Price Changes, Trading Volume, Open Interest and Volatility: A Multivariate Cointegration and VECM for S&P CNX Nifty Futures Market in India

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Abstract: In this paper the causal nexus between futures return, trading volume, open interest and volatility for S&P CNX Nifty futures markets were analyzed for the period from January 1, 2002 to September 30, 2009. In view of the priority given to dynamic relationship in conducting this study, the Johansen-Juselius Multivariate cointegration, Vector Error Correction Model (VECM), Impulse Response Function (IRF) and Variance Decomposition (VDC), are used as empirical evidence. Our result reveals, that the causal linkage of return are influenced by all the other variables, whereas the ECTs coefficients are negative and significant in the long-run but their values are too high to be in equilibrium. We conclude that, any deviation from the equilibrium Cointegrating relationships, as measured by the ECTs, is mainly caused by changes in returns and volatility. In the case of IRF appears to be broadly consistent with earlier VECM results trading volume, open interest and volatility remain consistent over the period, whereas the fluctuation in futures return was mainly determined by the other future market variables. Finally, there exist a bi-directional causal relationship exist between futures market variables in the short-run and unidirectional causality running from trading volume and open interest with return and volatility bears the brunt of short-run adjustment to long-run equilibrium.

Key Words: Futures Returns, Trading Volume, Open Interest, Volatility, Cointegration, VECM

JEL Classification: C1; E44

Introduction:

Financial media regularly reports daily trading activities to the stock markets. The information content of this data has long attracted the attention of many researchers, policy makers and investors to examine if there is an asymmetric relationship between these variables. However, trading volume offers useful information for practitioners and investors in investment decisions, as well as for researchers and policy makers in testing the theories of financial economics. The contemporaneous relation between price movements, trading volume and open interest on financial markets has long attracted the attention of many financial economists. Our initial analysis centers on the volume and price change relative are positively related to each other and it was first documented by Ying (1966). Similarly, Karpoff (1987) seminal paper summarizes the importance of this research area by presenting the following argument. First, the returns or trading volume relation provides insight into the structure of financial markets. Second, the returns or trading volume relation is important for event studies that use a combination of stock returns and trading volume data to draw inferences. Third, the returns or trading volume relation is critical to the debate over the empirical distribution of speculative prices.

A considerable amount of empirical research has been directed towards examining the relationship between futures and the underlying spot prices. In particular, the focus of attention has been on the existence of cointegration relationship between return, trading volume, open interest and volatility for S&P CNX Nifty futures markets. Additionally, this paper also investigates the speed of equilibrium between the multivariate variables and to forecast the innovation to shocks and relies on the rate of information arrival in futures market. One of the main limitations of the earlier analyses on the stock return and trading volume relationship is that they are all performed on stock markets. Meanwhile, the results from stock index futures markets will be quite interesting for several reasons. First, price movements can only capture the impact of that 'news' on the average change in investor's expectations. Second, trading volume has the specificity of reflecting the cumulative response of investors. Third, open interest can prove useful towards the end of the major market moves. Finally, volatility is a measure used to assess the trading strategies to exploit risk movements. Many studies reported a contemporaneous correlation between stock returns and trading volume variables, but the casual relationship between these variables in global markets were quite limited and still it remains like muddy water.

The structure of the paper is as follows. Section 2 reviews the previous studies on the price-volatility relationship and highlights their conclusions. Section 3 presents the methodology used in this paper to investigate the relationship between futures market variables. The data and their properties are discussed in section 4, while section 5 presents the empirical results and discussion. Implications of findings and conclusions are the subject of the last section.

Literature Review

There are a large number of studies in the literature on the price-volume relationship. Clark (1973) offers a competing explanation for the existence of positive price volatility and trading volume relationship. The Mixture of Distribution Hypothesis (MDH) is based on the assumption that both price changes and volume have a joint probability distribution. He argues that, price change and trading volume should be positively correlated because they jointly depend on a common underlying variable, which is normally interpreted as the random flow of information to the market. This means that both price changes and trading volume simultaneously respond to the new information and they are contemporaneously correlated. Additional evidence in support of the MDH is also provided by Epps and Epps (1976) who suggest that the change in the logarithm of price can be viewed as following a mixture of distributions, with transaction volume being the mixing variable.

The Sequential Information Flow (SIF) hypothesis proposed by Copeland (1976) and discussed further in Jennings et al (1981) assumes that information is disseminated in the market sequentially and randomly. Therefore, informed trades who obtain the information first take positions and adjust their portfolios accordingly, which results in shifts in supply and demand and a series of transitory equilibrium. Once the information is fully absorbed by all traders, informed and uninformed, then equilibrium is restored. This sequential dissemination of information initiates transactions at different price levels during the day, the number of which increases with the rate of information flow to the market. Consequently, both trading volume and movement in prices increase as the rate of arrival of information to the market increases which implies the existence of a positive relationship between the two variables.

To address the controversy related to endogeneity between stock return and trading volume, Clark (1973) put forward the Mixture of Distributions Hypothesis plays a prominent role in the empirical finance arena. As initially suggested by Morgan (1976) volume is regarded as a major risk factor contributing to the volatility of returns, particularly in less liquid and thin markets including emerging markets. In the mixture model of Epps and Epps (1976), trading volume is used to measure disagreement among traders as investors revise their reservation prices based on the arrival of new information to the market. Similarly, positive contemporaneous relationship between variance of price change and trading volume was linked by Ragalski (1978), Figlewski and Cornell (1981) who studied the basic relationship between the variables. Tauchen and Pitts (1983), and Lastrapes and Lamoureux (1990) alleges that the conditional heteroskedasticity in stock returns can be explained by a serially correlated mixing variable that measures the rate at which information is transmitted to the market. These authors have shown that the information arrivals stemming from the existence of exogenous variables can be identified by the mixture of distributions, and these variables exhibit time-varying ARCH effect.

Recent studies have also examined the price-volatility relationship in a dynamic framework using GARCH type models where trading volume is used as a proxy for the rate of information flow to the market to explain market volatility. For instance, Lamoureux and Lastrapes (1990) examined the relationship between return volatility and information flow for other markets Martikainen et. al (1994) and Pyun et. al (2000). Omran and Mckenzie (2000) investigated the relation between volume of trade and conditional variance of trade and found the significant relation between timing of innovational outliers in returns and volume. Chen et.al (2001) report the persistence in volatility is not eliminated when lagged or contemporaneous trading volume level is incorporated into the GARCH model, a result contradicting the findings of Lamoureux and Lastrapes (1990). Brailsford (1996) found the irrespective of the direction in price change was significant across three measures of daily trading volume for the aggregate market and was significant for individual stocks. Miyakoshi (2002) finds that the inclusion of the trading volume variable in both ARCH and exponential GARCH eliminate the ARCH/GARCH effect for individual stocks listed on the Tokyo stock Exchange and their price index.

An overwhelming number of studies have examined both theoretical and empirically, the relationship between future return, trading volume and open interest. Ragunathan and Pecker (1997) focus on the relationship between volume and price variability for the Australian futures market and explore positive relationship between volume and volatility by documenting asymmetric volatility response to unexpected shocks in trading volume by using the model developed by Bessembinder and Seguin (1993). Positive unexpected shocks to trading volume were found to induce an average increase in volatility at 76 per cent, while negative unexpected shocks to trading volume induce a smaller response in volatility. Daigler and Wiley (1999) examine the volume-volatility relation in futures markets for Chicago Board of Trade for four types of traders. Bessembinder & Seguin (1992) have reported that active futures markets enhance the liquidity and depth of equity markets. In contrast, the results obtained here provide low cost of futures trading attracts additional informed traders, and support for the alternate theory that futures trading leads to price destabilization. Bessembinder and Seguin (1993) investigated the relations between volume, volatility, and market depth in eight physical and financial futures markets and suggested that unexpected volume shocks have a larger effect on volatility, the role of open interest provides information to mitigate volatility and he suggested that the volatility-volume relation in financial markets depends on the type of trader. Toshiaki Watanabe (2001) examines the relation between price volatility, trading volume and open interest for Nikkei 225 stock index futures and evidenced the relation between price volatility; volume and open interest may vary with the regulation.

A large number of studies have conducted at international level by the authors of recent origin to test the relationship between futures return, trading volume and open interest contacts, whereas in India the empirical works are quite limited. Pati and Kumar (2006) tested the maturity, volume effects and volatility dynamics for Indian futures market and suggested that time-to-maturity is not a strong determinant for futures price volatility, but rate of information arrival proxies by volume and open interest are the important sources of volatility. Finally, they concluded that Samuelson Hypothesis does not provide support for Indian futures market so the investors should not base their investment decision on time-to-maturity. Srinivasan, Malabika and Murugesan (2009) evidenced that return volatility is influencing by both expected and unexpected trading volume and open interest respectively, they concluded that unexpected volume and open interest are more likely to have a greater impact on volatility than the expected trading volume and open interest.

Despite this plethora of studies on the relationship between price variability, trading volume and market depth in financial markets, but only a handful of studies have come out to examine the casual nexus between futures market variables at the national level Pati and Kumar (2006), Srinivasan, Malabika and Murugesan (2009). To our knowledge, there has been no studies have investigated to explore the long-term relationship between future return, trading volume, open interest and volatility in futures market. This is unfortunate given the importance of to our economies. Despite the obvious importance of the relationship between price changes, trading volume, open interest and volatility is a paucity of research on this topic in emerging markets. The contribution of this paper is to fill the existing gaps by using multivariate Johansen's cointegration techniques, Vector Error Correction Model (VECM), Variance decomposition and Impulse Response function for examining the relationship between futures market variables.

Material and Methods:

Step: 1 Johansen Multivariate Cointegration Test

In order to estimate the VECM, we first consider whether each series is integrated of the same order, to do this we consider the standard Augmented Dickey Fuller (ADF) test. Assuming that each series contains a single unit root, and thus each series is integrated of order one, the potential for co movement between series exists, suggesting the existence of a long-run relationship amongst these variables.

To investigate the long-run relationship between stock return, trading volume and volatility as a system of equations, we employed the Johansen multivariate cointegration test. The relationship among the variables is based on the following models;

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + ... + \Gamma_{k-1} \Delta X_{t+1} + \Pi X_{t-k} + \mu + \Phi D_t + \varepsilon_t \qquad (1)$$

Where, $\Gamma_i = -I + \Pi_1 + \Pi_2 + ... + \Pi_i$ for I =1, 2, k-1;

$\Pi = -I + \Pi_1 + \Pi_2 + ... + \Pi_k$ I is an identity matrix

The matrix Γ_i comprises the short-term adjustment parameters, and matrix Π contains the long-term equilibrium relationship information between the X variables. The Π could be decomposed into the product of two n by r matrix α and β so that $\Pi=\alpha\beta$ where the β matrix contains r cointegration vectors and α represents the speed of adjustment parameters. Johansen (1988)

Johansen developed two likelihood ratio tests for testing the number of Cointegration vectors (r): the trace and the maximum Eigen value test. The trace statistics tests the null hypothesis of $r = 0$ against the alternative that $r > 0$. The maximum Eigen value statistics test the null hypothesis that the number of Cointegrating vectors is r against the specific alternative of $r = 1$ Cointegrating vectors.

Step: 2 Vector Error Correction Models

Utilizing the Cointegrating vector obtained from Johansen procedure, the short run vector auto regression in the error correction model (VECM) can be expressed as follows:

$$\Delta Rt_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta Rt_{t-1} + \sum_{i=1}^{p} \alpha_{2i} \Delta Tr_{t-1} + \sum_{i=1}^{p} \alpha_{3i} \Delta Op_{t-1} + \sum_{i=1}^{p} \alpha_{4i} \Delta Vo_{t-1} + \alpha ECT_{t-1} + u_{1t} \qquad (2)$$

$$\Delta Tr_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta Rt_{t-1} + \sum_{i=1}^{p} \beta_{2i} \Delta Tr_{t-1} + \sum_{i=1}^{p} \beta_{3i} \Delta Op_{t-1} + \sum_{i=1}^{p} \beta_{4i} \Delta Vo_{t-1} + \beta ECT_{t-1} + u_{2t} \qquad (3)$$

$$\Delta Op_t = \psi_0 + \sum_{i=1}^{p} \psi_{1i} \Delta Rt_{t-1} + \sum_{i=1}^{p} \psi_{2i} \Delta Tr_{t-1} + \sum_{i=1}^{p} \psi_{3i} \Delta Op_{t-1} + \sum_{i=1}^{p} \psi_{4i} \Delta Vo_{t-1} + \psi ECT_{t-1} + u_{3t} \qquad (4)$$

$$\Delta Vo_t = \xi_0 + \sum_{i=1}^{p} \xi_{1i} \Delta Rt_{t-1} + \sum_{i=1}^{p} \xi_{2i} \Delta Tr_{t-1} + \sum_{i=1}^{p} \xi_{3i} \Delta Op_{t-1} + \sum_{i=1}^{p} \xi_{4i} \Delta Vo_{t-1} + \xi ECT_{t-1} + u_{4t} \qquad (5)$$

Where, the lagged difference terms are being determined by minimum number of residuals free from autocorrelation. This could be tested for in the standard way such as Akaike Information Criterion (AIC) or Schwartz Bayesian Criterion (SIC). Return movements can only capture the impact of "news" on the average change in investor's expectations, trading volumes reflect the cumulative response of investors, open interest is a total number of contracts that are not closed at the end of a particular day and volatility is a measure used to assess the trading strategies to exploit risk movements and it is described as the "rate and magnitude of changes in prices". α_0, β_0, ψ_0 and ξ_0 are the constant indicating intercepts, respectively; Δ is a first difference operator; ECT_{t-1} is the error correction term obtained from the Cointegration test that is normalized with respect to each variable; and α_0, β_0, ψ_0 and ξ_0 are the coefficients that show the speed of adjustment back to along-run equilibrium relationship. In addition u_{1t}, u_{2t}, u_{3t} and u_{4t} are serially uncorrelated random error terms with a zero mean.

The null hypotheses this paper is interested in are $\alpha_{2i} = 0$ indicates that trading volume does not cause returns and $\beta_{1i} = 0$ implying returns does not cause trading volume. Even though both t-and F-tests can be used for the statistical inferences regarding the hypotheses because all the variables in equations (2)-(5) are cointegrated of the same order, the standard t-test is used for the inferences regarding individual coefficients in this study.

Step: 4 Impulse Response Function (IRF) and Variance Decomposition (VDC)

Information gathered from Variance decomposition (VDC) can also be presented with impulse-response function (IRF). Impulse-response function display the effect of one unit standard deviation shock coming to one of the random error terms on the current and future values of endogenous variables. Consequently, the IRF was used to explain how the changes in one variable will respond to the shock in another variable in the future and portray the dynamics multipliers giving about the size and the direction of the effect. As the VEC model is under-identified, the Choleski clarification method is used to orthogonalize all innovation. Despite, all the above, this method is very sensitive and dependent on the order of variables.

On the other hand, Variance decomposition decomposes the change in one of the endogenous variables as separate shocks affecting all endogenous variables. VDC gives information about the dynamic structure of the system in this respect. The goal of VDC is to figure out the proportion of movements in a variable due to it "own" shocks versus shocks to other variable.

Data Properties

The data used are settlement prices, trading volume, open interest and volatility for S&P CNX Nifty futures traded in National Stock exchange (NSE). The database used for the sample period for the study covers 9 years, from January 2002 to September 2009. The analysis for testing the relationship between futures market variables were retrieved from the website of NSE with detail contract specifications. One of the major reasons for considering S&P CNX Nifty futures was due to diversification of 50 liquid stocks of the economy. During the study period, trading on derivatives segment takes place on all days of the week except Saturdays and Sundays as holiday declared by the exchange in advance and the securities trade from 09: 55 hrs to 15: 30 hrs. Nearby futures contracts are selected for this study, because they are the most actively traded futures contracts within their own classification. The closing price indices were converted to daily compounded return by taking the log difference as $R_t = \log (P_t/P_{t-1})$, where P_t represents the value of index at time t. As for as, trading volume and open interest is concern, the study applied logarithmic procedure on these variables to account for non-stationary in the series.

The daily volatility of index futures returns are estimated by the model developed by Schwert (1990) and Schwert and Seguin (1990). The following equations are

$$\sigma^2 = \sqrt{\pi / 2}\, | R_t - \mu |$$

Where, R_t is the return for selected index futures contracts calculates as described above and μ is mean of the series.

Results:

Step 1: Unit-root tests

In this study, to measure the stationarity of the futures market variables like futures returns, trading volume, open interest and volatility Augmented Dickey Fuller (ADF) unit-root tests were used to measure the z-statistic and it will be compared to the critical value given by MacKinnon (1991) and the test results are presented in Table 1. The time series under consideration should be integrated in the same order before we can proceed to co integration analysis and causality test. Table 1 presented the results of the stationarity test at level and first difference. From the result, it is found that the null hypothesis of non stationary at level for all the time series failed to be rejected. Notwithstanding the above, all null hypotheses are rejected for every test at first difference. The results clearly indicate that all variables are stationary at I(1).

Step 2: Multivariate Cointegration test

The cointegration test, which was the precondition for estimating VECM, was performed under the assumption that there are linear trends in the data, so the model allows the non-stationary relationships in the model. From the results in Table 2, we can conclude that there exists three significant Cointegrating vector. So, it can be concluded that these four variables are bound together by long-run equilibrium relationship. The number of Cointegrating vectors found in Table 2 results in a corresponding number of residual series, and hence error-correction terms (ECTs), which can be embodied as exogenous variables appearing in their lagged-levels as part of the vector error-correction model (VECM), Table 3.

Step 3: Vector Error Correction Model

The results of Vector Error Correction model can be applied next to co-integrated series and the results are reported in Table: 3, we find that, all the futures market variables are significant in the short-run, but the variables like trading volume and open interest which is statistically exogenous in the long-run. The statistically significant coefficients associated with ECT provide evidence of an error correction mechanism that drives the variables back to their long-run relationship, which shows the econometrical exogeneity of the ECT series.

As we note that neither the ECT nor the short-term channels of Granger-causality is temporarily active. Although the error-correction term is insignificant in trading volume and open interest equations, each variable is influenced by significant short-run causal influences from variables. Here we can visually discern the Granger-causal linkage patterns of return are influenced by all the other variables, whereas the ECTs coefficients are negative and significant in the long-run but their values are too high to be in equilibrium. We conclude that, any deviation from the equilibrium Cointegrating relationships, as measured by the ECTs, is mainly caused by changes in returns and volatility, i.e. unidirectional causality exist between trading volume and open interest with return and volatility bears the brunt of short-run adjustment to long-run equilibrium.

Step: 4 Impulse Response Function (IRF) and Variance Decomposition (VDC)

Dynamic simulations are used to calculate VDC and visualize the IRF in order to corroborate the results obtained through VECM. An analysis of the IRF is presented in Figure 1. A ten-period horizon is employed to allow the dynamics of the system to work out. in each figures, the point estimates are plotted with solid lines for return, bold dotted lines represent trading volume, open interest were denoted with thin dotted lines and thin lines envisage volatility of the shocks. The IRF's, Figure: 1, tend to suggest that one standard deviation shock to return relatively has an impact on the other variables. A shock to output variable significantly affects the future market variables. The impulse response function of the futures market variables fluctuate during the period, whereas the response of return and volume converge over the time, but the response of open interest and volatility will take a long time to die out, this shows that the information is persistent in open interest and volatility. In case of return the shocks begins with positive response, then fluctuates around zero and finally becomes less than zero towards volatility, open interest and volatility. For trading volume, the IRF begins with positive shocks and shows significant positive response towards the end. Shocks to open interest and volatility have small response on return but the impact is not persistent almost stabilize during the period. Therefore, the IRF appears to be broadly consistent with earlier VECM results trading volume, open interest and volatility remain consistent over the period, whereas the fluctuation in futures return was mainly determined by the other future market variables.

The results of VDCs are reported in Table: 4, A ten-period horizon is employed to convey a sense of the dynamics of the system. The chain implied by the analysis of VDC tends to suggest that return series is relatively the leading variable, being the most exogenous of all, except open interest. VDC in trading volume, besides being explained by its own variable, trading volume can be explained by open interest and volatility. In case of open interest it is explained by its own shocks and trading volume. The same can be said for volatility, in addition to being explained by the variable itself, it is explained by return.

Conclusion:

The main objective of this study is to view the relationship between futures returns, trading volume, open interest and volatility using S&P CNX Nifty futures market by applying the cointegration test in the VECM framework. The VDC and IRF are viewed to verify the results obtained through VECM. The evidence of cointegration between the variables, suggest the existence of a long run stable relationship between variables. This gives the implication that even though there is a momentary dispersal from the long-run, the power of endogenous variables will promote the relationship back to long-run equilibrium.

The finding from cointegration test or the relation of long-run stability between variables especially futures returns, trading volume, open interest and volatility is vital for policy maker. The combination of VECM, VDC and IRF provide a valuable implication on the direction of relationship between variables examined. In the view of the feedback effect, in the determination of futures market variables in the short-run, but the linkage pattern of return are influenced by all the other variables, whereas the ECTs coefficients are negative and significant in the long-run but their values are too high to be in equilibrium. We conclude that, any deviation from the equilibrium Cointegrating relationships, as measured by the ECTs, is mainly caused by changes in returns and volatility i.e. unidirectional causality exist between trading volume and open interest variables. This study concludes that information based upon trading volume, open interest are not the key determining factors for futures price volatility, but the rate of information arrival proxies like trading volume, open interest and volatility are the important sources for measuring the fluctuations in future returns.

Our result would be interesting for the researchers, policy makers and market participants. The study suggested that the fluctuations in future return are mainly due to the other futures market variable. But, there is no link between the individual variables like open interest and volatility, whereas trading volume was the variable having meager impact on open interest and volatility. Two of the market participants interested in the results are hedgers and speculators. Hedgers enters the futures market to offset the risk of substantial loss in the future, while speculators take positions based on their expectation of the movements of that contract. Since, open interest does not hold in the Indian futures market, the investors should not base their investment decision according to open interest. The trading volume is still important in influencing the futures returns, open interest and volatility in futures markets. In conclusion, the empirical results show that, financial development significantly causes growth in the short-run, and in the long-run. There is a bi-directional causal relationship exist between futures market variables in the short-run and unidirectional causality running from trading volume and open interest with return and volatility bears the brunt of short-run adjustment to long-run equilibrium.

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Table 1 Augmented Dickey Fuller Test

	Level		First Differences	
Particulars	**Intercept**	**Trend & Intercept**	**Intercept**	**Trend & Intercept**
Return	-1.37378	-1.36529	-32.77378*	-32.76529*
Trading Volume	-1.56389	-1.56521	-28.56389*	-28.56521*
Open Interest	-0.01332	-0.01320	-26.01332*	-26.01320*
Volatility	-1.23162	-1.22325	-32.23162*	-32.22325*

Note: t-value in the level accepts the null hypothesis of unit root whereas the t-values in the first difference reject the hypothesis at 1 per cent level of significance. Thus, the table shows that all the variables have the same single unit roots, I(1).

Table 2 Results of Johansen Cointegration test

Null Hypothesis	Alternative Hypothesis	95 per cent C.V	λ_{trace} Statistics
r = 0	r > 0	47.8561	749.8426*
r ≤ 1	r > 1	29.7970	289.4407*
r ≤ 2	r > 2	15.4947	93.7091*
r ≤ 3	r > 3	3.8418	3.8256

λ_{max} Test

Null Hypothesis	Alternative Hypothesis	95 per cent C.V	λ_{trace} Statistics
r = 0	r = 0	27.5843	460.4019*
r = 1	r = 1	21.1316	195.7315*
r = 2	r = 2	14.2640	89.8835*
r = 3	r = 3	3.8414	3.8256

Note: denotes the number of Cointegrating vectors and the 95 per cent confidential level of the trace and maximum eigenvalue statistics. * denotes significance at 1 per cent significant level.

Table 3 Results of Multivariate Vector Error Correction Models for Futures Market Variables

Dependent Variables	Return	Trading Volume	Open Interest	Volatility
ECM	-1.0028 (-18.021)[a]	1.3587 (1.657)	0.9961 (1.472)	-0.5080 (-11.190)[a]
$Returns_{t-1}$	0.0429 (0.852)	-2.6312 (-3.544)[a]	-1.1029 (-1.800)	0.3438 (8.363)[a]
$Returns_{t-2}$	0.0125 (0.287)	-1.7616 (-2.751)[b]	-1.1732 (-2.220)[b]	0.2135 (6.022)[a]
$Returns_{t-3}$	0.0322 (0.930)	-1.5058 (-2.948)[a]	-0.7243 (-1.718)	0.1160 (4.100)[a]
$Returns_{t-4}$	0.0302 (1.257)	-1.0892 (-3.071)[a]	-0.7917 (-2.705)[a]	0.0298 (1.518)
Trading $Volume_{t-1}$	-0.0027 (-1.709)	-0.5779 (-24.382)[a]	-0.0506 (-2.592)[b]	-0.0003 (-0.301)
Trading $Volume_{t-2}$	-0.0020 (-1.136)	-0.4453 (-16.878)[a]	-0.0357 (-1.643)	0.0004 (0.331)
Trading $Volume_{t-3}$	0.0002 (0.120)	-0.2913 (-11.105)[a]	0.0192 (0.888)	0.0024 (1.672)
Trading $Volume_{t-4}$	-0.0025 (-1.595)	-0.1769 (-7.635)[a]	-0.0313 (-1.641)	0.0012 (0.934)
Open $Interest_{t-1}$	-0.0007 (-0.370)	0.0333 (1.183)	-0.1200 (-5.167)[a]	0.0031 (2.015)[b]
Open $Interest_{t-2}$	0.0001(0.070)	0.1558 (5.567)[a]	-0.1316(-5.700)[a]	-0.0010 (-0.700)
Open $Interest_{t-3}$	-0.0014 (-0.774)	0.1185 (4.189)[a]	-0.1437 (-6.157)[a]	0.0008 (0.518)
Open $Interest_{t-4}$	-0.0019 (-1.025)	0.0692 (2.432)[b]	-0.0984 (-4.190)[a]	0.0009 (0.593)
$Volatility_{t-1}$	0.3152 (10.645)[a]	1.6539 (3.791)[a]	-0.6129 (-1.702)	-0.6854 (-28.372)[a]
$Volatility_{t-2}$	0.2376 (7.074)[a]	0.5523 (1.116)	-0.3948 (-0.967)	-0.5422 (-19.783)[a]

$Volatility_{t-3}$	0.1615(4.904)[a]	0.8720 (1.797)	-0.3442 (-0.859)	-0.4009 (-14.920)[a]
$Volatility_{t-4}$	0.0915(3.384)[a]	0.7403 (1.857)	-0.1735 (-0.527)	-0.1813 (-8.214)[a]
C	2.4405 (0.055)	0.0048 (0.755)	0.0026 (0.503)	-1.9105 (-0.053)
R – Squared	0.4826	0.2782	0.0623	0.4399
F – Statistics	104.7783	43.2927	7.4703	88.1983

Note: All variables are in the first differences with the exceptional of lagged error correction term ECT generated from Johansen's Cointegration test. a and b represent at 1 per cent and 5 per cent level of significance.

Figure 1 Impulse Response Function

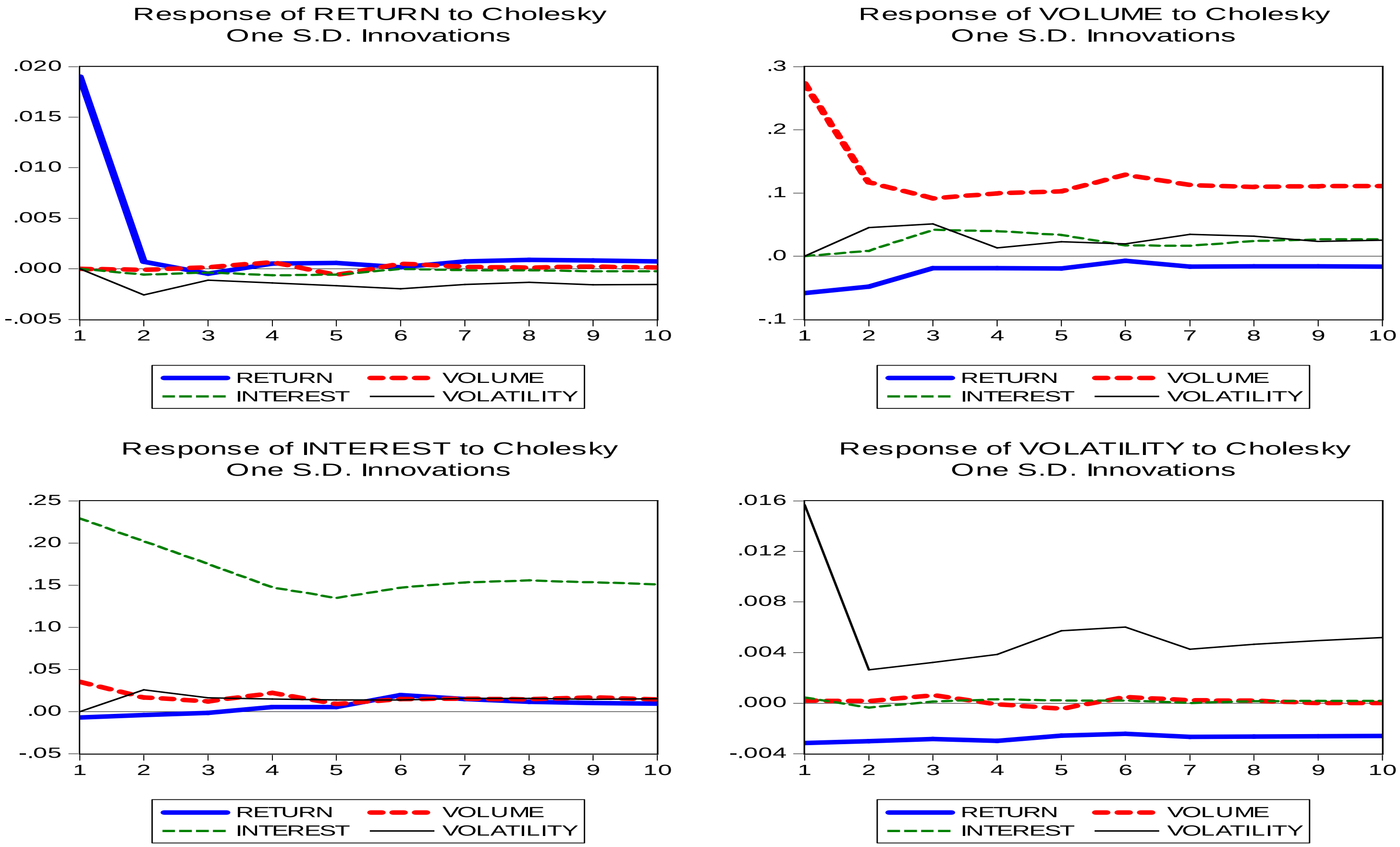

Table 4 Decomposition of Variance (Return, Trading Volume, Open Interest, Volatility)

Days after Shocks	Response of Return to innovation in			
	Return	Trading Volume	Open Interest	Volatility
1	100.0000	-	-	-
3	99.1160	0.0216	0.2311	0.6310
6	95.9158	0.2464	0.6334	3.2043
9	94.4356	0.2458	0.7443	4.5741
Days after Shocks	**Response of Trading Volume to innovation in**			
	Return	Trading Volume	Open Interest	Volatility
1	5.2647	94.7352	-	-
3	7.2324	90.1306	1.6473	0.9894
6	6.3009	89.5018	3.1897	1.0074
9	5.8898	89.5600	3.3863	1.1637
Days after Shocks	**Response of Open Interest to innovation in**			
	Return	Trading Volume	Open Interest	Volatility
1	0.2282	2.7200	97.0516	-

3	0.1743	1.5983	98.2121	0.0151
6	0.2064	1.6080	98.1671	0.0184
9	0.1987	1.5240	98.2583	0.0188

Days after Shocks	**Response of Volatility to innovation in**			
	Return	Trading Volume	Open Interest	Volatility
1	1.6875	2.2225	0.6845	95.4053
3	10.0910	2.2475	0.7477	86.9136
6	17.0668	2.5161	0.9051	79.5118
9	20.7357	2.7313	0.9209	75.6120

Note: Figures in the first column are horizons; all other figures are estimates rounded to two decimal places, so rounding errors may sometimes prevent a perfect percent decomposition. Several alternative orderings of these variables were also tried, but they did not alter the results substantially. This is possibly due to the variance-covariance matrix of residuals being diagonal, obtained through Choleski decomposition in order to orthogonalize the innovations across equations.