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A STUDY OF LEAD LAGS RELATIONSHIP BETWEEN NSE EQUITY MARKET AND SINGLE STOCK FUTURES

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ABSTRACT

The relationship between the NSE equity and equity derivative markets well documented. Many studies concluded that future contracts have better price predicting power than spot market and identified future prices lead spot prices. This study aimed to identify the lead-lag relationship between equity spot and future market and to assess the role of stock futures market in price discovery process at NSE FO segment. High frequency one-minute data of spot and futures prices for 80 stocks collected for the period of four years i.e. from January 2012 to September 2015. The selected stocks pooled from 11 industries which are also present in SENSEX and NIFTY indices representing almost 70% of market capitalisation. A Bi-variate VAR model is deployed in order to identify causal relation between the markets and found bi-directional causality. An impulse response function deployed in order to assess the speed of price adjustment between the market and found the prices in both markets adjust together very quickly within the time frame of 3 minutes. Variance decomposition analysis resulted in depicting spot market strength in price discovery over the futures market.

KEYWORDS

Bi-variate VAR, impulse response function, lead-lag relationship, NSE single stock futures, variance Decomposition.

INTRODUCTION

Since derivative products are facilitating trading on stocks at lower cost and margin requirements with ease of leverage positions comparing to spot market, it is hypothesised that informational traders would prefer to trade in derivative products. If so the dissemination of any information regarding the securities would impact upon the derivative prices first and derivative products would lead the spot market prices. In contrary to this argument some advised that the speculators at spot market are more attracted towards derivative products since they are cheaper products for magnifying the return on investments and it would cause FO market to be more volatile resulting prices deviate from their intrinsic values. This in turn would compel the informed traders to prefer spot market and price discovery takes place in spot which would lead the derivative prices.

The lead lag relationship between two market prices would reveal the facts about superiority of one over another market in price formation and trader's preference towards markets. In connection with this study for identifying the lead lag relationship between spot and FO market prices is important as identifying the lead time or lag time between spot and future prices of stocks would be used as the benchmark performance for the stock futures at NSE.

This study is aimed at identifying how quickly the two market prices are adjusted together and the understanding the accuracy of the markets in price discovery mechanism. Specifically, this is attempted to study the superiority of markets in price formation and seek to identify the causal relationship of spot and FO markets at NSE.

LITERATURE REVIEW

Many researchers contributed for the development of NSE FO market. A pioneer work done by Kawaller, Koch and Koch (1987) in identifying the lead lag relationship between spot and futures market at S&P 500 and found futures lead spot prices by 20 to 30 minutes while spot leads futures by lesser than in two minutes. Kumar and Tse (2009) used order book data and found spot market plays significant role in price formation in the market. Shastri et al. (2008) studied the role of single stock futures at NYSE and found their contribution in price discovery process is limited to 24%. Chan (1992) studied index futures at MMI and found significant domination of future market in leading the spot market. Raju and Karande (2003) deployed VECM model on intraday prices to identify the causality between nifty indices and found bi-directional relationship. Mukherjee and Mishra (2006) also followed similar methodology in identifying the causality between NSE nifty futures and concluded bi-directional relationship.

RESEARCH METHODOLOGY

High frequency one minute intraday data is used for testing the lead-lag relationship between the spot and futures market. Stock prices for sampled set of 10 stock futures along their corresponding spot prices for the period of four years ranging from 2012 to 2015 obtained for the study. The data is pooled from all stocks for conducting panel data analysis since the study is expected to test the causality between the markets but not the stock specific lead-lag relationship. The selected data is log transformed and then first differenced in order to make them representing stock returns. Thus we obtained two series of data DLOGSPOTPRICE and DLOGFUTUREPRICE representing returns for pooled stocks from spot and futures markets respectively.

In order to identify the lead-lag relationship between stock spot and future returns we deploy a bivariate VAR model. Since it is the precondition to check for data stationarity to proceed further to test VAR we deployed ADF-fisher test of unit root for testing panel data statinarity. The following table 1.1 presents the results from ADF fisher unit root test on both stock spot and future returns at level data.

TABLE 1.1: ADF UNIT ROOT TEST

Null Hypothesis: Unit root (individual unit root process)				
Series: DLOGFUTUREPRICE				
Sample: 2/02/2012 09:07 7/13/2015 16:37				
Total number of observations: 1513334				
Cross-sections included: 10				
Method			Statistic	Prob.**
ADF - Fisher Chi-square			184.207	0.0000
ADF - Choi Z-stat			-11.7606	0.0000
Intermediate ADF test results DLOGFUTUREPRICE				
Cross section	Prob.	Lag	Max Lag	Obs
DLF	0.0001	4	4	298543
GAIL	0.0001	4	4	116414
IDBI	0.0001	4	4	143778
JUBLFOOD	0.0001	4	4	100940
MM	0.0001	4	4	238032
MRF	0.0001	4	4	8404
OFSS	0.0001	4	4	13014
ORIENTBANK	0.0001	4	4	138462
RCOM	0.0001	4	4	280858
UNITECH	0.0001	4	4	174889

Null Hypothesis: Unit root (individual unit root process)				
Series: DLOGSPOTPRICE				
Sample: 2/02/2012 09:07 7/13/2015 16:37				
Total number of observations: 2792840				
Cross-sections included: 10				
Method			Statistic	Prob.**
ADF - Fisher Chi-square			184.207	0.0000
ADF - Choi Z-stat			-11.7606	0.0000
Intermediate ADF test results DLOGSPOTPRICE				
Cross section	Prob.	Lag	Max Lag	Obs
DLF	0.0001	4	4	317506
GAIL	0.0001	4	4	309388
IDBI	0.0001	4	4	309534
JUBLFOOD	0.0001	4	4	283075
MM	0.0001	4	4	314264
MRF	0.0001	4	4	179781
OFSS	0.0001	4	4	144442
ORIENTBANK	0.0001	4	4	300039
RCOM	0.0001	4	4	317558
UNITECH	0.0001	4	4	317253

The above table exhibits that the P values of ADF fisher for spot and future price series are less than 0.05 suggest to reject the null hypothesis of unit root existence in both the data series at 5% significance level. That explains both series of data has no unit roots and thus they are identified stationary which permits the study to proceed further to test causality under VAR environment.

To identify the precise VAR model for spot and future prices it is needed to identify optimum lag length to construct the model. For this purpose, we considered the following system suggested lag lengths under different methods of lag-length criteria and chosen Schwarz criterion (SC) of lag structure which is conservative and reliable in modelling VAR.

TABLE 1.2: LAG LENGTH CRITERIA UNDER VAR

VAR Lag Order Selection Criteria
Endogenous variables: DLOGSPOTPRICE DLOGFUTUREPRICE
Exogenous variables: C
Sample: 2/02/2012 09:07 7/13/2015 16:37
Included observations: 629832

Lag	LogL	LR	FPE	AIC	SC	HQ
0	6556523.	NA	3.11e-12	-20.8199	-20.81987	-20.81989
1	6629574.	146102.2	2.47e-12	-21.05186	-21.05175	-21.05183
.	.	.	.	.	.	.
.	.	.	.	.	.	.
34	6687931.	88.95975	2.05e-12	-21.23675	-21.23427	-21.23606
35	6687983.	102.4489	2.05e-12	-21.2369	**-21.23434***	-21.23619
36	6687989.	11.92949	2.05e-12	-21.23691	-21.23428	-21.23617
.	.	.	.	.	.	.
.	.	.	.	.	.	.
44	6688121.	77.77834	2.05e-12	-21.23723	-21.23402	**-21.23633***
.	.	.	.	.	.	.
.	.	.	.	.	.	.
49	6688165.	29.05739	2.05e-12	-21.23731	-21.23374	-21.2363
50	6688173.	**16.39529***	**2.05e-12***	**-21.23732***	-21.23368	-21.2363

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The above table 1.2 exhibits that the Schwarz criterion (SC) for lag structure suggests that a lag structure of 35 would best fit the VAR model for selected spot and future price series. Thus we constructed VAR model using a lag length of 35 lags for spot and future price series and obtained the following VAR equations.

VAR EQUATIONS

DLOGSPOTPRICE = C(1)*DLOGSPOTPRICE(-1) + C(2)*DLOGSPOTPRICE(-2) + ……..+ C(70)*DLOGFUTUREPRICE(-35) + C(71) **Equation 1**

DLOGFUTUREPRICE = C(72)*DLOGSPOTPRICE(-1) + C(73)*DLOGSPOTPRICE(-2) + ……..+ C(141)*DLOGFUTUREPRICE(-35) + C(142) **Equation 2**

Equation 1 would reveal the empirical evidence for assessing whether future stock prices lead spot prices at NSE or not. Since we deal with the pooled data comprising of 10 selective security prices, we use panel least square method to regress the VAR system specified equations. The following table 1.3 presents the result from regression equation 1 for identifying causality from future prices to spot prices.

TABLE 1.3: ESTIMATION OF EQUATION 1 USING PANEL LEAST SQUARES

Dependent Variable: DLOGSPOTPRICE
Method: Panel Least Squares
Sample (adjusted): 2/02/2012 09:51 7/13/2015 15:30
Periods included: 270929
Cross-sections included: 10
Total panel (unbalanced) observations: 784301

	Coefficient	Std. Error	t-Statistic	Prob		Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.298	0.002	-155.072	0.000	C(36)	0.265	0.002	144.026	0.000
C(2)	-0.214	0.002	-91.169	0.000	C(37)	0.207	0.002	91.303	0.000
C(3)	-0.184	0.003	-71.106	0.000	C(38)	0.170	0.002	68.004	0.000
C(4)	-0.146	0.003	-53.217	0.000	C(39)	0.140	0.003	53.085	0.000
C(5)	-0.121	0.003	-42.464	0.000	C(40)	0.119	0.003	43.236	0.000
C(6)	-0.103	0.003	-35.345	0.000	C(41)	0.101	0.003	36.027	0.000
C(7)	-0.100	0.003	-33.708	0.000	C(42)	0.097	0.003	33.886	0.000
C(8)	-0.096	0.003	-31.554	0.000	C(43)	0.090	0.003	30.912	0.000
C(9)	-0.088	0.003	-28.605	0.000	C(44)	0.082	0.003	27.875	0.000
C(10)	-0.070	0.003	-22.683	0.000	C(45)	0.071	0.003	23.660	0.000
C(11)	-0.062	0.003	-19.888	0.000	C(46)	0.068	0.003	22.498	0.000
C(12)	-0.061	0.003	-19.374	0.000	C(47)	0.064	0.003	21.121	0.000
C(13)	-0.050	0.003	-15.824	0.000	C(48)	0.052	0.003	17.017	0.000
C(14)	-0.043	0.003	-13.434	0.000	C(49)	0.044	0.003	14.462	0.000
C(15)	-0.037	0.003	-11.425	0.000	C(50)	0.041	0.003	13.129	0.000
C(16)	-0.034	0.003	-10.475	0.000	C(51)	0.033	0.003	10.527	0.000
C(17)	-0.027	0.003	-8.259	0.000	C(52)	0.031	0.003	9.897	0.000
C(18)	-0.034	0.003	-10.405	0.000	C(53)	0.030	0.003	9.473	0.000
C(19)	-0.029	0.003	-8.808	0.000	C(54)	0.027	0.003	8.675	0.000
C(20)	-0.025	0.003	-7.686	0.000	C(55)	0.023	0.003	7.435	0.000
C(21)	-0.023	0.003	-7.044	0.000	C(56)	0.023	0.003	7.446	0.000
C(22)	-0.028	0.003	-8.614	0.000	C(57)	0.022	0.003	6.870	0.000
C(23)	-0.024	0.003	-7.527	0.000	C(58)	0.029	0.003	9.350	0.000
C(24)	-0.017	0.003	-5.389	0.000	C(59)	0.024	0.003	7.789	0.000
C(25)	-0.015	0.003	-4.720	0.000	C(60)	0.018	0.003	5.769	0.000
C(26)	-0.006	0.003	-1.984	0.047	C(61)	0.006	0.003	1.935	0.053
C(27)	-0.007	0.003	-2.205	0.027	C(62)	0.010	0.003	3.311	0.001
C(28)	-0.008	0.003	-2.554	0.011	C(63)	0.012	0.003	3.943	0.000
C(29)	0.005	0.003	1.555	0.120	C(64)	0.000	0.003	0.048	0.962
C(30)	0.027	0.003	8.736	0.000	C(65)	-0.021	0.003	-7.107	0.000
C(31)	0.027	0.003	8.978	0.000	C(66)	-0.019	0.003	-6.780	0.000
C(32)	0.020	0.003	6.972	0.000	C(67)	-0.020	0.003	-7.269	0.000
C(33)	0.023	0.003	8.611	0.000	C(68)	-0.022	0.003	-8.466	0.000
C(34)	0.019	0.002	7.818	0.000	C(69)	-0.016	0.002	-7.061	0.000
C(35)	0.011	0.002	5.506	0.000	C(70)	-0.009	0.002	-4.663	0.000
					C(71)	0.000	0.000	-4.620	0.000

R-squared	0.031964	Mean dependent var	-6.18E-06
Adjusted R-squared	0.031878	S.D. dependent var	0.001581
S.E. of regression	0.001556	Akaike info criterion	-10.0937
Sum squared resid	1.897917	Schwarz criterion	-10.0927
Log likelihood	3958334	Hannan-Quinn criter.	-10.0934
F-statistic	369.9278	Durbin-Watson stat	1.998859
Prob(F-statistic)	0		

The above table represents the coefficients of lag values of both spot and future market up to 35 lags for each market returns regressed on spot returns. The corresponding P values are found statistically significant at 95% confidence levels. We use WALD test to test whether all lag values of future returns together significant in explaining the spot market returns. The following table 1.4 exhibits the results from WALD test for joint effect of lag values of future returns on spot market returns.

TABLE 1.4: WALD TEST 1 FOR EQUATION 1

Wald Test:			
Test Statistic	Value	df	Probability
F-statistic	610.2414	(35, 784230)	**0.0000**
Chi-square	21358.45	35	0.0000

Null Hypothesis: C(36)=C(37)=C(38)=C(39)=C(40)=C(41)= C(42)= C(43)= C(44)=C(45)=C(46)= C(47)= C(48)=C(49)= C(50)= C(51)= C(52)= C(53)=C(54)= C(55)=C(56)=C(57)=C(58)=C(59)=C(60)=C(61)=C(62) = C(63)= C(64)=C(65)=C(66)= C(67)= C(68)=C(69)= C(70)= 0

Normalized Re-striction (= 0)	Value	Std. Err.	Normalized Restriction (= 0)	Value	Std. Err.	Normalized Re-striction (= 0)	Value	Std. Err.
C(36)	0.264627	0.001837	C(47)	0.064119	0.003036	C(59)	0.024316	0.003122
C(37)	0.206578	0.002263	C(48)	0.052007	0.003056	C(60)	0.017943	0.003110
C(38)	0.169682	0.002495	C(49)	0.044465	0.003075	C(61)	0.005987	0.003094
C(39)	0.140312	0.002643	C(50)	0.040594	0.003092	C(62)	0.010167	0.003071
C(40)	0.118596	0.002743	C(51)	0.032705	0.003107	C(63)	0.011979	0.003038
C(41)	0.101407	0.002815	C(52)	0.030863	0.003118	C(64)	0.000144	0.002994
C(42)	0.097316	0.002872	C(53)	0.029616	0.003126	C(65)	-0.02	0.002935
C(43)	0.090156	0.002917	C(54)	0.027174	0.003132	C(66)	-0.02	0.002858
C(44)	0.082315	0.002953	C(55)	0.023305	0.003134	C(67)	-0.02	0.002746
C(45)	0.070603	0.002984	C(56)	0.023344	0.003135	C(68)	-0.02	0.002577
C(46)	0.067769	0.003012	C(57)	0.021526	0.003133	C(69)	-0.02	0.002308
			C(58)	0.029261	0.003130	C(70)	-0.01	0.001833

Restrictions are linear in coefficients.

The above table exhibits that the P value for F statistic calculated under WALD test is '0" indicating the strong rejection of null hypothesis at 5% significance level. This interprets the lag values of future market returns jointly affects the spot market returns. From this test we conclude that there is empirical evidence that stock future prices leads spot market prices.

We regress the equation 2 estimated under VAR to assess the causality from spot market to futures market. The following table 1.5 presents the test output from regression equation 2 estimated using panel ordinary least squares.

TABLE 1.5: ESTIMATION OF EQUATION 2 USING PANEL LEAST SQUARES

Dependent Variable: DLOGFUTUREPRICE
Method: Panel Least Squares
Sample (adjusted): 2/02/2012 09:51 7/13/2015 15:29
Periods included: 269967
Cross-sections included: 10
Total panel (unbalanced) observations: 775288

	Coefficient	Std. Error	t-Statistic	Prob		Coefficient	Std. Error	t-Statistic	Prob
C(72)	0.451688	0.002032	222.3384	0	C(107)	-0.459185	0.001947	-235.7834	0
C(73)	0.373652	0.002488	150.1553	0	C(108)	-0.363482	0.002395	-151.7685	0
C(74)	0.293043	0.002744	106.7826	0	C(109)	-0.289868	0.002642	-109.7289	0
C(75)	0.247493	0.002902	85.29613	0	C(110)	-0.238477	0.002794	-85.36414	0
C(76)	0.206913	0.003009	68.76827	0	C(111)	-0.201375	0.002896	-69.52809	0
C(77)	0.18366	0.003086	59.51706	0	C(112)	-0.178464	0.002972	-60.05351	0
C(78)	0.152723	0.003146	48.5433	0	C(113)	-0.148425	0.003031	-48.96114	0
C(79)	0.128108	0.003193	40.12169	0	C(114)	-0.128453	0.003077	-41.7476	0
C(80)	0.114782	0.003231	35.52593	0	C(115)	-0.113882	0.003114	-36.5703	0
C(81)	0.109796	0.003265	33.62962	0	C(116)	-0.105488	0.003147	-33.5152	0
C(82)	0.101398	0.003294	30.78661	0	C(117)	-0.092807	0.003176	-29.22184	0
C(83)	0.083898	0.003318	25.28489	0	C(118)	-0.079225	0.003201	-24.75332	0
C(84)	0.080407	0.003341	24.06601	0	C(119)	-0.077352	0.003222	-24.00464	0
C(85)	0.072813	0.003364	21.64642	0	C(120)	-0.070317	0.003243	-21.68218	0
C(86)	0.067927	0.003384	20.07568	0	C(121)	-0.062363	0.003261	-19.12446	0
C(87)	0.059342	0.0034	17.45571	0	C(122)	-0.05938	0.003275	-18.12937	0
C(88)	0.059724	0.003412	17.50405	0	C(123)	-0.053643	0.003287	-16.31842	0
C(89)	0.036454	0.003422	10.6538	0	C(124)	-0.041659	0.003296	-12.63776	0
C(90)	0.036413	0.003427	10.62559	0	C(125)	-0.037249	0.003302	-11.28134	0
C(91)	0.04223	0.003429	12.31374	0	C(126)	-0.042006	0.003304	-12.71395	0
C(92)	0.037893	0.003432	11.04213	0	C(127)	-0.036172	0.003305	-10.94603	0
C(93)	0.030563	0.00343	8.910374	0	C(128)	-0.036048	0.003303	-10.91302	0
C(94)	0.027986	0.003426	8.169586	0	C(129)	-0.023874	0.003299	-7.236119	0
C(95)	0.032927	0.003417	9.636702	0	C(130)	-0.024561	0.003291	-7.461999	0
C(96)	0.031866	0.003404	9.362328	0	C(131)	-0.030761	0.003278	-9.382657	0
C(97)	0.033143	0.003385	9.789907	0	C(132)	-0.033685	0.003261	-10.32936	0
C(98)	0.030472	0.00336	9.068838	0	C(133)	-0.025661	0.003237	-7.927658	0
C(99)	0.022992	0.003325	6.913983	0	C(134)	-0.017359	0.003203	-5.419878	0
C(100)	0.037647	0.003278	11.48308	0	C(135)	-0.032207	0.003156	-10.20571	0
C(101)	0.050297	0.00322	15.62112	0	C(136)	-0.044251	0.003096	-14.29119	0
C(102)	0.047853	0.003138	15.25153	0	C(137)	-0.042184	0.003016	-13.98679	0
C(103)	0.035278	0.003018	11.68939	0	C(138)	-0.037146	0.002897	-12.82283	0
C(104)	0.034915	0.002838	12.30128	0	C(139)	-0.034143	0.002719	-12.55806	0
C(105)	0.031018	0.002555	12.14097	0	C(140)	-0.029279	0.002435	-12.02307	0
C(106)	0.01746	0.002051	8.514542	0	C(141)	-0.016566	0.001934	-8.564801	0
					C(142)	-9.69E-07	1.85E-06	-0.523571	0.6006

R-squared	0.071	Mean dependent var	-3.84E-06
Adjusted R-squared	0.071	S.D. dependent var	0.00169
S.E. of regression	0.002	Akaike info criterion	-10.0021
Sum squared resid	2.056	Schwarz criterion	-10.001
Log likelihood	4E+06	Hannan-Quinn criter.	-10.0018
F-statistic	849.5	Durbin-Watson stat	1.9942
Prob(F-statistic)	0		

Above results from regression analysis exhibits coefficients of lag values for stock and future returns and their corresponding P values. They are found almost zero for all regression coefficients estimated which means all independent variables are significant in explaining the stock future returns. To identify the causality from spot market to futures market we use the following WALD test to assess the joint effect of lag values of spot prices on future price. The following table 1.6 exhibits the results from WALD test for joint effect past values of spot prices on present future price to confirm the causality from spot market to futures market.

TABLE 1.6: WALD TEST 2 FOR EQUATION 2

Wald Test:								
Test Statistic	Value	df	Probability					
F-statistic	1468.959	(35, 775217)	**0.0000**					
Chi-square	51413.57	35	0.0000					
Null Hypothesis: C(72)= C(73)=C(74)= C(75)=C(76)=C(77)=C(78)=C(79)=C(80)=C(81)=C(82)= C(83)= C(84)=C(85)=C(86)= C(87)= C(88)=C(89)= C(90)= C(91)= C(92)= C(93)=C(94)= C(95)=C(96)=C(97)=C(98)=C(99)=C(100)=C(101)=C(102)= C(103)= C(104)=C(105)= c(106)=0								
Normalized Re-striction (= 0)	Value	Std. Err.	Normalized Re-striction (= 0)	Value	Std. Err.	Normalized Re-striction (= 0)	Value	Std. Err.
C(72)	0.451688	0.002032	C(83)	0.083898	0.003318	C(95)	0.032927	0.003417
C(73)	0.373652	0.002488	C(84)	0.080407	0.003341	C(96)	0.031866	0.003404
C(74)	0.293043	0.002744	C(85)	0.072813	0.003364	C(97)	0.033143	0.003385
C(75)	0.247493	0.002902	C(86)	0.067927	0.003384	C(98)	0.030472	0.003360
C(76)	0.206913	0.003009	C(87)	0.059342	0.003400	C(99)	0.022992	0.003325
C(77)	0.183660	0.003086	C(88)	0.059724	0.003412	C(100)	0.037647	0.003278
C(78)	0.152723	0.003146	C(89)	0.036454	0.003422	C(101)	0.050297	0.003220
C(79)	0.128108	0.003193	C(90)	0.036413	0.003427	C(102)	0.047853	0.003138
C(80)	0.114782	0.003231	C(91)	0.042230	0.003429	C(103)	0.035278	0.003018
C(81)	0.109796	0.003265	C(92)	0.037893	0.003432	C(104)	0.034915	0.002838
C(82)	0.101398	0.003294	C(93)	0.030563	0.003430	C(105)	0.031018	0.002555
			C(94)	0.027986	0.003426	C(106)	0.017460	0.002051
Restrictions are linear in coefficients.								

It is noted that the F statistic for above WALD test is statistically significant at 95% confidence level suggesting the rejection of null hypothesis of non-causality. This implies that the causality from spot prices to stock future prices do exist at NSE.

From the results of above regression analysis for VAR equations we conclude that there is bi-directional causality between NSE spot market and future market returns within the intraday trades confirming faster mutual price adjustments.

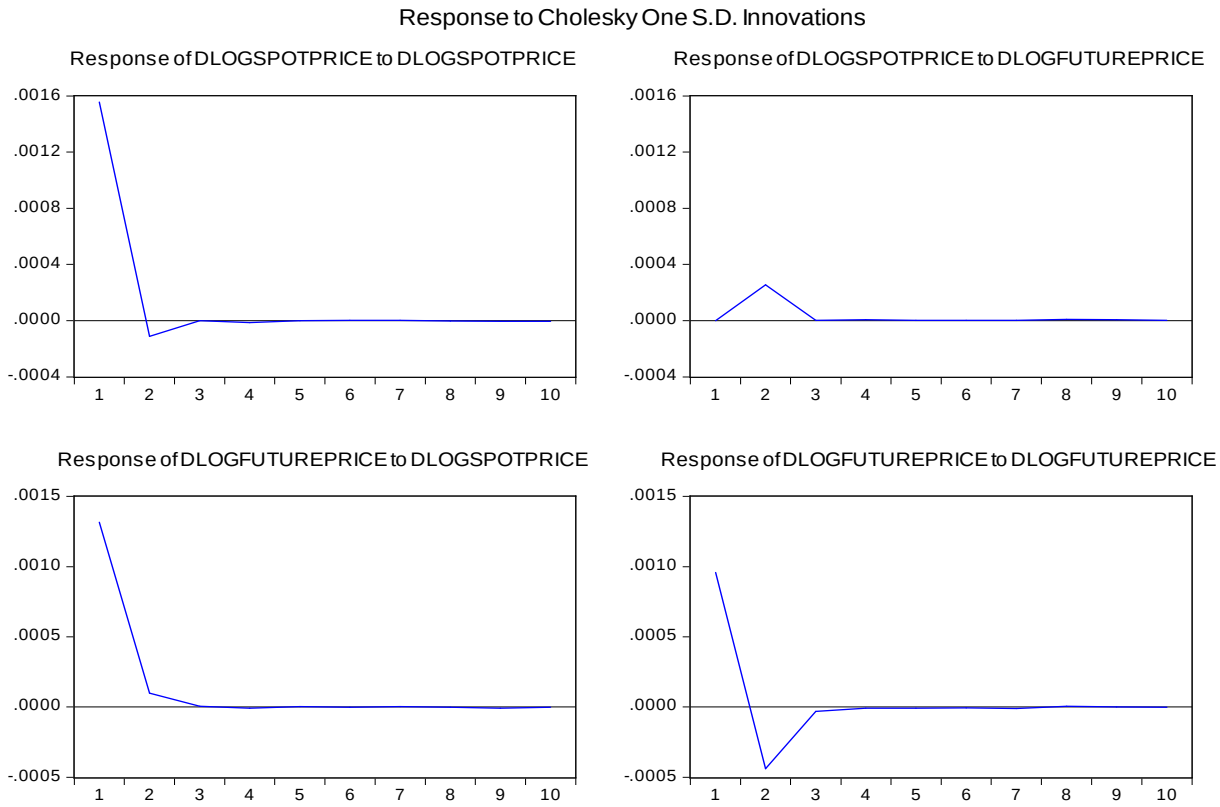
We further test impulse response function (IRF) and variance decomposition technique since this study seeks to identify the speed of price adjustment if any between the markets and to find the markets contribution towards the price formation. Impulse response function helps in identifying the response in endogenous variables in the VAR system when one unit of shock is given to error term in each VAR equation. This helps in identifying the speed of response between the variables in the VAR system. Variance decomposition technique helps in identifying the contribution of each variable in the system towards variance on its own and in other variables variance.

The following table 1.7 along with the graph 2.1 exhibits the output from impulse response function tested in the VAR system constructed above.

TABLE 1.7

IMPULSE RESPONSE FUNCTION (IRF)					
Response of DLOGSPOTPRICE:			**Response of DLOGFUTUREPRICE:**		
Period	**DLOGSPOTPRICE**	**DLOGFUTUREPRICE**	**Period**	**DLOGSPOTPRICE**	**DLOGFUTUREPRICE**
1	0.001557	0.000000	1	0.001315	0.000957
2	-0.000113	0.000257	2	9.93E-05	-0.000438
3	-7.83E-07	2.37E-06	3	7.26E-06	-3.05E-05
4	-1.40E-05	5.36E-06	4	-6.79E-06	-6.96E-06
5	-4.13E-07	1.76E-06	5	3.70E-06	-7.82E-06
6	3.04E-06	2.44E-06	6	-1.36E-06	-5.77E-06
7	6.57E-07	2.39E-06	7	4.22E-06	-9.96E-06
8	-3.07E-06	9.22E-06	8	-6.16E-07	4.98E-06
9	-5.55E-06	5.70E-06	9	-6.92E-06	1.36E-06
10	-5.11E-06	2.51E-06	10	-1.96E-06	-1.49E-06
Cholesky Ordering: DLOGSPOTPRICE DLOGFUTUREPRICE					

GRAPH 2.1: IMPULSE RESPONSE FUNCTION



The above result shows that the speed of adjustment of prices between two markets is quick since one minute data deployed for analysis. The graph exhibits the affect lasts for few minutes and dies off afterwards which indicates the model consistency. It is noted that the shocks to error term for each of the VAR specified equations found response from the variables within 3 minutes of time. This indicates that NSE spot and FO market prices are quickly adjusted together within 3 minutes of time frame.

The below table 1.8 present the results from variance decomposition technique for understanding the explanatory power of markets on each other's price variations. The variance of spot market prices and future market prices are decomposed and reported.

TABLE 1.8: VARIANCE DECOMPOSITION

Variance Decomposition of DLOGSPOTPRICE:			
Period	S.E.	DLOGSPOTPRICE	DLOGFUTUREPRICE
1	0.001557	100.0000	0.000000
2	0.001582	97.37037	2.629630
3	0.001582	97.37015	2.629848
4	0.001582	97.36924	2.630762
5	0.001582	97.36912	2.630883
6	0.001582	97.36890	2.631105
7	0.001582	97.36867	2.631325
8	0.001582	97.36538	2.634622
9	0.001582	97.36415	2.635853
10	0.001582	97.36393	2.636071
Variance Decomposition of DLOGFUTUREPRICE:			
Period	S.E.	DLOGSPOTPRICE	DLOGFUTUREPRICE
1	0.001626	65.38580	34.61420
2	0.001687	61.09104	38.90896
3	0.001688	61.07179	38.92821
4	0.001688	61.07138	38.92862
5	0.001688	61.07025	38.92975
6	0.001688	61.06956	38.93044
7	0.001688	61.06768	38.93232
8	0.001688	61.06715	38.93285
9	0.001688	61.06777	38.93223
10	0.001688	61.06777	38.93223
Cholesky Ordering: DLOGSPOTPRICE DLOGFUTUREPRICE			

The above table represents the proportion of total variance explained by self and other variable in the system. The results depict that the future prices are more endogenous than spot prices implies spot market perform better in price formation comparing to futures market and disseminate the price changes to future market. Though both the markets show bi-directional causality the spot market found to have greater power of price discovery.

CONCLUSION

Many empirical studies gave implications for the development of NSE FO market. Previous studies provided mixed results in regard to the causal relationship between NSE spot and FO markets. VAR model for estimating the causality between the markets found appropriate since the variables exhibit endogenous behaviour. The results from WALD restrictions depicts that there is indeed the bi-directional causality between NSE spot and FO market. The IRF exhibits the price

adjustments between the markets is quick and the prices from both markets influence each other and thereby adjust together within the time frame of three minutes. The variance decomposition analysis shows that the future market variance is explained by future market itself and also by variance in spot market. The variance in spot market is more self-explanatory and future prices have lower power in influencing the price variance in spot market. Thus this study concludes NSE spot and future markets have bi-directional causality and their prices are adjusted very quickly. Comparing to futures market spot market has greater influence in price discovery process.

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