional relationship between the turnover & the no. of trades. Also, there is a bidirectional relationship between the turnover & the shares traded.

4.1. Vector Auto Regression (VAR) model:

The VAR is an econometric model which is used to capture the linear inter-dependencies among multiple time series. It is a generalized form of the univariate AR model. It allows empirical investigation by taking more than two variables at a time (Unlike Granger Causality, which allows only pairwise empirical investigation). All the variables taken in this study are treated symmetrically, although it is possible that their respective response coefficients might be different. Each of the variables has an equation which explains their evolution that is based on lags of other variables as well as lag of its own. This model doesn't need much information about forces which influence the variables as we need in the case of structural models having simultaneous equations. A list of all the variables that can be hypothesized to affect each other is prerequisite for applying VAR.

A VAR model describes evolution of a variable set over the same sample period like t =1, T as a linear function of only their past values.

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t,$$

The granger causality test throws light on any causal relation between the given variables. It helps us in finding dependency on pairwise variables. Using the VAR test, we can actually find the coefficients & form an equation by taking multiple variables at the same time which can give us an idea about the future trends. This explains there reason of using the VAR test in this paper after establishing significant relationships between some of the select variables.

ISSN (Print Version) 0975-3931
ISSN (On Line Version) 2278-1277

Table 3: VAR test probabilities for Sensex returns with other parameters

Vector Auto Regression Estimates

Included observations: 1240 after Adjustments

Standard errors in ( ) & t-statistics in [ ]

	D(SENSEX_CLOSE)
D(SENSEX_CLOSE(-1))	0.085967
	(0.02849)
	[3.01726]
D(SENSEX_CLOSE(-2))	-0.043732
	(0.02852)
	[-1.53360]
C	9.975372
	(19.4456)
	[0.51299]
NO_TRADES	1.12E-05
	(1.3E-05)
	[0.86001]
SHARES_TRADED	-0.842863
	(1.14454)
	[-0.73642]
TURNOVER	-0.001071
	(0.01008)
	[-0.10626]
R-squared	0.009619
Adj. R-squared	0.005606
Sum sq. resids	59477922
S.E. equation	219.5434
F-statistic	2.397060
Log likelihood	-8441.998
Akaike AIC	13.62580
Schwarz SC	13.65059
Mean dependent	4.634774
S.D. dependent	220.1614

Source: As per author's calculations

Analysis of VAR test:

If probability value is less than 0.05, the null hypothesis is rejected in favor of the alternate hypothesis. So, from the above results, it can be seen that the LN returns in the Sensex closing value are dependent on the LN return of Sensex closing value of the previous day & also of the day before that day, no. of trades & the turnover. While, it is independent of the shares traded. So, now, an equation can be formed to get predict the future of Sensex closing value on the basis of its own historical closing values of previous and two days prior to the actual trade day. No. of trades and turnover of shares traded also enable us to predict future values of Sensex close. The results are in contradiction to the pairwise Granger Causality test conducted between No. of trades and Sensex Returns, where this unidirectional relation was not found significant. However on applying all the other variables to predict Sensex Returns in the VAR equation, the no. of trades exhibits significant causal relations on Sensex Returns.

5. Conclusions

To understand the relation between volume & return in a market is equally important for researchers, policy makers & traders. The returns distribution has many implications on the risk management practices & the financial models. The relation between volume & returns can help the people in understanding market clearing process as well as friction in the market. Also, forecasting using different models helps traders with the short term investment horizon & also to the portfolio managers having a long term investment plan. In emerging markets & especially in the Indian markets, there are very few studies which address this relationship. This paper presents an empirical study about the Indian Stock market, especially BSE Sensex.

We analyzed volume vs. returns relation for Sensex, focusing on the contemporaneous relation between volume & returns & the lead lag relation between them. This relationship has been modeled using Granger Causality & VAR model. Those findings imply the evidences to decide that there is a positive contemporaneous correlation between trading volume & stock returns in Sensex. These results also imply that in Sensex, daily no. of trade transactions and shares turnover can prove to be a better proxy of the information flow than total no. of shares traded.

6. References

Alex, W.H.C. 2010. Return Volume Relation in the Tail: Evidence from six Emerging Markets. Banking & Finance Letters, Vol. 2(2), 291-308

Blume, L., Easley, D. and O'Hara, M. 1994. Market Statistics & Technical Analysis: The Role of Volume. Journal of Finance, Vol. 49, 153–181

Clark, P.K. 1973. A Subordinated Stochastic Process Model for Speculative Prices with Finite Variance. Econometrica, Vol. 41, 913-935

Copeland, T.E. 1976. The model of Assets Trading under an Assumption of Sequential Information Arrival. Journal of Finance, Vol. 31, 1149- 1186

Epps, T.W. and Epps, M.L. 1976. The Stochastic Dependence of the Security Price Change & Transaction Volumes: Implications for the Mixture of Distribution Hypothesis. Econometrica, Vol. 44, 305-321

Foster, A. 1995. Volume Volatility Relationships for Crude Oil Futures Markets. Journal of Futures Markets, Vol. 15, 929-951

Jennings, R.H., Starks, L.T. and Fellingham, J.C. 1981. An Equilibrium Model of Asset of Trading with Sequential Information Arrival. Journal of Finance, Vol. 36, 143-161

Karpoff, J.M. 1987. The Relation between Price changes & Trading Volume: A Survey. Journal of Financial & Quantitative Analysis, Vol. 22, 109-126

Kumar, B. and Singh, P. 2009. The Dynamic relationship between stock returns, trading volume & volatility: Evidence from Indian stock market. IIM Ahmedabad Working Paper No. 2009–12–04

Lamaoureux, C.G. and Lastrapes, W.D. 1990. Heteroscedasticity in Stock Returns Data: Volume vs. GARCH Effects. Journal of Finance, Vol. 45, 221-229