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Lead Lag Relationship between Nifty Index Futures and Spot Market

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Derivatives were introduced in Indian securities market as it offers various benefits like price discovery, efficiency and transparency. This paper analyses lead lag relationship between Nifty Index futures and Nifty Index spot prices. By taking daily price data from 4-06-2000 to 05-02-2015 of Nifty Index futures and Nifty index cash market price, we have tried to understand whether Nifty futures prices leads the spot market price or vice versa. By using cointegration test, granger causality test, Vector error correction model and diagnostic testing results have been analysed. VECM results indicate that there is long run causality which exists running from near month nifty futures to nifty index and short run relationship also exists between two markets.

1. Introduction

Lead lag relationship establishes relationship between Index futures prices and underlying spot market prices and shows how quickly one market reflects new information to other market and understand how the two markets are linked. There will be difference in futures and spot market prices because of cost of carry model. In a perfect efficient market, investors are indifferent about trading in either market and new information comes simultaneously. But if one market reacts faster to information and other market is slow because of market frictions like transaction cost or market microstructures, a lead lag relationship is observed.

Lead-lag relationship between futures and cash markets has been a subject of interest for practitioners, traders, regulatory bodies and other stakeholders as leading market may help the variables to initiate regulatory changes and correct the market inefficiencies (Raju and Karande (2003)). It can also support portfolio managers to hedge their risk and improve their participation in the futures market, which may help in achieving cash market stabilization. Understanding of lead lag relationship can be useful in various ways. Firstly this issue is related with market efficiency and arbitrage opportunities. Secondly it informs about price discovery function of derivatives market. The third issue can be related with volatility spillover effect of futures trading. If volatility spillover exists than volatility transmitting market can be used by market agents for price discovery.

Despite the benefits of introducing derivatives like lower transaction cost, improved trading efficiency, there are studies which claim that futures have lead to increased volatility in underlying which leads to lower liquidity and high cost. So, another important issue relating to futures market is that futures market has lead to destablising influence on the cash market (Harris, 1989).

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In India, number of reforms in the financial markets has increased. After the global economic crisis, there were changes in the dynamics of the market, and it becomes important to study that whether lead lag relationship has changed in the market. What is the direction of change needs to be seen? Thamilselvan & Srinivasan (2014) found that post crisis volatility has significantly changed. Sudhan, Iyer & Morais (2015) identified that for price discovery some stock leads the future market while other stock lags the market.

This study tries to examine the lead lag relationship between Nifty Index futures prices and Nifty Index spot prices. The short run and long run relationship is studied based on cointergration test and VECM analysis. The data has been taken for near month, second month and far month for Nifty futures.
The rest of the paper is organized as follows: section two relates with review of literature, section three defines the methodology of the study, section four analyses the data and section five concludes the study.

2. Review of Literature

Jain, Biswal and Ghosh (2016) examined the causal relationships between volatility and volume across spot and futures market. The sample size consisted of the CNX NIFTY Index companies. Vector autoregression (VAR) and asymmetric VAR models were applied which indicated the presence of significant causal relations from both the spot and futures volume to both the spot and futures volatility. Also, Bidirectional causal relationships between spot and futures volume were observed for almost all stocks but few stocks displayed a similar relationship between volatilities. It is concluded that volume is important in absorbing information.

Sudhan, Iyer & Morais (2015) analysed the price discovery function of futures market and the spot market. The analysis was conducted using a sample of 8 Banking stocks in midcap sector along with index such as Nifty and Bank Nifty. Daily data was obtained from the NSE website since its inception to 31st December 2013. Johansen Cointegration and Vector Error correction models were used. The results confirmed the existence of Price discovery function in Midcap stocks by leading of futures market but lags in few stocks.

Vasantha & Mallikarjunappa (2015) examined the lead-lag relationship between spot and futures market of pepper in India. He also studied the price discovery process and employed the Johansen's cointegration test and the bivariate VECM-EGARCH(1, 1) models. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were also used to check the stationarity of the price series. It was found that the information is absorbed by the spot market faster than futures market. Thus, the spot market plays a significant role in the price discovery process.

Jusoh, Bacha & Masih (2014) studied the lead-lag relationship between stock index and stock index futures. The study was conductd on Malaysian Stock Exchange by using a new approach based on the Continuous Wavelet Transform (CWT) and the Discrete Wavelet Transform (DWT). It was found that the lead-lag relationship varies across frequency ranges and time scales, Lead-lag interactions between the markets also showed strong correlations.

Thamilselvan & Srinivasan (2014) examined the effects of global turbulence and market volatility in Indian Capital market for the period ranging from January 1,2003 to August 31,2013. The study was divided into pre and post-crisis. Generalized Autoregressive Conditional Heteroskedasticity (1,1) model was applied to measure the volatility persistence. Cointegrating Regression Augmented Dickey Fuller (CRADF) and Vector Error Correction Model (VECM) was also applied to investigate the causality between spot and futures market considering short and long run equilibrium. The lead-lag relationship between the bivariate variables was investigated through squared residuals of VECM. Findings of the study indicate that there was a significant change in the post crisis period for spot and futures market volatility.

Ullah & Shah (2013) studied the Efficient Market Hypothesis (EMH) by studying the lead-lag relationship of the future market prices and spot market prices in the Pakistani stock market. The sample consisted of one hundred and forty firms listed on the Karachi Stock Exchange selected randomly from January 1995 to March 2012. The Price-Weighted index method was used to develop the Spot and future indices. Augmented-Dicky Fuller test was used to test the stationarity of the data. GARCH (1,1) model was estimated for both the spot and future index returns to investigate the volatility . The results suggested that the previous day volatility has impact on the current day volatility in both the spot and future index. It was found that the future market price volatility has more prominent role in explaining the spot market prices. Thus, it was concluded that there exists lead-lag relationship between the spot and future index. Also, it was found that future market leads the spot market. Granger casualty test was used to triangulate the results of GARCH (1,1) model. The results showed that the spot market is Granger caused by future market while the spot market does not Granger causes the future market.

Theissen (2012) studied the price discovery mechanism in spot and futures markets. A threshold error correction model was used. The model was used to allow for arbitrage opportunities to have an impact on the return dynamics. The model was estimated using quote midpoints, and modification was done to account for time-varying transaction costs. It was found that the futures market leads in the process of price discovery and there is a strong impact of the presence of arbitrage opportunities on the dynamics of the price discovery process.

Ingyu Chiou et al. (2011) investigated the lead-lag relationship between three stock markets (Tokyo, London and New York) over 10 years and considered two variables like return-volatility. They examined the relationship between three international markets affects and how they each other by using regression model. They found that Tokyo leads London and New York; London leads New York and Tokyo and New York leads Tokyo and London. They observed strongest relationship between London and New York.

Debasish, S.S. (2009) studied lead-lag relationship between the NSE Nifty stock market index and futures and options index using autoregressive moving average (ARMA) models with hourly returns on the NSE Nifty index. It was found that Nifty derivatives market lead the underlying stock index. The futures and options market also leads the cash market overall.

Hsu, H. et al. (2008) examined the lead-lag relationship between prices of index futures and the rate of return of the underlying index. By using VAR, Granger causality test and generalized impulse response function (GIRF), they revealed no interaction in the US market but found a good relationship in Taiwan Market.

Maniar, H.M. et al. (2007), examined arbitrage opportunities and lead-lag relationship between futures, options and cash markets considering intraday trading by employing Granger-Sims causality regression model with weighted average of 50 stocks. They concluded that futures lead both cash and options index returns by 10 minutes.

Gupta, K. and Singh, B. (2006) studied price discovery efficiency and lead lag relationship between spot and futures market. They applied VAR (Vector Auto regression) and VECM (Vector Error Correction Methodologies) models. They found fifteen individual stocks lead individual stock futures by five to fifty five minutes and no relationship found in eight individual stocks with their related futures contracts. This study also shows strong and long run positive relationship between two markets.

Brooks, Rew and Stuart (2001) studied the lead-lag relationship between futures contract and spot index. They have used two forms of the ECM to forecast future changes to the spot index. One where the cointegration equation is simply the log-level relation between spot and futures prices, and the other, which incorporates the cost of carry relation. They used intraday data and found futures market lead to spot market by using Engle-Grenger test which is used to test the cointegration.

Mukharjee and Mishra, R.K. (1999) investigated lead-lag relationship between spot market index and index futures by using intraday data from April to September 2004 of the same index. They checked lead-lag relationship from different factors like volatility, returns and price discovery. On the basis of these factors they found cash market is stronger than futures market.

Cheng, C. et al. (1995) asserted lead-lag relationship, volatility asymmetry and overreaction phenomenon between USA and Taiwan. Using GJR-GARCH (1,1) model they found that the TAIEX led the spot and futures prices of the US market and on the other hand the spot and futures prices in the USA led the spot index in Taiwan.

Chan, K. (1992) analysed intraday data of 20 stocks three different periods (august 1984, June 1985, September 1987) to investigate lead-lag relationship between MM (Major Market) cash index and MM and S&P futures index returns under different situations. The MMI is used in this study because it is less problematic that may arise due to infrequent trading because infrequent trading does not reveal fresh or exact result. That is why he used intraday data of 5 minutes intervals and found that futures market leads cash market by using GARCH. He has also observed the impact of Good news or bad news, trading activity and market wide movement on lead-lag relations between spot and futures market. He found S&P 500 index or MMI futures lead MMI cash during good or bad news in the market and due to trading activities he could not find any significant change in the relations. Similarly, Chan, K. et al. (1991) used a bivariate GARCH model and find that S&P 500 futures returns lead spot returns by about five minutes.

Stoll and Whaley (1990) studied the lead-lag behavior between spot and futures index. They have used intraday data and frequency of trading was high and they found that S&P 500 index and MMI (Major Market Index) futures returns lead the stock market returns by about five minutes and they have also tried to provide the explanation of leading spot market by futures market. They explained it even in case of highly traded stocks or after adjusting for infrequent trading of component stocks.

The review of past studies shows mixed results on price discovery function of derivatives market. In some markets spot markets leads the futures market in other cases futures market leads the spot market. Various studies have taken data of different time periods so that they can capture the impact of frequency of data on lead lag relationship. Most of the techniques have used granger causality test, cointegration test, VECM model and GARCH model for analysis.

3. Methodology of the Study

The objective of the study is to understand whether spot market leads the futures market or vice versa. The sample includes data price of S&P CNX Nifty index, Nifty Futures near month contracts, Nifty Futures second month contracts and Nifty Futures far month contracts starting from 12-06-2000, since the inception of futures trading on Nifty till 05-02-2015. Sample size includes data for a time period of 15 years as it is the maximum available data till date on derivatives market in India. Data has been collected for Nifty index as it is barometer of performance of Indian financial markets. The price data was used to measure the lead lag relationship between Nifty Index futures and Nifty Index. The data was historical and was collected from NSE Website. This study is very comprehensive on the lead lag relationship as it includes the data of derivatives market since inception and the models used are most appropriate and are taken from the available literature. Based on the literature reviewed the statistical techniques which has been used in the study includes ADF test, Johnson Cointegration test, Granger Causality test and Vector Error Correction Models and diagnostic tests.

4. Analysis and Interpretation

This study covers data from the time when Nifty futures were introduced from 12-06-2000 till 05-02-2015. Index futures were introduced for the purpose of price discovery, reducing volatility increasing liquidity in the markets etc. The data used was Nifty prices and Nifty futures near month, next month Nifty futures prices and far month Nifty futures prices.

The mean return is positive for all series in the sample period (12-06-2000 to 05-02-2015). Table 1 shows that Nifty index mean price is 3451.554 with standard deviation of 1842.285. The mean price of near month Nifty futures contract is 3453.244 with standard deviation of 1847.665. Second month Nifty futures contract mean price is 3458.404 with standard deviation of 1855.467 far month Nifty futures contract mean price is 3463.801 with standard deviation of 1861.536. The returns are negatively skewed for all series except for month Nifty futures contract which means that there is higher probability of earning returns greater than mean kurtosis is 1.42.

Table 1: Descriptive Statistics of Sample Period (12-06-2000 to 05-02-2015)

	S&P CNX Nifty	Near Month Nifty Futures	Next Month Nifty Futures	Far Month Nifty Futures
Mean	3451.554	3453.244	3458.404	3463.801
Median	3567.15	3570.35	3569.4	3566.55
Maximum	6363.9	6391.75	6445.75	6481.6
Minimum	854.2	855.4	860.3	865.15
Std. Dev.	1842.285	1847.665	1855.467	1861.536
Skewness	-0.017049	-0.011199	-0.00316	0.003304
Kurtosis	1.42012	1.42251	1.425266	1.427537
Jarque-Bera	355.1202	353.9533	352.6522	351.6364
Probability	0	0	0	0
Sum	11780152	11785920	11803533	11821954
Sum Sq. Dev.	1.16E+10	1.16E+10	1.17E+10	1.18E+10

The results of Jarque-Bera test indicate a rejection of null hypothesis of a normal distribution of price data for all the series at (1 percent level of performance).

Table 2: Augmented Dickey-Fuller Results for Full Period (with Drift and Trend)

Price Series		t-Statistic	Prob.*	Lag Length
CNX Nifty		-2.9546	0.1455	1
	(first Difference)	-54.7195	0.0000	0
Near Month		-2.9275	0.1537	0
	(first Difference)	-57.0933	0.0000	0
Next Month		-2.9433	0.1489	0
	(first Difference)	-56.6348	0.0000	0
Far Month		-2.9462	0.1480	0
	(first Difference)	-56.3309	0.0000	0

*MacKinnon (1996) one-sided p-values.

Exogenous: Constant, Linear Trend

SC: Schwarz information criterion

Table 2 shows Augmented Dickey Fuller test results with drift and trend. All the four price series were found to be non-stationary at level (0) but were found to be stationary at first difference at 1 percent level of significance. This makes the data eligible for applying co-integration test.

Table 3: Granger Causality Results during Total Period (12-06-2000 to 05-02-2015)

Null Hypothesis:	Obs	F-Statistic	Prob.
NEAR_MONTH does not Granger Cause NIFTY	3411	1.80414	0.1648
NIFTY does not Granger Cause NEAR_MONTH		**9.0178**	0.0001
NEXT_MONTH does not Granger Cause NIFTY	3411	2.00534	0.1348
NIFTY does not Granger Cause NEXT_MONTH		**6.64829**	0.0013
FARMONTH does not Granger Cause NIFTY	3411	1.91567	0.1474
NIFTY does not Granger Cause FARMONTH		**8.01457**	0.0003
NEXT_MONTH does not Granger Cause NEAR_MONTH	3411	0.95967	0.3831
NEAR_MONTH does not Granger Cause NEXT_MONTH		1.92415	0.1462
FARMONTH does not Granger Cause NEAR_MONTH	3411	1.06776	0.3439
NEAR_MONTH does not Granger Cause FARMONTH		**4.25824**	0.0142
FARMONTH does not Granger Cause NEXT_MONTH	3411	1.20838	0.2988
NEXT_MONTH does not Granger Cause FARMONTH		**5.19464**	0.0056

Table 3 shows Granger causality result which is used to identify the direction of relationship between two variables. The results show that Nifty has unidirectional relationship with near month Nifty futures contract and Nifty causes near month Nifty futures as F value is highly significant at 1 percent level of significance. Nifty also causes next month Nifty futures as F value of 6.64829 is highly significant at 1 percent level of significance. Also Nifty causes far month Nifty futures as the results of F statistics are highly significant. Near month Nifty futures causes far month Nifty futures is also seen as F value of 4.25824 is highly significant at 1 percent level of significance. Next month Nifty futures cause far month Nifty futures as F statistics is highly significant.

Granger Causality results, which suggests that there is unidirectional Granger Causality between Nifty and Nifty futures, where Nifty significantly granger cause Nifty futures at 5% significance level. These findings are consistent with the findings of Wahab and Lashgari (1993), Chan and lien (2001), Chen et al., (2002), Lin et al., (2002). The cost-of-carry model presumes that the magnitude of mispricings should be positively associated with the time to maturity of the contract because as soon as the contract approaches maturity date, the uncertainty regarding future cash flows reduces.

Table 4: Cointegration Test Results of Nifty Index and Futures Market Contracts

Symbol	Hypothesized No. of CE(s)	Eigenvalue	Trace Test		Maximum Eigen Value Test		No. of Cointegrating Equations
			Test Statistics	P value**	Test Statistics	P value**	
Near Month Futures	None*	0.0377	138.6292	0.0001	131.0548	0.0001	2
	At the Most 1*	0.0022	7.5744	0.0059	7.5744	0.0059	
Next Month Futures	None*	0.0121	47.8067	0.0000	41.3615	0.0000	2
	At the Most 1*	0.0019	6.4452	0.0111	6.4452	0.0111	
Far Month Futures	None*	0.0082	34.4030	0.0001	28.2018	0.0008	2
	At the Most 1*	0.0018	6.2013	0.0128	6.2013	0.0128	

**MacKinnon-Haug-Michelis (1999) p-values

Included observations: 3408

Trend assumption: Quadratic deterministic trend

Table 4 shows results of co-integration test which depicts two co-integrating equations which are highly significant at 5 percent level of significance as per trace test and maximum eigen value test. Johansen Cointegration test suggests that both markets are integrated of order two, hence, price convergence on contract expiry date does take place, which implies that Indian equity futures and cash markets observe strong and stable long-run relationship. These findings are consistent with Thenmozhi (2002), Raju and Karande (2003), Gupta and Singh (2006a and 2006b), Sah and Kumar (2006) and Bose1 (2007). Hasbrouck (1995) mentioned that existence of cointegration relationship between Indian equity futures and cash markets further suggest that both markets share same information set, thus, law of one price may hold in the long-run, which implies that there is no lead-lag relationship between two markets during long-run. Vasantha & Mallikarjunappa (2015) found that the information is absorbed by the spot market faster than futures market.

Table 5: Vector Error Correction Estimates (VECM)

Cointegrating Eq:				
	Coefficient	**Std. Error**	**t-Statistic**	
NEAR_MONTH(-1)	-0.997154	-0.00047	-2100.78	
C	-8.149254			
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
CointEq1	0.152876*	0.083668	1.827178	**0.0678**
D(NIFTY(-1))	-0.172522	0.137042	-1.258896	0.2082
D(NIFTY(-2))	-0.130174	0.124341	-1.046911	0.2952
D(NEAR_MONTH(-1))	0.232483*	0.131263	1.771124	**0.0766**
D(NEAR_MONTH(-2))	0.128505	0.120187	1.069211	0.2851
C	1.263959	0.988885	1.278166	0.2013
R-squared	0.005573	**Mean dependent var**		1.345132
Adjusted R-squared	0.004112	**S.D. dependent var**		57.83489
S.E. of regression	57.71586	**Akaike info criterion**		10.9507
Sum squared resid	11339135	**Schwarz criterion**		10.96149
Log likelihood	-18664.94	**Hannan-Quinn criter.**		10.95456
F-statistic	3.815066	**Durbin-Watson stat**		2.00085
Prob(F-statistic)	0.001897			
D(NIFTY) = C(1)*(NIFTY(-1) - 0.99715441422*NEAR_MONTH(-1) - 8.14925415772) + C(2)*D(NIFTY(-1)) + C(3)*D(NIFTY(-2)) + C(4)*D(NEAR_MONTH(-1)) + C(5)*D(NEAR_MONTH(-2)) + C(6)				
Determinant resid covariance (dof adj.)	209795.9			
Determinant resid covariance	209058.3			
Log likelihood	-30564.04			
Akaike information criterion	17.93433			
Schwarz criterion	17.95952			

Sample (adjusted): 6/15/2000 2/05/2015

* Significant at 10 per cent level

Included observations: 3410 after adjustments

These results show that VECM can be applied so that long run causality and short run causality relationship can be identified between Nifty and Nifty futures.

The results of vector error correction model are shown in table 5. The VECM tries to predict long run causality and short run causality between Nifty and near month Nifty futures prices.

The co-integration equation shows that the error correction term C(1) is significant at 10 percent level of significance which also depicts the speed of adjustment towards equilibrium. The error correction term coefficient is 0.152876 which means 15 percent is the speed of adjustment with which the price will reach the Nifty equilibrium. So, there is long run causality which exists running from near month Nifty futures to Nifty index. Near month Nifty futures at lag one coefficient is (0.2324483) is also significant at 10 percent level of significance and is non-zero which shows that there exists short run causality between Nifty futures and Nifty. Sakellariou, I.K. (2010) also found short run effects between the spot and futures markets across time. Since R^2 of VECM model is not very high so explanation of the model is not very good. Since F statistics and its P value is significant it means that our model is fitted well.

The short run causality can also be tested with the help of diagnostic test like wald statistics whose results are presented in table 6.

Table 6: Diagnostic Testing of VECM Model

Wald Test			
Test Statistic	**Value**	**Df**	**Probability**
F-statistic	1.632831	(2, 3404)	0.1955
Chi-square	3.265662	2	0.1954
Residual Diagnostics: Breusch-Godfrey Serial Correlation LM Test			
F-statistic	2.171472	**Prob. F(2,3402)**	0.1142
Obs*R-squared	4.347607	**Prob. Chi-Square(2)**	0.1137
Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	30.69511	**Prob. F(6,3403)**	0
Obs*R-squared	175.0745	**Prob. Chi-Square(6)**	0
Scaled explained SS	1036.562	**Prob. Chi-Square(6)**	0

The result of diagnostic test is shown in table 6. Wald test was performed to identify if there is any short run causality between variables since chi square results (3.26566) is not significant. So, null hypothesis is accepted which means that there is no short term causality running from Nifty futures to Nifty.

The result of Breush-Goldfrey serial correlation LM test shows F value of 2.1714 is not significant so null hypothesis is accepted. Thus there is no serial correlation in the residual so, the model is good. Breusch – Pagan – Godfrey test of heteroskedasticity shows that the F value is highly significant so null hypothesis is rejected so, the model has problem of hetroskedasticity.

5. Conclusion

This study takes data for a time span of 15 years starting from 12-06-2000 (when derivatives were launched in India) to 05-02-2015. The study gives a comprehensive picture of lead lag relationship in Indian markets because of longer time frame used. Augmented Dickey Fuller test results shows that all series were found to be non-stationary at level (0) but were found to be stationary at first difference for total period (from 12-06-2000 till 05-02-2015). Granger causality results show that Nifty causes Nifty futures contracts. Johansen Cointegration test suggests that both markets are integrated of order two, hence, price convergence on contract expiry date does take place, which implies that Indian equity futures and cash markets observe strong and stable long-run relationship. VECM results indicate that there is long run causality which exists running from near month nifty futures to nifty index and short run relationship also exists between two markets. The findings of this study are also relevant now as markets have seen lot of changes due to impact of global economic crisis which has been captured by this study. The limitation of the study is that data could have been studied for shorter time span like minute to minute data could have been recorded for more accuracy instead of closing data of the day.

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