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ORIGINAL ARTICLE

PRICE DISCOVERY AND INFORMATION TRANSMISSION IN SPOT AND OPTIONS SEGMENTS FOR NSE 50: AN EMPIRICAL STUDY

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Abstract:

In the absence of market imperfections or frictions, any new information is expected to reflect in both spot and derivative market instantaneously but in reality this hardly exists. The nature of the market microstructure results in a lead/ lag relationship and one market acts a dominant while other acts a satellite market. In this study, we examine the information transmission process between spot and options segments of the NIFTY 50, benchmark index of India. The daily data files stretch from 1 April 2009 to 31 March 2014. Cointegration and related tools were used to examine the price discovery process and it was found out that spot is the dominant trading platform vis-à-vis options for NIFTY 50 index and price signals emanating from spot are being factored in by speculators to hedge their risk in derivatives market. The findings are useful for investment professionals, traders, regulators and academia.

KEYWORDS:

price discovery, information transmission, cointegration, market efficiency .

INTRODUCTION

Ever since the introduction of derivatives segment in the Indian equity markets in early 2000, there has been interactions between the cash and derivative market segments. Though market microstructures of the two markets are different, yet they are linked to one another through information transmission and other linkages. Price discovery is one of the central functions of derivatives market. Price discovery is the process by which markets attempt to find their fair prices (Schreiber and Schwartz, 1986). The study of price discovery is of interest for many reasons like market efficiency, microstructure design, mispricing and riskless profit making opportunities (Pati and Rajib, 2009). Incase of efficient and frictionless markets, both the spot and derivatives market should react to new information simultaneously, and there should not be any lead-lag relationship between the two. Presence of an organized derivatives market furnishes the legitimate traders to hedge non diversifiable risk element contained in their portfolio. Ever since the introduction of derivative segments in Indian capital markets, it has witnessed a manifold increase in the volumes. Trading and pricing of options find an important place in derivatives market. Active trading in the options market simultaneously affects the cash market information dissemination efficiency, volatility and liquidity because both markets are linked through arbitrage process.

CNX Nifty 50 Index of the National Stock Exchange (NSE) which is India's leading stock exchange provides fully automated screen-based trading system with pan India presence. The daily traded volume of equity was USD 4,450 mn as on May 23 2014. The Exchange introduced trading in Index Options (also based on Nifty 50) on June 4, 2001. The daily traded volume of index options was USD

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30,038 mn as on May 23 2014.

The purpose of this study is to examine the price discovery and information transmission efficiency of the spot and options market trading platform for NSE 50 stock index. The remainder of the paper is organized as follows: Section two gives a brief review of literature. Section three discusses data sources and description. Section four deals with the methodology while section five discusses the empirical results. Section six provides summary and concluding observations.

REVIEW OF LITERATURE

According to Schwarz and Laatsch (1991), futures markets are an important means of price discovery in spot markets. Powers (1970) argued that futures markets increase the overall market depth and informativeness. Stroll and Whaley (1988) stated that futures markets enhance market efficiency. Manaster and Rendleman (1982), Bhattacharya (1987), and Anthony (1988) provide evidence that the options price leads the stock market. Finucane (1991) also reports that the measure of the relative index options price leads the stock market by at least 15 min. But, Stephan and Whaley (1990) document that price changes in the stock market lead price changes in the options market for active CBOE call options about 15 to 20 min on average with a 5-min option price series. Seung et al (2006) examined the price discovery of KOSPI 200 stock index derivatives market and reported that KOSPI 200 stock index futures lead the stock index as was found out by other studies and the at-the-money options lead the stock index. Chan, Chung, and Johnson (1993) confirm that stocks lead options by 15 min. They argue that the lead can be caused by the relatively larger option tick, and it might be a spurious lead induced by infrequent trading of options. Fleming, Ostdiek, and Whaley (1996) provide a trading cost hypothesis for the relative rates of price discovery in the stock index, futures, and options markets. Their empirical results with 5-min returns for the markets show that S&P 500 index futures lead the S&P 500 stock index, and S&P 100 index options lead the S&P 100 stock index, even after controlling for the effects of infrequent trading on the indexes. Gwilym and Buckle (2001) also examine the lead–lag relationships between the FTSE 100 stock index and its derivatives markets with hourly data. They report that the index call options strongly lead the index futures, and the futures strongly lead puts, which suggest that expectations of rises or falls in the market may affect the lead–lag relationship between markets. As for the Indian context, studies have been mainly concentrated on cash and futures segments. Thenmozhi (2002), Anandbabu (2003), Pati and Rajib (2009) have found that the futures market in India has more power in disseminating information and therefore has been found to play the leading role in the matter of price discovery. Mukherjee and Mishra (2004) have investigated the possible lead-lag relationship, both in among the Nifty spot index and index futures markets in India and found a strong contemporaneous and bidirectional relationship between the returns in the spot and futures markets. Debasish and Mishra (2008) examine the returns at hourly intervals of NIFTY 50 and found that both index options and futures leads the cash index.

Although there is no dearth of literature available on the price discovery and information transmission in the mature markets but the literature in the Indian context is more based on spot and futures segments of the equity markets. This paper is an attempt in the direction to ascertain the lead lag relationship between the spot and options segment in the NSE 50 index spanning a more recent study period.

3 DATA SOURCES AND ITS DESCRIPTION

The sample used in the study is the NIFTY 50 spot index and NIFTY index call options. The data used in the study covers the period from 1st April 2009 to 31 March 2014. The daily prices data for NIFTY 50 spot and NIFTY index call options were retrieved from National Stock Exchange (NSE) website for the said period. For all the available liquid index call option contracts for a given day, for which the strike price of the next month maturity contract which was at the money (ATM) contract or nearest ATM contract for that day was selected. 91 day Treasury bill yield, which was used as risk free proxy in the Black Scholes Option Pricing model, was available from Bloomberg for the said period.

4 METHODOLOGY

Black Scholes Option pricing model was used to obtain the implied index level from the NSE 50 call options price each day. As an input for the volatility for each day, we compute the conditional volatility estimates of the NSE 50 spot index prices from the GARCH (1,1) model of the previous day. Thus we have obtained a time series of spot and implied index level from call options prices (henceforward called as options). The methodology used includes first converting the daily closing price data of spot and options to daily returns by taking the log first difference. Return Rt at time t is given by $Rt = \ln Pt - \ln Pt\text{-}1$, where Pt is

the closing price for day t. This was followed by an analysis of the characteristic properties of the return series, by looking at the first four moments (mean, standard deviation, skewness and kurtosis), and substantiating the results of skewness and kurtosis through the Jarque Bera Test for testing normality, and finally, the Ljung Box to check the independence of the series. Thus, the i.i.d. (identically and independently distributed) property of the all the series was tested.

This was followed by testing for stationarity of the data through the Augmented Dickey Fuller (ADF) Test. Then, the appropriate lag length for the autoregressive process, was estimated through the Schwarz Information Criteria (SIC), by selecting the lag length which minimized the SIC. Next, the Johansen's Cointegration procedure was applied to the data to capture the presence of any long run equilibrium relationships between the spot and futures segments. In the context of the spot and futures segments in a market, the current futures (or spot) price could be represented as being dependent on the spot (or futures) price, as under:

$$F_t = \alpha_1 + \beta_1 S_t + ?_{1t} \text{ ----------} \quad (1)$$

or

$$S_t = \alpha_2 + \beta_2 F_t + ?_{2t}, \text{ ----------} \quad (2)$$

where F_t and S_t are the futures and the spot prices at time t.
The above can be re-written with residuals, as under:

$$F_t - \alpha_1 - \beta_1 S_t = \hat{e}_{1t} \ldots\ldots\ldots\ldots \quad (3)$$

or

$$S_t - \alpha_2 - \beta_2 F_t = \hat{e}_{2t}, \ldots\ldots\ldots\ldots \quad (4)$$

where êt is the white noise residual term. Equations 3 and 4 are linear combinations of F_t and S_t. If either $\hat{e}_{1t}$ or $\hat{e}_{2t}$ is stationary, then one of them is I(0) and there is at least one long run relationship between Ft and St.After confirming the long run relationship, Vector Error Correction Model (VECM) test was undertaken to check their short-run dynamics. Accordingly, the VECM for change in the say futures prices and in the spot prices can be represented as under:

$$?F_t = \delta_f + a_f \hat{e}_{t-1} + ß_f ?F_{t-1} + ?_f ?S_{t-1} + ?_{ft} \quad (5)$$
$$?S_t = d_s + a_s \hat{e}_{t-1} + ß_s ?S_{t-1} + ?_s ?F_{t-1} + ?_{st}, \quad (6)$$

where $\hat{e}_{t-1}$ measures how the current price of the dependent variable adjusts to the previous period's deviation from the long run, while $?S_{t-1}$ and $?F_{t-1}$ measure how the current price adjusts to the change in the variables in the previous period. The first part represents the error correction (EC), and its coefficients (α_f and α_s) indicate the speed of adjustment in the futures prices and the spot prices respectively; the smaller the absolute value of the EC term, faster is the adjustment made by the concerned market towards equilibrium and leads the price discovery process. Results of the VECM tests were confirmed through the Granger Causality Test which indicates direction of the causality.

5. Empirical Results

The descriptive statistics regarding daily returns for the Nifty spot and futures are given below:

Table 1: Descriptive Statistics of Return Series

Statistic	Spot	Options
Mean	0.000609	0.000592
Maximum	0.1633	0.1102
Minimum	-0.0638	-0.0715
Std. Dev.	0.0141	0.0140
Skewness	1.3506	0.6691
Kurtosis	19.1699	9.2115
Jarque Bera	13516.60 (0.000)**	2030.451 (0.000)**
Ljung Box (Q Statistic)	18.111 (0.112)	17.306 (0.138)
Observations	1207	1207

Note: Fig. in ( ) indicate p-values; ** denotes significance at 1% level; * denotes significance at 5% level. Ljung Box statistics are reported upto 12 lags.

The Nifty Index Spot has daily mean returns of .061%, with standard deviation, as a measure of volatility, being 1.41%. The option (implied index from black scholes option model) has a slightly lower mean return of .059% percent, with standard deviation being at 1.40%. Both the Nifty Spot and Options returns show evidence of fat tails, since the kurtosis exceeds three, which is the normal value, implying leptokurtic distribution; these returns also show evidence of positive skewness, which means that the positive tail is particularly extreme. This result is confirmed by the Jarque Bera test which indicates zero probability for both series, thus the null hypothesis of normal distribution is rejected. Accordingly, both the series are not normal, i.e., not identically distributed. Next, the Ljung Box (LB) test at level indicates a p-value for Q-statistic (for 12th lag) of more than 0.05 for spot series as well as for futures series. Thus, the null hypothesis of no autocorrelation is accepted. Therefore, past values of the innovations do not affect current values in both series, implying that both series are independently distributed.

The results for the stationary tests are as shown below:

Table 2 – Test for Stationarity

Test Statistic	Spot	Options
At Level	-2.7692 (0.2091)	-2.8392 (0.1834)
At First Difference	-32.7109 (0.0000)*	-33.7230 (0.0000)*

Note: Figures in brackets indicate the p-values;

*denotes significance at 5% level

Results confirm the existence of unit root at level and exhibit stationarity at first difference for all sample series thus conforming that they are integrated to the first order. The Johnson Cointegration results as shown in Table 3 below clearly confirm the strong informational linkages between the two trading platforms having 2 cointegrating vectors.

Table 3. Results of Johansen's Cointegration Test

Test Statistic	r=0	r=1
Maximum Eigen value	39.2238 (0.0000)*	6.8567 (0.0088)*
Trace Statistic	46.0806 (0.0000)*	6.8567 (0.0088)*
Lag length#	2	2

Note: r – cointegration rank of the model; Figures in brackets indicate the p-values;
* denotes significance at 5% level;
# - Based on minimum values of the Schwarz Information Criteria which was 2 in this case

This also implies that there is informational efficiency across the spot and options segments in equity market. The VECM has been estimated with the lags as indicated by the Schwarz Information Criteria, and the results are reported below in table 4:

Table 4: VECM Analysis

Test Statistic	Spot	Options
Error Correction Coefficient [T-stat]	-0.0054 [-0.1016]	0.0943 [1.9945]*

Note: T Statistic [ ];
*denotes significance at 5% level;

It shows error correction coefficient of the spot is smaller than optionss. Hence if the co-integrated series is in disequilibrium in the short-run, it is the spot price that makes less adjustment than the options price in order to restore the equilibrium. In other words, the spot markets lead the price discovery process. The information provides market traders an incentive to sell/short-sell spot (as they are overvalued as seen from the coefficient of the EC term) and go long on options (as they are undervalued as seen from the coefficient of the EC term) and exercise lending opportunities to make arbitrage profits. Such an arbitrage process is probably ensuring a long-run equilibrium relationship between these market pairs as confirmed by cointegration results. Further Granger causality test was performed to ascertain the direction of relationship. The results for the same are shown below in Table 5:

Table 5: Granger Causality Test

Null Hypothesis	F Statistic	P-value
Spot does not Granger Cause Options	25.561	.000*
Options does not Granger Cause Spot	1.5700	0.209

Note: Lag structure based on minimum values of the Schwarz Information Criteria;
*denotes significance at 5% level

It can be inferred that we have a unidirectional causality from spot to the options segments of the equity market. Combining this result with VECM results, shows that spot market relatively leads in price discovery.

6. SUMMARY AND CONCLUSIONS

This paper examines the price discovery process in the spot and options markets for Nifty 50 in India during the sample period from 1 April 2009 to 31 March 2014. Black Scholes Option Pricing model was used to obtain the inferred index level (termed here as options) from the call price. The spot and options price series were found to be integrated to order 1 and subsequently longrun equilibrium relationship was confirmed. VECM analysis showed that the spot market relatively leads in price discovery process and is the dominant platform to trade the NIFTY 50 index vis-à-vis options which acts as a satellite platform for the same. Thus the empirical results suggest information flow is from spot to options which are contrary to the huge volumes seen in the derivatives segments. This probably indicates investor's stickiness for being in the spot segments and generating the price signals for the speculators to take notice while hedging their risk exposure trading in the options market. Since inspite of low trading cost and fewer restrictions in options market, price signals seem to be emanating from spot, challenges the market efficiency theory and points that other competing markets within India, e.g. the market for BSE as well as markets abroad where Nifty is traded, e.g. Singapore, have been ignored. It is quite possible that signals to the Nifty spot or for that matters options markets are coming from a third market. The study is useful for the investment professionals who can make long/short strategies to make profits. It is also useful for the regulators to see the imperfections prevailing in the market microstructure in order to efficiently manage the markets.

However, the study has been limited to analysis of information flows between the spot and futures segments of the market. Volatility has been examined only with reference to the standard deviation. In order to broad-base the results of the study, volatility patterns could be studied in greater detail through higher order moments, to arrive at conclusions regarding volatility persistence and clustering, which could increase the usefulness of the study. The relevance of the study could also be enhanced further by extending its scope to cross-markets analysis, to include inter-market linkages, particularly volatility spillovers between markets. Further research could be undertaken along these lines.

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