A Testing of Lead-lag Relationship between Nifty Spot and Futures Index Returns and Volatility

Govind Chandra Patra, Shakti Ranjan Mohapatra

Abstract

It has been almost a decade since the introduction of derivatives instruments in Indian bourses like Options and Futures trading replacing thereby age old Badla transactions and almost two decades since the introduction and implementation of liberalization, privatization and globalization policies in Indian economy. This has resulted in a sea change in growth and development of Indian economy and enhanced activity and trade in Indian stock markets. This paper examines and compares the reaction of futures and cash markets to the flow of information and tries to establish a lead-lag relationship between the two markets in terms of returns and volatilities being experienced by NIFTY and NIFTY futures indices in two different markets. Our results suggests that though there is a strong contemporaneous and bi-directional relationship among the returns in the spot and futures market, the spot market has been found to play comparatively stronger leading role in disseminating information available to the market, and therefore said to be more efficient. Apart from this, there is also interdependence (in both direction) and therefore symmetric spillovers among the stock return volatility in the spot and futures market.

Keywords: Lead-lag, VAR model, GARCH model

JEL Classification: G1

Introduction

Indian capital markets have witnessed major transformations and structural changes since past one or two decades as a result of initiation of liberalization, privatization and globalization policies and consequential financial sector reforms. Introduction of derivatives instruments in Indian stock exchanges is one such important step in right direction replacing age-old Badla transaction, the aim of which was to establish greater stabilization in markets and to introduce sophisticated risk management tools. Worldwide, the futures trading in stock markets has grown rapidly since their introduction because it has contributed in achieving economic functions such as price discovery, liquidity enhancement, portfolio diversification, speculation and hedging against the risk of adverse price movements. Movements in cash market gets greatly affected by speculation, hedging and arbitraging activities in futures market. Thus, it becomes important to understand the influence of one market over the other and their reaction to flow of information. Whichever market reacts faster to the news is said to lead the other market.

In an efficient capital market where all available information is fully and instantaneously utilized to determine the market price of securities, price of derivatives and spot market should move simultaneously without any delay. However, due to market frictions such as transaction costs, capital market microstructure effects etc., significant lead-lag relationship between the markets has been observed.

With the advancement in technology, investor awareness, consciousness, involvement and excessive greed of earning

Govind Chandra Patra is Assistant Professor at Regional College of Management Autonomous, Bhubaneswar.
Email: govindpatra@yahoo.com
Shakti Ranjan Mohapatra is Dean, MBA Department, Biju Patnaik University of Technology.
Email: shakti.r.mohapatra@gmail.com

superior return, greater reach of markets to widely scattered investors, it is foolish to believe that any market can lead the other in terms of number of days. If at all a market leads the other, it will be hardly for a few minutes. Thus, we have regressed high frequency data, i.e., one- minute returns and volatility here in cash and futures markets to establish the lead-lag relationship between the two.

The uncertainty of existing theoretical literature implies that the issue of whether derivatives market leads or lags the underlying spot market remains an empirical one. Thus, the aim of this study is to establish lead-lag relationship between spot and futures markets through regression of futures and spot NIFTY index return and volatility utilizing Vector Auto Regression (VAR) model and time variant Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) class of models.

Literature Review

As far as the temporal relationship among the spot and derivatives viz., futures and options (call and put) market is concerned, several studies have attempted to examine the lead-lag relationship between the spot and the futures market both in terms of return and /or volatility. These studies include Ng.(1987), Kawaller, Koch and Koch (1987), Harris (1989), Stoll and Whaley (1990), Chin, Chan & Karolyi (1991), Chan (1992), Abhyankar (1995), Koutmos (1996), Jong and Nijman (1997), Choudhury. T (1997), Pizzi (1998), De Jong (1998), Chatrath (1998), Abhyankar (1998), Min (1999), Tse (1999), Frino (2000), Cellier (2003), Thenmozhi (2002), Anand Babu (2003), Liena and Yang (2003), Simpson (2004) etc. Almost all of these studies have concluded that there is a significant lead-lag relationship among the spot and futures and / or options market, and also have tried to provide the possible explanation behind this. Most of the studies have suggested that the leading role of futures / options market varies from five to thirty minutes, while the spot market rarely leads the other markets beyond five minutes.

While explaining the causes behind such relation, Kawaller *et al*.(1987) attribute the stronger leading role of the futures market to the infrequent trading of component stocks. Though at the same time, Stoll & Whaley (1990), Chan (1992) etc., proved the existence of such relation even in case of highly traded stocks or after adjusting for infrequent trading of component stocks. Chan (1992) have investigated the intraday lead-lag relationship between MM cash index and MM and S&P futures index returns under different situations. Their results confirmed the leading role of the futures market even against all component stocks. They have also empirically proved the leading role of the futures market for the release of any market-wide information.

Chatrath (1998) had examined the intraday behaviour of the spot and futures market following the release of information and also investigate the role of such information in the volatility spillover among the two markets. Their results have supported that one market leading to greater volatility in the other is partly driven by information; therefore the leading role played by the futures market may be the result of new information efficiently reflected in the futures market.

Abhyankar (1998) had tried to capture the linear and non-linear casual relationship between the index futures and spot market. Their results evidenced that the index futures tend to lead the spot index by about five to fifteen minutes. The linear lead-lag relationship was found to persist even after the return series were adjusted for volatility persistence. Their most important finding was that if non linear effects are taken into consideration, neither market was found to lead or lag the other.

De Jong (1998) have confirmed that even in the presence of significant contemporaneous correlation among the spot, futures and the options market, the futures price changes lead both the changes in the cash index and index option by five to ten minutes. But, among the cash and the options market, the relations are largely symmetrical and neither market consistently leads the other.

Pizzi M.A.(1998) had attempted to investigate the relationship between S&P 500 stock index and three and six months futures contracts over the same time period. By applying the Engle-Granger two step procedure, they have found a significant co-integration among the spot index with both the three and six month futures index. Their results clearly revealed that both the three and six months futures market lead the spot market by at least 20 minutes.

Min and Najand (1999) had investigated the possible lead-lag relationship in return and volatilities between cash and futures market in Korea. Their results have suggested that unlike the lead-lag relationship in the returns of spot and futures markets, there is significant but time-dependent bidirectional casualty between the markets, as far as volatility interaction among the markets is concerned.

Frino (2000) had examined the temporal relationship among the spot and futures market around the release of different types of information. They had found that the lead of the futures market strengthens significantly around the release of macro-economic information. While, the leading role of the futures market weakens around stock specific information release. Therefore, according to them the disintegration in the relationship between the two markets is mainly driven by noises associated with trading activity around the release of different types of information.

By looking at the Indian markets, Thenmozhi (2002), Anand Babu (2003) etc., had found that the futures market in India has more power in disseminating information and therefore has been found to play the leading role (for one or two days) in the matter of price discovery.

Anand Babu and Bhole (2003) attempted to examine the temporal relationship between the index futures and its underlying cash index by using daily price observations. Their results had supported the fact that the index futures market in India leads the underlying Nifty index market and the lead-lag pattern between those two markets keeps changing over different periods.

Research Objectives

The present research is being contemplated with the following specific objective:

To examine the lead-lag relationship (if any), both in terms of return and volatility, among Indian spot and derivatives viz., futures market. If such relationship exists, then the focus will be to test which market leads or lags the other market and by how much time gap.

Sample Data

In order to examine the lead-lag relationship between the underlying spot and futures market, the basic data used are intraday price histories for the nearby contract of CNX NIFTY index futures and CNX NIFTY spot index traded and recorded in a frequency of one minute interval during a period of twelve months for the calendar year 2010. Each day trading hour has been partitioned into one minute intervals. The last price observation of each one minute interval has been picked up from the trading data of spot and futures index. Data on futures index comprise price series only for the near month contract. If there is any missing observation due to non trading in any interval, the common practice is to remove that specific interval from the sample.

All the relevant data relating to the spot and futures market in India has been collected from NSE website, i.e., www.nseindia.com and also the CD-ROM provided by NSE, Mumbai. The intraday price series both in the spot and futures market have been sorted out in MATLAB version 6.5 and in MS-EXCEL.

Methodology

Generally, as the previous studies suggest, some lead-lag relationship exists in spot and derivatives markets. Thus, here we tried to derive the intraday lead-lag relationship among CNX NIFTY cash and futures index returns and volatility through the models as described below:

To find out the significant length of leads or lags, we ran a cross correlation test among the returns in spot and futures markets in order to determine the extent to which the two markets are correlated to each other. In order to get the length of leads (β_{+k}) and the length of lags (β_{-k}), we have examined the cross correlation coefficient between the current spot returns ($R_{S,t}$) and past futures returns ($R_{F,t-k}$) and between the past cash returns ($R_{S,t-k}$) and current futures returns ($R_{F,t}$) respectively. The significant length of lead or lag will be determined through the cross correlation coefficients as detailed above based upon the studies made by Stoll and Whaley (1990), Abhyankar (1995), Min and others (1999). Now, the length of lead or lag can be determined by the t-test.

After determining the lead-lag length, the next step is to examine the lead-lag behaviour between the cash and futures markets by estimating the following regression equations:

$$R_{S,t} = \alpha + \sum_{k=-n}^{n} \beta_k R_{F,t+k} + \delta Z_{t-1} + C_t \qquad (1)$$

Wherein, $R_{S,t}$ and $R_{F,t}$ represent intraday returns in cash and futures markets at time t, collected at one minute interval each. The coefficients with negative subscripts (β_{-1}, β_{-2}-----, β_{-n}) are lag coefficients and those with positive subscripts (β_1, β_2-----, β_n) are lead coefficients. If the lag coefficients become significant, then from the above equation, it can be inferred that left hand side return, i.e., spot return lags the right hand side return, i.e., futures return. In other words, significance of lag coefficients

in the above mentioned equation reveals that futures lead the cash index return. On the other hand, if the lead coefficients become significant, then from the above equation, it can be inferred that left hand side return, i.e., spot return leads the right hand side return, i.e., futures return. In other words, significance of lead coefficients in the above mentioned equation reveals that spot index leads the futures index return. If the contemporaneous β coefficient (β_0) shows the maximum value among all other lead-lag coefficients, then it can be inferred that the two markets move simultaneously without any lead or lag time. Again, along with the highest value of contemporaneous β coefficient (β_0), if both lead and lag coefficients are found to be significant, then neither market is said to lead or lag the other and both the markets react simultaneously to flow of information.

'Z_{t-1}' is an error correction term taken to be the first lag of contemporaneous difference between the two price levels to account for the possibility that the two return series are co-integrated as per the study made by Engel and Granger (1987).

$$ECT_{t-1} = Y_{t-1} - \alpha_0 - \alpha_1 X_{t-1} \qquad (2)$$

The above-mentioned equation is the equation for error correction term representing the residuals from the equilibrium equation lagged by one period indicating that whether the proportion of disequilibrium from one period is corrected in a later period and the relative magnitude of adjustments in each market towards equilibrium.

Again, the intraday lead-lag relationship among the spot and futures index returns is also tested through another important and reliable model called Vector Auto Regression (VAR) model. It is basically an econometric model used to capture the interdependence between multiple time series, generalizing the univariate AR models.

All the variables in a VAR model are treated symmetrically by including for each variable an equation explaining its evolution based upon its own lags and lags of all other variables in the model. The model is delineated below.

$$R_{S,t} = \alpha_0 + \sum_{i=1}^{5} \alpha_i R_{S,t-1} + \sum_{j=1}^{5} \beta_i R_{F,t-1} + \delta Z_{t-1} + C_t \qquad (3)$$

$$R_{F,t} = \alpha_0 + \sum_{i=1}^{5} \alpha_i R_{F,t-1} + \sum_{j=1}^{5} \beta_i R_{S,t-1} + \delta Z_{t-1} + C_t \qquad (4)$$

where, $R_{S,t}$ and $R_{F,t}$ represent intraday returns in spot and futures markets. The value of time lags taken to be 5 here.

Now, the lead-lag relationship between spot and futures markets in terms of intraday return volatility, popularly known as volatility spillover, has been tested through another VAR model as shown below :

$$\sigma_{S,t} = \alpha_0 + \sum \alpha_t \sigma_{S,t-1} + \sum \beta_j \sigma_{F,t-j} + C_t \qquad (5)$$

$$\sigma_{F,t} = \alpha_0 + \sum \alpha_t \sigma_{S,t-1} + \sum \beta_j \sigma_{F,t-j} + C_t \qquad (6)$$

Here, GARCH(1,1) residuals as the proxy measure of volatility are incorporated in the above VAR model. The GARCH residuals are generated both for spot and futures index return series separately. The value of lags are also taken to be 5 here and one minute interval returns identical with previous calculations are also considered.

Empirical Findings

The descriptive statistics of intraday CNX NIFTY index returns in cash and Futures market for the sample period from 1st January 2010 to 31st December 2010 are shown in Table 1. The table reveals that the mean intraday returns has been found to be significantly close to zero. The difference between the maximum and minimum value of NIFTY returns (range) in cash market is higher than futures market. The range of variations of return and standard deviation are almost similar in both cash and futures markets which may help to believe that futures market reduces the return variation in spot market. Now, if we look into the skewness figures that represent the asymmetry in return series, it can be seen that both the return series in cash and futures markets are negatively skewed. This negative skewness reveals that the chances or the probability of negative return deviation from the average return is higher than that of a positive deviation. At the same time, kurtosis figures represent that the value is more than three and therefore all return distributions are leptokurtic in nature or fat tailed. This represents that the probability of large return deviations are comparatively higher which indicates the level of destability in the market. The Jarque-Bera statistics and their probability show that the return series in both cash and derivatives markets are non-normal.

The autocorrelation and partial auto correlation figures for one minute cash and futures markets index returns are represented in Table 2 and 3. The autocorrelation and partial auto correlation coefficients for NIFTY cash and futures markets have been computed up to tenth

order, selected randomly. The serial correlations of the cash and futures market's index returns for the first lag are significantly large and slowly reduces for other lags. Though relatively small in magnitude, the auto correlation figures of the cash and futures index returns are significant up to six lags. Consistent with previous studies, our auto correlation estimates in the cash index return are found to be positive at the first three lags and then shifted to a negative serial correlation after lag 2. The difference in the result of auto correlation of cash and futures index returns may be attributed to the non-synchronous trading of underlying NIFTY stocks in both the markets.

The basic step for determining the lead-lag relationship between two different markets through regression equation is to determine the significant length of leads and lags proposed to be included in the equations. By looking into the cross correlation among the one minute returns of two different markets, e.g. spot and futures markets, we can assess the possible lead-lag relation among two markets. The cross correlations among two one minute NIFTY return series are presented in Table 4. The significant cross correlation figures can suggest the number of leads and lags expected to be included in the regression analysis. The cross correlation figures have been estimated up to ten leads and lags. The results present that though the contemporaneous correlation among the NIFTY return series are found to be highly significant, both the lead and lag coefficients are also found to be significant to some extent.

Apart from using only a multiple regression model to analyse the intraday lead – lag relationship among the spot and futures markets, another attempt has also been made to explore the interrelationship using VAR model. Intraday interrelationship among the index returns in cash and futures markets along with volatility spill over in the markets are described in the following sections.

Lead-Lag Relationship among Cash and Futures Index Returns

Lead lag relationship among cash and futures markets for NIFTY index returns have been measured with minute by minute trading data. In current capital market scenario with technological innovations and efficient markets, no market is expected to lead or lag by a day or two. If at all lead or lag effect exists between different markets, it will be for a maximum period of few minutes. For spot market, the lead-lag relationship has been estimated for both simple return and cash return innovations derived from the AR(5) process as indicated by the significant autocorrelation in the spot index return.

Intraday lead-lag relationship among the spot and futures index returns for both spot return and spot return innovations are reported in Table 5. The table comprise regression results where the present spot return is regressed on the past and future return and a lagged error correction term taking into consideration the possible co-integration among the spot and future index returns.

Regression results, as shown in cross correlation figures, reveal that both lead and lag coefficients in the index futures market in India are found to be significant. It is observed from the table that the contemporaneous β coefficient 'β_0' exhibits highest value both for spot return and spot return innovations. This indicates that both spot and futures markets react simultaneously to most of the news flow. The table also reveals that lag coefficients are found to be significant up to one lag wherein lead coefficients are significant up to two lags.

Again, the joint significance tests (F and LR test) reveal that the joint significance of the lag coefficients are stronger than that of lead coefficients and vice versa for spot return innovations. Whereas, the futures market leads the spot market by one minute only, the spot market leads the futures market by two minutes.

Another important dimension of this study is to utilize bivarite VAR model on the intra day spot and futures index return series in India as shown in Tables 6 and 7, one for spot and futures index return and another for spot return innovation and futures index return series. As in case of previous regression model, here also lags of five intervals are considered for both the return series. This model also considers error correction term as an exogenous variable and therefore have been taken into account in both the equations of the model. The VAR results reveal that the lagged future coefficients in spot return and lagged spot coefficients in futures return are found to be significant up to fourth and first order respectively. Also, the overall significance test, i.e., Chi-square test reveals that the lagged NIFTY spot return coefficients are comparatively stronger than the NIFTY futures return coefficients. Apart from this, Granger casualty test results provide the information that though both the null hypothesis (futures does not Granger cause spot and spot does not granger

cause futures) are rejected, the power of rejection is more stronger in case of "spot does not granger cause futures", thus revealing the fact that spot market is more stronger in disseminating information and the discovery of prices. The same calculation for spot return innovations and futures market also reveals the same result, i.e., stronger role of spot market in Granger causing the futures market.

Lead-Lag Relationship among Spot and Futures Index Return Volatility

Apart from the interdependence in terms of only returns in different markets, there also exists interrelationship among volatility of different markets. In other words, there is a volatility spillover from one market to another market. This investigation has been carried out by using different proxy measures simultaneously in a similar kind of VAR framework. The results towards the intraday volatility spillover considering different proxy measures in spot and futures market in India are shown below:

The intraday interrelationship among the spot and futures index return volatility is presented in Table 8 utilising GARCH(1,1) framework basing upon a series of spot and futures return residuals as a proxy for the volatility measure. The results clearly reveal that four out of five lagged volatility in one market can significantly explain the volatility in the other market. The individual significance of lagged spot return volatility in explaining the volatility in futures market and at the same time, the significant role of lagged futures return volatility in describing the volatility in spot market, can reveal the fact that there is a strong bidirectional interrelationship among the spot and futures index return volatility. Therefore, it is difficult to predict which market leads the other market.

This problem can be resolved by looking at the joint significance test on the lagged coefficients of spot return volatility and futures return volatility in explaining the intraday volatility of the other market. It should be noted here that the joint significance tests are carried out only to test the significance of the lagged coefficients in the counter market, not the own lagged coefficients of any market. Not only the individual test of significance, but the joint significance test also exhibits the same picture. The lagged coefficients in any counter market are also found to be jointly significant as reflected in Chi-square test.

Here, the intraday volatility in spot index return are found to play stronger leading role in predicting the future movements of the intraday volatility in the futures market going by the residuals from the GARCH(1,1) model. Since the stronger leading role of the spot return volatility is supported by a VAR framework, it is expected to be robust in Indian markets. Thus, we can conclude that there is a systematic pattern in the intraday volatility spillover among the spot and futures market in India.

Table 1 **Descriptive Statistics of Intraday Spot and Futures Index Returns**

NIFTY SPOT	*Futures Index*	
Mean	0.000003	0.000003
Median	0.000011	0.000001
Maximum	0.033509	0.041582
Minimum	-0.050180	-0.030273
Std. Deviation	0.000558	0.000876
Skewness	-5.028081	-4.354189
Kurtosis	592.655900	847.501200
Jarque Bera	790000000	1920000000
Probability	0.0000	0.0000
Sum Sq. Deviation	0.0453	0.0587
No.of Observations	118760	118760

Table 2 **Auto-Correlation Coefficients of Intraday Returns in Spot and Futures Market Auto-Correlation Test**

No. of Lags	*NIFTY Spot*	*Futures*
1	0.213**	0.067**
2	0.045**	0.054**
3	0.038**	-0.019*
4	-0.019**	-0.032**
5	-0.043**	-0.016**
6	-0.022**	-0.009**
7	-0.002**	-0.004**
8	-0.001*	-0.003*
9	-0.002*	-0.005*
10	0.004*	-0.001*
No.of Observations	118760	118760

Table 3 Partial Auto-Correlation Coefficients of Intraday Returns in Spot and Futures Market Partial Auto-Correlation Test

No. of Lags	*NIFTY Spot*	*Futures*
1	0.213**	0.067**
2	-0.037**	-0.069**
3	-0.016**	-0.009**
4	-0.027**	-0.039**
5	-0.049**	-0.022**
6	-0.031**	-0.010**
7	-0.013**	-0.008**
8	-0.011**	-0.007**
9	-0.003**	-0.007**
10	0.006*	0.001*
No.of Observations	118760	118760

Note : ** and * represent significant at 1% and 5% level of significance. Above two measures are required to find out the significant number of lags in an ARMA framework

Table 4 Cross Correlation Coefficients of One Minute Returns among NIFTY Spot and Futures Markets

No. of Lags	*Coefficient*	*t–values*
–10	0.0178	0.8973
–9	–0.0153	–1.8544
–8	–0.0134	–2.8948
–7	–0.0129	–3.5647
–6	–0.0323	–9.8541
–5	–0.0378	–5.3578
–4	–0.0415	–4.9484
–3	–0.0287	6.8432
–2	–0.0125	12.6645
–1	0.1582	64.9864
0	0.4986	112.3576
1	0.1980	50.3467
2	0.0675	1.3587
3	0.0098	–4.9845
4	–0.0435	–9.9832
5	–0.0176	–12.9984
6	–0.0225	–5.6176
7	–0.0892	–3.9851
8	–0.0072	0.5954
9	0.0019	1.8972
10	0.0015	0.9471

Table 5 Lead-lag Relationship among NIFTY Spot and Futures Index Returns

	NIFTY Spot Return	*NIFTY Spot Return Innovations*
	$R_{S,t} = \alpha + \sum_{k=-n}^{n} \beta_k R_{F,t+k} + \delta Z_{t-1} + C_t$	
Constant α	0.0000 (0.0583)	0.0000 –(0.7651)
FUTIDX(–5) β_{-5}	–0.0089 –(0.6172)	0.0167 (1.5963)
FUTIDX(–4) β_{-4}	–0.0156 –(1.5338)	0.0345 (2.8975)
FUTIDX(–3) β_{-3}	–0.0299 –(2.5666)	0.0038 (0.2183)
FUTIDX(–2) β_{-2}	–0.0123 –(1.5348)	0.0098 (0.5873)
FUTIDX(–1) β_{-1}	0.3112 (4.4018)	–0.0975 –(1.5676)
FUTIDX β_0	0.5546 (7.1894)	0.3456 (5.8973)
FUTIDX(1) β_1	0.1286 (1.7869)	0.0789 (1.5378)
FUTIDX(2) β_2	0.04531 (2.4958)	–0.0123 –(0.9847)
FUTIDX(3) β_3	–0.0476 –(3.1176)	–0.0158 –(1.5476)
FUTIDX(4) β_4	–0.0157 –(1.5479)	–0.0259 –(1.9583)
FUTIDX(5) β_5	–0.0385 –(0.9895)	–0.0352 –(0.9283)
ECT(–1) δ	0.0000 –(5.4351)	0.0000 –(5.7892)
F–Lag	1984.764 (0.0000)	987.332 (0.0000)
LR–Lag	9885.859 (0.0000)	4867.159 (0.0000)
F–Lead	1865.675 (0.0000)	1576.826 (0.0000)
LR–Lead	5483.978 (0.0000)	4384.928 (0.0000)

Note: F statistics and log likelihood ratio statistic are used to test the joint significance of the lead and lagged coefficients of futures returns.

Table 6 **VAR Results among NIFTY Spot and Futures Index Returns**

NIFTY Spot and Futures Return

$$R_{S,t} = \alpha_0 + \sum_{i=1}^{5} \alpha_i R_{S,t-1} + \sum_{j=1}^{5} \beta_i R_{F,t-1} + \delta Z_{t-1} + C_t$$

$$R_{F,t} = \alpha_0 + \sum_{i=1}^{5} \alpha_i R_{F,t-1} + \sum_{j=1}^{5} \beta_i R_{S,t-1} + \delta Z_{t-1} + C_t$$

	NIFTY	*FUTIDX*
NIFTY(–1)	–0.0456**	0.2755**
	–(9.5468)	(5.4733)
NIFTY(–2)	–0.1968**	0.0023**
	–(21.3458)	(2.9867)
NIFTY(–3)	–0.1454**	0.0009**
	–(13.9856)	(0.7464)
NIFTY(–4)	–0.1989**	–0.0144**
	–(18.9456)	–(0.5553)
NIFTY(–5)	–0.0892**	–0.0255**
	–(8.6672)	–(1.0767)
FUTIDX(–1)	0.3855**	–0.3378**
	(76.8454)	–(29.9465)
FUTIDX(–2)	0.1764**	–0.1289**
	(43.8959)	–(16.7454)
FUTIDX(–3)	0.0955**	–0.0785**
	(27.9932)	–(7.7968)
FUTIDX(–4)	0.0682**	0.0120**
	(16.8152)	(1.8498)
FUTIDX(–5)	–0.0483**	0.0094*
	(9.1874)	(0.7698)
Constant	0.0000	0.0000
	(0.8856)	(0.8492)
ECT(–1)	0.0000	0.0000
	–(1.5957)	(2.3658)
Chi–Sq–FUTIDX		6543.9856**
		(0.0000)
Chi–Sq–NIFTY		9088.1476**
		(0.0000)
FUTIDX does not Granger Cause NIFTY		1052.9948**
		(0.0000)
NIFTY does not Granger Cause FUTIDX		2076.1144**
		(0.0000)

Table 7 **VAR Results among NIFTY Spot Return Innovations and Futures Index Returns**

NIFTY Spot Return Innovations and Futures Return

$$R_{SI,t} = \alpha_0 + \sum_{i=1}^{5} \alpha_i R_{SI,t-1} + \sum_{j=1}^{5} \beta_i R_{F,t-1} + \delta Z_{t-1} + C_t$$

$$R_{SI,t} = \alpha_0 + \sum_{i=1}^{5} \alpha_i R_{SI,t-1} + \sum_{j=1}^{5} \beta_i R_{F,t-1} + \delta Z_{t-1} + C_t$$

	NIFTY	*FUTIDX*
NIFTYIN(–1)	–0.2786**	0.6354**
	–(49.7763)	(62.9578)
NIFTYIN(–2)	–0.2493**	0.0985**
	–(31.6667)	(14.8434)
NIFTYIN(–3)	–0.1987**	0.0242**
	–(18.5564)	(3.8761)
NIFTYIN(–4)	–0.1254**	0.0087**
	–(9.3156)	(0.9211)
NIFTYIN(–5)	–0.0677**	–0.0540**
	–(2.9867)	–(4.2739)
FUTIDX(–1)	0.2545**	–0.3357**
	(42.5969)	–(60.4352)
FUTIDX(–2)	0.2137**	–0.1249**
	(29.8435)	–(31.9481)
FUTIDX(–3)	0.1598**	–0.0545**
	(22.3782)	–(3.2693)
FUTIDX(–4)	0.0987**	–0.0023
	(13.9862)	–(1.9873)
FUTIDX(–5)	0.0436**	–0.0012
	(8.8191)	–(0.8133)
Constant	0.0000	0.0000
	–(0.5435)	(0.9678)
ECT(–1)	0.0000**	0.0000**
	–(1.8746)	(2.7771)
Chi–Sq–FUTIDX		6620.9586**
		(0.0000)
Chi–Sq–NIFTYIN		9322.4589**
		(0.0000)
FUTIDX does not Granger Cause NIFTYIN		1104.5676**
		(0.0000)
NIFTYIN does not Granger Cause FUTIDX		2150.9542**
		(0.0000)

Table 8 **VAR Results among Volatility of Spot and Futures Index Return Through GARCH Model**

$\sigma_{S,t} = \alpha_0 + \Sigma\alpha_t\sigma_{S,t-i} + \Sigma\beta_j\sigma_{F,t-j} + \varepsilon_t$
$\sigma_{F,t} = \alpha_0 + \Sigma\alpha_t\sigma_{S,t-i} + \Sigma\beta_j\sigma_{F,t-j} + \varepsilon_t$

	NIFTY VOLATILITY	*FUTIDX VOLATILITY*
NIFTY VOL(–1)	–0.2244**	0.2867**
	–(40.3612)	(43.8564)
NIFTY VOL(–2)	–0.1978**	0.1654**
	–(31.5876)	(20.9125)
NIFTY VOL(–3)	–0.1789**	0.0919**
	–(19.2851)	(9.2167)
NIFTY VOL(–4)	–0.1473**	0.0672**
	–(10.8576)	(5.1542)
NIFTY VOL(–5)	–0.0989**	0.0281**
	–(4.3142)	(2.8173)
FUTIDX VOL(–1)	0.3145**	–0.1912**
	(72.4134)	–(35.6740)
FUTIDX VOL(–2)	0.2798**	–0.1263**
	(54.9756)	–(17.1612)
FUTIDX VOL(–3)	0.1864**	–0.0658**
	(30.4821)	–(8.4531)
FUTIDX VOL(–4)	0.0983**	–0.0125**
	(12.6789)	–(1.1978)
FUTIDX VOL(–5)	0.0346**	–0.0069**
	(5.4417)	–(0.3586)
Constant	0.0000	0.0000
	–(0.8956)	–(1.0783)
Chi Sq. NIFTY	9576.5434**	
	(0.0000)	
Chi Sq. FUTIDX	6132.7600**	
	(0.0000)	

Note: ** and * represent significant at 1% and 5 % level of significance. This table shows volatility interrelationship among NIFTY Spot and Futures index returns where the residual derived from a simple GARCH(1,1) model is used as a proxy for volatility in both the markets. 'VOL' represents volatility. Chi-square test statistics represent the joint significance of lagged spot (futures) returns in explaining the movement of futures (spot) returns.

Conclusion

The current research had conducted a series of methods and tests such as descriptive statistical measures to describe the basic characteristics of Spot and futures markets, multiple regression analysis and Vector Auto Regression (VAR) model to analyze the interrelationship among the markets and ARCH family of models to measure conditional volatility in different markets, individual and joint tests of significance and Granger casualty tests etc.

The lead-lag relationship among the spot and futures markets are tested for NIFTY indices in two different markets for both returns and volatility of returns. The primary idea about the interrelationship among the intraday price series in two markets are generated through the cross correlation test results. This clearly reveals that apart from being contemporaneously correlated, the indices are leading or lagging the other index up to some extent. These results prove the presence of some lead-lag relationship among the intraday index return and the volatility of intraday index return.

This basic test is then followed by modeling of interrelation in a multiple regression framework and then in a VAR framework. It has been commonly found that though the lead or lag coefficients are found to be significant up to a certain extent, the contemporaneous coefficient exhibits the highest value, thus representing a stronger contemporaneous correlation among the two markets. Both the multiple regression and VAR analysis provides the overall significance of spot index, thus depicting stronger leading role of spot market over future market; in other words, spot index returns Granger cause the futures index return.

Apart from examining the intraday lead-lag relation among the index return series, an effort has been made to determine the intraday interrelation among the volatility of index returns in these two markets. These results depict the intraday volatility spillover from one market to other, and only based upon VAR models but with different proxy measures of volatility.

As far as intraday volatility spillover is concerned, the lagged coefficients in both the markets are found to be significant in explaining the future volatility movements in the other market. In other words, a strong bidirectional interrelation among the volatility of spot and futures index return has been observed and also the same observation has been made for different proxy measures of intraday volatility. Apart from being individually significant in both the markets, the joint significance of lagged coefficients reveal that the lagged volatility in spot market has proven to play a stronger leading role over the futures index return volatility.

References

Bhatia S. (2007) : Do the S&P CNX Nifty Index And Nifty Futures Really Lead/Lag? Error Correction Model: A Co-integration Approach, Source : www.nseindia.com

Mukherjee K.N. and Mishra R.K.(2005): Lead-Lag Relationship between Equities and Stock Index Futures Market and It's Variation around Information Release: Empirical Evidence from India, www.nseindia.com

Chan K.(1992) , A Further Analysis of the Lead-Lag Relationship between the Cash Market and Stock Index Futures Markets, *Review of Financial Studies* 5 (1) ,123-152.

De Jong F. and Donders M.W.M. (1998), Intraday Lead-Lag Relationship between Futures, Options and Stock Market, European Finance Review 1, 337-359

De Jong F. and Nijman T. (1997), High Frequency Analysis of Lead –Lag Relationship between Financial Markets, Journal of Empirical Finance 4, 259-277

Frino A. & Others (2000) : The Lead-Lag relationship between Equities and Stock Index Futures Markets Around Information Releases, Journal of Futures Market 20(5), 467-487

Lihara et al ,(1996) , Intraday Return Dynamics between the Cash and the Futures Markets in Japan, *Journal of Futures Markets* 16 , 147-162.

Min J.H. and Najand M. (1999): A further Investigation of the Lead-Lag relationship between the Spot Market and Stock Index Futures: Early Evidence from Korea, Journal of Futures Market19(2), 217-232

Pizzi M.A. et al. (1998): An Examination of the Relationship between Stock Index Cash and Futures Markets:A cointegration approach, Journal of Futures Market 18(3), 297-305

Shyy G., Vijayraghavan V. and Scott-Quinn B. (1996): A Further Investigation of the Lead-Lag Relationship between the Cash Market and Stock Index Futures market with the use of Bid-Ask Quotes; The Case of France, Journal of Futures market 16(4), 405-420

Tse Y. (1999): Price Discovery and Volatility Spillovers in the DJIA Index and Futures Market, Journal of Futures Market 19(8), 911-930

Roope M and R Zurbruegg (2002) The intra day price discovery process between the Singapore exchange and Taiwan futures exchange, *The Journal of Futures Markets*, Vol 22, No. 3, p 219 – 240

Wahab M and M Lashgari (1993), Price dynamics and error correction in stock Index and stock Index futures markets: A cointegration approach, *Journal of Futures Markets*, Vol 13, No. 7, p 711 – 742

Kamara A., T. Miller, and A. Siegel, "The Effects of Futures Trading on the Stability of the S&P500 Returns", *Journal of Futures Markets*, (12), 1992, pp.645 – 658.

Brooks, C., Garrett, I. and Hinich, M.J. 1999. An alternative approach to investigating lead-lag relationships between stock and stock index futures markets. *Applied Financial Economics*, 9:605-613

Chan, K.1992. A further analysis of the lead-lag relationship between the cash market and stock index futures market. *Review of Financial Studies*, 5(1): 123-152.

Engle, R.F. and Granger, C.W.G. 1987. Co-integration and Error Correction Representation, Estimation and Testing. Econometrica , 55: 251-276

Min, J.H and Najand, M.1999. A further investigation of lead-lag relationship between the spot market and stock index futures: Early evidence from Korea. *The Journal of Futures Markets*, 19(1):217-232

Mukherjee, K.N and Mishra, R.K. 2006. Lead-Lag Relationship between Equities and Stock Index Futures Market and its Variation around Information Release: Empirical Evidence from India. www.nseindia.com